The political economy of environmental technological change with a case study of the power sector in Vietnam

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Abstract

The escalating imperative of climate change mitigation implies a substantial change in the technologies of electricity generation and supply in industrialised and industrialising countries alike. Understanding how to effect this technological change is therefore imperative if the challenge of climate change is to be addressed. The literature is replete with technology and policy studies investigating technologies, policy instruments and processes of technological change, however, surprisingly little research has addressed the broader political economy context within which any technological change will need to be realised. This research investigates linkages between the sort of systematic environmental technological change implied by the imperative of climate change mitigation and the broader political economy context.

Firstly, considering evolutionary economics approaches to understanding technological change, we argue that evolutionary micro-foundations lend themselves to an analysis of political economy processes. Moreover, it is a direct consequence of evolutionary micro-foundations that technological change, and particularly that linked with structural change in an economy, is likely to have important political economy implications. Secondly, we show how heterodox approaches to understanding structural change and development in economic systems are consistent with evolutionary micro-foundations and allow the development of an analytical framework based upon an understanding of the process of economic rent creation and preservation. Thirdly, we apply these insights to a critical reconstruction of the evidence on the development of the electricity services industry (ESI), illustrating the importance of political economy considerations in understanding technological and institutional change in that sector. Finally, we apply these insights to a detailed case study of the ESI in Vietnam, investigating the ways in which political economy factors have influenced the broader development of the sector, and examining how the choice of specific technologies is likely to be affected by political economy of the sector.

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Acronyms

AC	Alternating Current
ADB	Asian Development Bank
AFD	Agence Française de Développement
AfDB	African Development Bank
AGM	Annual General Meeting
APEC	Asia Pacific Economic Cooperation
ASEAN	Association of South-east Asian Nations
BIDV	Joint Stock Commercial Bank for Investment and Development of Vietnam
BOO	Build-own-operate
BOT	Build-own-transfer
BT	Build-transfer
BTA	Bilateral Trade Agreement
BTO	Build-transfer-own
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanisms
CEMA	Council for Mutual Economic Assistance
CFC	Chlorofluorocarbon
CHP	Combined Heat and Power
CIC	China Investment Corporation
CIEM	Central Institute of Economic Management
CO_2e	Carbon dioxide equivalent
COD	Commercial operations date
CP	Communist Party
CPC	Communist Party Congress
CSG	China Southern Grid
DC	Direct Current
DSM	Demand Side Management
ECA	Export credit agency
EDF	Électricité de France
EGAT	Electricity Generating Authority of Thailand
EIA	US Energy Information Administration
EOP	End of Pipe
EPC	Engineering, Procurement Construction
EPTC	Electricity Power Trading Company
ERAV	Electricity Regulatory Authority of Vietnam
ESI	Electricity Services Industry
ESMAP	Energy Sector Management Assistance Programme
EVN	Electricity Vietnam
FC	Financial close/closure
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GSO	General Statistical Office
HCMC	Ho Chi Minh City

HVDC	Hifh voltage direct current
IAEA	International Atomic Energy Agency
ICT	Information and Communication Technologies
IDA	International Development Association
IEA	International Energy Agency
IFI	International Financial Institution
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPO	Initial Public Offering
IPP	Independent power provider
IPR	Intellectual Property Rights
IPS	Integrated Power Sector
IRS	Increasing Returns to Scale
ISO	Independent System Operator
JBIC	Japan Bank for International Cooperation
JETRO	Japan External Trade Organisation
JICA	Japanese International Cooperation Agency
JSC	Joint Stock Company
JV	Joint venture
Km	Kilometre
kV	Kilovolt
kVA	Kilovolt ampere
kWh	Kilo-watt hour
LRMC	Long run marginal cost
M&A	Mergers and acquisitions
MIGA	Multilateral Investment Guarantee Agency
MNE	Multinational Enterprises
MoE	Ministry of Energy
MoI	Ministry of Industry
MOIT	Ministry of Industry and Trade
MPI	Ministry of Planning and Investment
MRC	Mekong River Commission
MW	Mega-watt
MWh	Mega-watt hour
NDLC	National Dispatch and Load Centre
NGO	Non-governmental Organisation
NIC	Newly Industrialised Country
NIE	New Institutional Economics
NIS	National Innovation Systems
NO_x	Nitrogen Oxides
NPTC	National Power Transmission Company
OCGT	Open cycle gas turbine
ODA	Overseas Development Assistance
OECD	Organisation for Economic Cooperation and Development
OECF	Overseas Economic Cooperation Fund (Japan)
PACE	Pollution Abatement Capital Expenditures

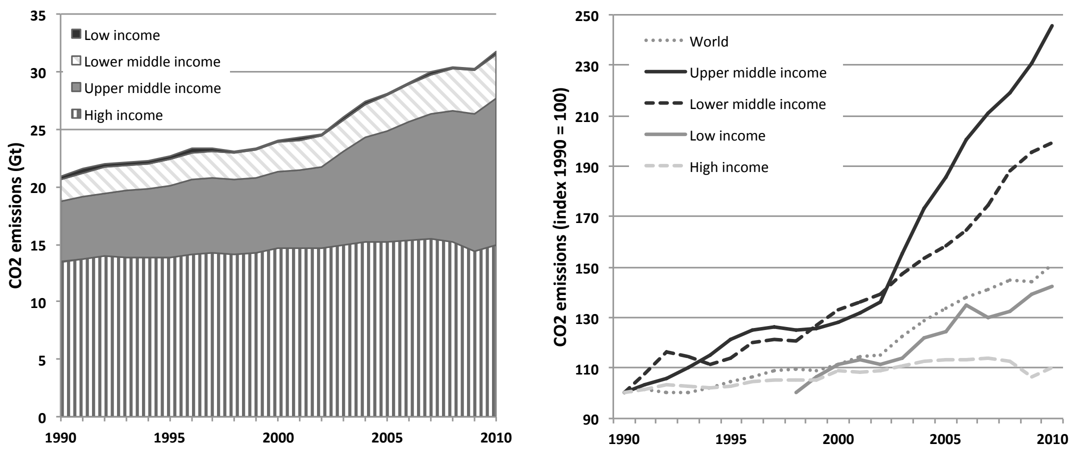
PDP	Power Development Plan
PM	Prime Minister
PPA	Power Purchase Agreement
ppmv	Parts per million volume
PRG	Partial Risk Guarantee
PURPA	Public Utility Regulatory Policies Act
PVN	Petrovietnam
R&D	Research and development
RD&D	Research, development and demonstration
ROT	Renovate-own-transfer
SBV	State Bank of Vietnam
SCIC	State Capital Investment Corporation
SEG	State Economic Group
SOCB	State owned commercial banks
SOE	State Owned Enterprise
Solar PV	Solar Photovoltaic
SO_x	Sulphur Oxides
SPV	Special purpose vehicle
SRMC	Short-run marginal cost
T&D	Transmission and distribution
TEPCO	Tokyo Electric Power Company
TFP	Total Factor Productivity
TKV	Vinacoal/Vinacoalmin
TNC	Transnational Companies
TPES	Total primary energy supply
TVA	Tennessee Valley Authority
TWh	Terawatt hour
UK	United Kingdom
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
US	United States
US$	United States Dollar
USA	United States of America
USSR	Union of Soviet Socialist Republics
VND	Vietnam Dong
VSH	Vinh-Son Song Hinh Hydroelectric JSC
WCD	World Commission on Dams
WNA	World Nuclear Association
WTO	World Trade Organisation

Chapter 1: Introduction

1.1 Climate change, GHG emissions and environmental technological change

There is a general scientific consensus that anthropogenic climate change poses a serious threat to the development prospects of many countries in the medium to long term. Recent projections discussed by the Inter-governmental Panel on Climate Change (IPCC) suggest that to stabilize the concentration of greenhouse gases (GHG) at a level below 490ppmv CO_2e[1] global GHG emissions would need to be cut by at least 50% from 2000 levels by 2050 and peak before 2015. This is likely to limit global warming to 1.4-3.6°C above pre-industrial levels depending on climate sensitivity (Metz et al 2007). Even temperature rises of this order are likely to pose a substantial threat to the climate system, temperature rises of above 2°C risk serious damage to ecosystems through exceeding key tipping points beyond which change is expected to increase rapidly (Metz et al 2007; Stern 2007).

Figure 1.1. Global CO_2 emissions from fossil fuel combustion by country income group 1990 - 2010



Source: World Bank 2013

Given the rapid growth in global GHG emissions over recent decades, and accelerating growth in emissions in middle income 'emerging' economies (Figure 1.1), there is an escalating imperative for countries to decrease the speed of emissions growth in the near term and reduce absolute levels of emissions in the longer term. Recent projections from the IEA suggest that even if OECD and other high income countries reduced their emissions to zero, without abatement effort in developing countries this would not be

[1] The notation indicates: ppmv – parts per million volume; and, CO2e - carbon dioxide equivalent, this includes other greenhouse gases such as Nitrous Oxide, Methane and CFCs weighted by their global warming potential.

enough to stabilize emissions at a level which would avoid an increase in global temperatures of above 2°C (IEA 2008). Despite disparities in per capita emissions abatement efforts are therefore imperative in both developed and developing countries.

At the most general level, the problem this research proposes to investigate is therefore how to induce a downward perturbation from current GHG emissions trajectories in order to stabilize atmospheric concentrations and reduce the risks associated with climate change. Reducing GHG emissions will be extremely challenging. Growing global population and growing economic activity imply increased energy demands. The predominant sources of energy available for economic use are fossil fuels, which generate carbon dioxide in their combustion. It is therefore widely accepted that technological innovation, technological change and technology transfer are central to addressing the problem of climate change (Olsen 2007; Gupta et al 2007; Stern 2007; de Coninck et al 2008).

1.2 Identifying the research gap

Given the need for technological change to address the issue of climate change the question becomes not so much whether change in technological systems is necessary, but how to achieve it. It becomes a question of what policies and institutions are likely to be the most effective in promoting the kind of technological change needed (2008). This is recognised by a number of authors, for example, Olsen (2007) notes the importance of broader development pathways and socio-economic choices in influencing mitigation outcomes and how these can be integrated with climate change mitigation policy. These issues are also explicitly recognised in towards the end of the IPCC's fourth assessment report on climate change, Gupta et al (2007) comment that in relation to developing countries:

"…additional work is needed to bolster the currently sparse body of research addressing the concerns of developing countries. Understanding how to accelerate policy adoption may be the most important research topic for the immediate future..." (Gupta et al., 2007:796)

Despite these considerations the paucity of research on climate change mitigation policy, policy choice and the determinants of broader socio-economic development pathways is somewhat surprising. In this respect a recent paper comments:

"The plethora of low-carbon scenarios, road maps and pathways developed in recent years by academia, businesses, governmental agencies and NGOs do not have a remote chance of becoming reality without conducive political and institutional conditions…[…]…future studies must go beyond studying technical-economic possibilities and consequences and put more emphasis on how these futures can be attained…*future studies will then benefit from integrating underlying political drivers and the complex institutional and social context through which policies are conceived, filtered and interpreted before they have an effect.*" [emphasis added] (Nilsson et al 2011:1127)

While the literature on climate change is replete with work on the micro and macro-economics of climate changed modelled using a variety of methods from a variety of methodological and theoretical standpoints, there are two important gaps in the literature that this research attempts to address. The first relates to the extent to which the political economy is addressed in the literature on technological change (Geels 2011). The micro foundations of evolutionary economics and other research conducted in broadly this tradition fail to satisfactorily address the implications of their approach for the relationship between technological change and political economy. Similarly, while a number of writers have gone some way to investigating the relationships between technological change, economic development and political economy, work on the implications this may have for climate change mitigation is largely absent (Mokyr 1992, 1997; Moe 2009, 2010). The second gap in the literature relates to the paucity of empirical research relating processes of environmental technological change to political economy considerations. There are growing bodies of research on the political economy of technological systems (and energy systems in particular) and institutional change, but these have generally failed to address considerations relating to the mitigation implications of technology choice in general and in developing countries in particular.

Formalising the focus of this thesis, in addressing these two gaps in the literature the question we first seek to answer is: *To what extent is the possibility for systematic environmental technological change affected by political economy. What are the linkages between technological change and political economy processes and how should we understand them?* In addressing the second gap in the literature, we seek to answer the question: *To what extent have political economy factors influenced the choice of technology in the electricity services industry of Vietnam?*

1.3 Overview of the argument

In order to answer these two questions our argument is developed in two main parts, the first concentrating on the theoretical and analytical basis (Chapter 2 and 3) and the second elaborating the application of the theoretical work to a particular sector (the electricity services industry (ESI)) (Chapter 4) and the case study country of Vietnam (Chapters 5, 6 and 7). The jumping off point in Chapter 2 is an overview of the literature on evolutionary approaches to technological change. We argue that the explanation of technological change calls for more realistic causal micro-foundations than those offered by the neo-classical economic cannon. The approach offered by evolutionary economics is found to offer realistic micro-foundations, which enable a more accurate description of empirical phenomena and a fruitful way of understanding the dynamic processes driving technological change. At the same time we find that the implications of evolutionary accounts as regards the role of the political economy have not been fully taken on board by the literature on technological change, and this is an important gap in the evolutionary literature on technological change. From this argument we conclude that when considering the possibility of environmental technological change, the political economy context is likely to be closely related to the technological context, and there is a strong *prima facie* argument for the examination of the political economy of technological change when seeking to address climate change mitigation.

Chapter 3 makes the same argument from the top down, through a review of the literature on institutional development and political economy in the process of economic development. This traces the implications of this literature for the understanding of technological change, with a particular emphasis on the process of economic development. In common with the bottom-up argument, from the top-down this account takes issue with broadly neo-classical explanations of the process of technological change in the wider development process. We find that attention needs to be paid to the structural aspects of technological change in the process of economic development and industrialisation, and in particular institutional and political economy factors. Again, we find close connections between the process of technological change and political economy. These institutionally mediated connections are likely to be an important factor in determining the possibility of technological change. We complete this chapter by sketching an analytical framework, which uses the notion of economic rents as a means to understanding political economy processes in developing countries.

Chapter 4 takes up the theory developed in Chapters 2 and 3, and develops a case study of the electrical services industry. This chapter uses secondary accounts in a critical reconstruction of the research on the sector to establish in greater detail the linkages between technological systems and the political economy. This review presents evidence to support the contention that technological choices made in the electrical services industry have often been subordinated to political economy processes. Based on the evidence presented in the chapter, Chapter 4 ends with an elaboration of the analytical framework developed in Chapter 3 with respect to the ESI.

Following on from this analysis Chapters 5 and 6 develop an empirical case study of the power sector in Vietnam examining in greater detail the coevolution of the electricity services industry and the political economy. Chapter 5 explains the rationale for the selection of Vietnam as a case study and presents background information on the political economy context in Vietnam to allow the development of the ESI case study in Chapter 6. Chapter 6 gives a history of the development of the ESI in Vietnam, with a particular focus on the development of the sector in the period between 1990 – 2010. In so doing it seeks to illustrate how the fundamental technological and economic attributes of the ESI have developed in Vietnam's institutional and political economy context. In particular, it seeks to draw out key linkages between the political settlement in Vietnam, the role of elites, and the development of the ESI.

The final chapter of this thesis concludes through drawing on the evidence presented in Chapters 4, 5 and 6 to illustrate more specifically how political economy factors have influenced technology choice. The chapter also looks at what this may imply for climate change mitigation in Vietnam and concludes with recommendations for further study.

Chapter 2: Getting the micro-foundations right - a critical reconstruction of the literature on technological change

"The current dialogue regarding policy toward innovation rests on two premises. The first is that technological advance has been a powerful instrument of human progress in the past. The second is that we have the knowledge to guide that instrument toward high priority objectives in the future. The first premise is unquestionable: the latter may be presumptuous." (Nelson & Winter 1977:38)

2.1 Introduction

Economists have long realised the importance of technological and institutional change as key causal factors in generating economic growth and development (Smith 1776; Marx 1867). In more recently, early growth accounting exercises found that technological change accounted for the largest proportion of productivity growth (Solow 1956; Denison 1962).[2] But, as the quotation from Nelson & Winter (1977) above suggests, while there has been a general agreement on the importance of technological change there still remains a deep disagreement as to the causal factors that drive technological change.

Initial characterisations of technological change explained it as a, more-or-less, linear process, either effectively driven by investment in research and development activities, or induced in firms through market price signals (Ruttan 2001). More recently, this 'induced innovation' account has been augmented by the suggestion that the process of technological change is subject to chronic market failures due to various externalities and knowledge asymmetries (Jaffe et al 2002; Jaffe et al 2005). Despite the continuing influence of the induced innovation account in the formation of technology (and environmental) policy, the empirical evidence is equivocal, and the account itself has been subject to considerable criticism on conceptual grounds (e.g. Mowery & Rosenberg 1979). Indeed, opponents have suggested that precisely in the explanation of the phenomena of technological change that the induced innovation account, and the neo-classical economic foundations upon which it rests, have been at their weakest (Nelson 1995; Nelson & Winter 2002; Dosi 2011).

Here we focus on alternative accounts of technological change that have rejected the primary causal role given to demand in determining technological change.[3] Drawing on

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[2] These are discussed in greater detail in Annex A3.
[3] For a critical review of the induced innovation account and realted empirical work see Annex A2.

Schumpeter (1934; 1939) and Simon (1955), evolutionary and path-dependency approaches have developed theories of technological change, which stress the role of uncertainty, technological inertia and path-dependency in technological change (Dosi 1982; Nelson & Winter 1982; David 1985; Arthur 1989). These accounts also emphasise the role and co-development of institutions in understanding technological change. In so doing, evolutionary and path-dependency accounts represent a departure from neo-classical micro-economics and present a challenge to the dominant paradigm (e.g. Dosi 2011).

A large case study literature from economic history and innovation systems stressing the role of the national institutions in realising technological change has been an important source of empirical evidence for the evolutionary approach (Lall 1994; Freeman 1995; Kim & Nelson 2000). More recently, focusing on the development of individual technologies or technological regimes, in respect of technological transitions towards greater environmental sustainability, developments in theorising technological change have drawn heavily on the insights of evolutionary economics, path-dependency, technological lock-in and new institutional economics (much of which is seen as broadly compatible with evolutionary micro-foundations). The sustainability transitions literature has yielded valuable insights into the way in which technological change is articulated in social systems (Rip & Kemp 1998; Unruh 2000; Geels 2005b; Geels & Schot 2007). Both the transitions literature and the evolutionary tradition in general have been productive of a great deal of detailed empirical research in support of the theory.

Evolutionary approaches have also been extended to the description of political processes. The application of evolutionary concepts to political analysis seems particularly promising (Pierson 2000; Pierson 2004). The implications of this research program have yet to be fully worked out or taken on board by other writers on technological change in the evolutionary tradition, with a few notable exceptions (e.g. Mokyr 1997; Moe 2010). By contrast, the treatment of politics in the sustainability transitions literature remains a largely ahistorical account of the technical difficulties with governing technology transitions (Smith et al 2005; Smith & Stirling 2010; Meadowcroft 2011). Given the amenability of political processes to an analysis through evolutionary micro-foundations the absence of a more descriptive evolutionary account of the relationship between the causal processes involved in technological, economic and institutional change, and the causal processes involved in political change is puzzling.

The main argument of this chapter is that there are good reasons to believe that an evolutionary account of technological change is correct. The implications of this for understanding the process of technological change and appropriate technology policy are significant and well developed in the literature. The focus of the argument here, however, is that *a direct consequence of evolutionary micro-foundations is that political processes are also subject to evolutionary dynamics*. The way in which these micro-foundations are likely to be articulated in political processes will lead to the co-determination of political and techno-economic processes, or to put it another way, the emergence of a determinate political economy. In effect, the implication is that a technological regime *is* a regime of political economy with implications for the distribution of wealth and power. These vested interests are likely to be a significant source of technological inertia.

In developing this argument this chapter serves both to present a brief review of the theoretical literature on evolutionary approaches to technological change, and to place the political economy analysis that will form the basis of following chapters on clear micro-foundations.[4] The chapter also extends the theory relating to technological change (particularly as relates to radical or disruptive technological change), though showing how evolutionary micro-foundations could lead to the emergence of a political economy process, and so constitutes a novel addition to the literature.

Section 2.2 introduces evolutionary and path-dependency approaches to technological change and elaborates their implications. Section 2.3 addresses some of the main criticisms of the evolutionary approach. Section 2.4 takes up a key criticism relating to the failure to treat political processes adequately within the evolutionary tradition, and shows how political economy processes might emerge from evolutionary micro-foundations, and section 2.5 concludes.

2.2 Evolutionary economics approaches to technological change

[4] While this often seems to be regarded as an unnecessary step, there are important epistemological reasons relating to the identification of causal patterns in social systems (i.e. open systems which cannot effectively be closed), which point to the importance of realistic causal micro-foundations.

The main theoretical alternatives to the induced innovation approach are path-dependency and evolutionary economics approaches.[5] Both approaches represent a significant departure from the micro-foundations of neo-classical economics through the development of an account of causal mechanisms able to explain the empirical phenomena of technological change. The strategy of neo-classical economics has been to attempt to show how empirical evidence on innovation can be made to accord with the established axioms and the deductive superstructure of the discipline. By contrast, these alternative approaches, put the dynamics of technical change at the heart of their understanding for economic processes. This is enabled by the adoption of what they see as more realistic micro-foundations.

2.2.1 Bounded rationality and its implications

The starting point for evolutionary approaches is the rejection of the perfectly rational economic actor, which lies at the heart of neo-classical theory:

> "The central presumption in neo-classical theory is that the observed configuration of economic variables can be explained as the result of rational actors…[…]…having made choices that maximize their utility, given the constraints they face, and that they have made no systemic mistakes about that…[…]…systematic mistakes associated with ignorance, or wrongheaded understanding, of the basic features of the situation are not admitted. The theory "works" by presuming the actors have a basically correct understanding of there actual choices and their consequences, as the theorist models that choice context…." (Dosi & Nelson 1994: 157)

The economic assumption of individual rationality is replaced by the notion of 'bounded rationality', that is the observation that economic agents (individuals, firms, other organizations) are more realistically characterised as being rational only within the limits of their cognitive capacities and access to information (Simon 1955; Simon 1959).[6]

Simon suggests that there are potentially significant costs associated with information gathering and working out the consequences of an action (notwithstanding actual limits to computational ability and available information). This implies a trade-off between additional advantage gained by investing in information gathering activities and the cost

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[5] See Annex A2.

[6] A similar rejection of rational choice theory is made in the influential behavoiral economics literature, "…the deviations of actual behavior from the normative model are too widespread to be ignored, too systematic to be dismissed as random error, and too fundamental to be accommodated by relaxing the normative system." (Tversky & Kahneman 1986: 253)

of engaging in these activities. On this account, agents do not seek optimal courses of action, rather within the constraints defined by their computational ability and their access to information, they seek a 'satisfactory' course of action with respect to an aspiration level, to use the term coined by Simon, they 'satisfice':

"…economic man is a satisficing animal whose problem solving is based on search activity to meet certain aspiration levels rather than a maximizing animal whose problem solving involves finding the best alternatives in terms of specified criteria." (Simon 1959: 278)

The level of aspiration, which defines the conditions for the satisfaction of a desire is based upon past experience and can move up or down in response to this (Simon 1959). In this way, the notion of bounded rationality, suggests a second-order rationalisation of satisficing behaviour – as procedural - to replace the first order, substantive rationality of neo-classical economics (Simon 1986). This approach opens up the possibility that actors may be wrong about the world, and that the social influences which form agents' perception of, and expectations about the world are central to understanding the decision making process (Foxon 2006).[7]

Simon (1959) suggests that firms (and organisations) also tend to act as satisficers rather than maximisers. That is, they seek to satisfy an attainable objective such as an acceptable market share or level of profit. The evolutionary theory of Nelson & Winter (1982) built on this notion in the development of their concept of 'routines'. Routines are patterns or satisficing rules of thumb adopted by firms that persist over time, act as guides in decision-making and together with environmental conditions determine firm behaviour. For example, in the context of the innovation process, Dosi makes the following observation relating to R&D expenditures:

"…firms tend to work with relatively general and event-independent routines (with rules of the kind . . . 'spend x% of sales on R&D,' 'distribute your research activity between basic research, risky projects, incremental innovations according to some routine shares . . .' and sometimes meta rules of the kind 'with high interest rates or low profits cut basic research,' etc.)." (Dosi 1988: 1134)[8]

[7] It should be noted that this picture of decision-making is largely supported by, and consistent with empirical evidence from behavioural economics (Tversky & Kahnemann 1986).
[8] This stands in marked contrast to the account related earlier given by Jaffe et al (2005) where R&D decisions are just the same as any other profit maximising decision made by the firm.

For Nelson & Winter (1982) routines form the basic building blocks of firm behaviour, playing a role analogous to that played by genes in evolutionary biology.[9] Routines are 'heritable', tend to show inertia and persist overtime. There are a number of reasons given for this, firstly, because learning alternative routines can be costly (as the account of bounded rationality suggests). Secondly, because firms are made up of individuals with differing goals, routines have almost always evolved as - amongst other things - ways of coping with conflict between different interest groups and individuals within the firm. Because any change in routine can open up sources of conflict there is a tendancy towards inertia. Thirdly, routines can also persist overtime as an irrational response to change (Nelson & Winter 1982, 2002).[10] [11] Given this persistence, routines are retained, and are passed on overtime from one generation to the next.

The economic system evolves through a process akin to natural selection. In a competitive market environment, successful routines are selected both as a result of negative feedback, as unsuccessful firms go out of business and their routines cease to exist, and through positive feedback as firms develop new successful routines in response to changes in firm objectives or external conditions. The evolutionary metaphor, in this case, implies both Darwinian and Lamarckian processes. Therefore, to paraphrase Nelson & Winter (2002), the acquisition of 'individual skills, organisational routines, advanced technologies and modern institutions' comes about through a process of 'trial-and-error cumulative learning.'

The process of selection also assumes variation between firms and their fitness in a particular context. This variation is a consequence of a complex changing environment and the satisficing behaviour of firms, meaning that a single optimal solution is unlikely to be obtained (Foxon 2006). The process is therefore one of constant change and the system highly dynamic:

"…the selection process is always in a transient phase, groping toward its temporary target. In that case, we should expect to find firm behaviour always maladapted to its current environment and in characteristic ways—for example, out of date because of learning and adjustment lags, or "unstable" because of on-going experimentation and trial-and-error learning … in reality, the broader currents of historical change in

[9] At the level of the individual the analogous analytical category is that of 'skill'.
[10] Of course, if we may already espy a third order rationality here, in that individuals, as a rule of thumb have internalized the rule as regards routine of the sort, 'if it ain't broke don't fix it.'

the socioeconomic system are forever imposing exogenous change on the economic subsystem, posing new and unfamiliar problems to firms. To capture the phenomena characteristic of this reality requires a fully dynamic analysis." (Nelson & Winter 2002: 26)

Schumpeter's conception of capitalist economies as dynamic systems prone to crisis driven by technological change has been an important influence in the development of the evolutionary approach, and as with Schumpeter the treatment of innovation and technological change is central to the theory. Innovation is largely endogenous to the system (although open to exogenous influence), firms search for better techniques and technologies and as with other routines, the competitive market selects more successful technologies for the particular market conditions. In this case, both demand-pull and supply-push are clearly important.

2.2.2 Hierarchical complexity

Foxon (2006) has also suggested that Simon's notion of hierarchical complexity relating to complex systems can also help understand key characteristics of an evolutionary system. Simon (1962) argued that in a complex system structural hierarchies consisting of subsystems are likely to be more successful than systems with no hierarchies. He suggested that in a complex evolutionary system made up of a large number of parts with complex interactions, a structural hierarchy is likely to evolve as it can respond faster to change. Simon drew an analogy with watchmakers creating their wares. When a watchmaker attempts to build a whole watch at one go, if they are disrupted they need to start the process again from scratch. If the watchmaker, however, builds a watch as a series of sub-assemblies, then if they are interrupted in the process they loose much less work. For sufficiently complex mechanisms consisting of many parts processes which employ sub-systems are much more robust to environmental shocks (Simon 1962). This implies that

"….[the] principle of faster evolution of a complex structure consisting of relatively stable sub-structures will apply to any biological or social system and so such hierarchic systems are likely to be much more common than non-hierarchic complex systems. For example, a problem-solving process, such as safe cracking, consisting of selective trial and error, in which partially successful approaches are retained, will find a solution much more rapidly than a completely random trial and error process." (Foxon 2006: 263)

In the case of economic systems - where economic agents are self-aware, and though bounded in their rationality, are satisficing – there is also room for positive feedback.

The productivity-enhancing division of labour in Adam Smith's (1776) apocryphal pin-factory, would seem to have been the result of just such a process of positive feedback.[12]

Another feature of hierarchical complexity is that systems are frequently '*nearly decomposable*' into their subsystems. That is to say that the links between subsystems are much weaker relative to those within subsystems. As a result, analytically, the short-run behaviour of a sub-system can be regarded as approximately independent of the short run behaviour of other sub-systems. Similarly, the long-run behaviour of the sub-system depends only on the approximate aggregate behaviour of other sub-systems (Foxon 2006).

Therefore, hierarchical complexity is likely to be common in evolutionary systems. It also presents a more tractable way of understanding how a system is constructed, in terms of system processes, functions and dynamics, rather than an understanding based upon a description of their configuration at a point in time (Foxon 2006). This not only has implications for the ontological categories admitted by evolutionary accounts (as opposed to neo-classical accounts), but also their method. In the rest of this section we examine the broader implications of these evolutionary micro-foundations in thinking about technological change.

2.2.3 Implications of the evolutionary account

The evolutionary account places technological change at the heart of understanding economic dynamics. It paints a picture of economic systems as open and dynamic, not necessarily operating at an equilibrium, and prone to both periods of inertia and periods of rapid change. Economic agents in these systems are heterogeneous, limited in their abilities to gather knowledge and accurately assess the implications of their behaviour. Instead, in the presence of bounded rationality, rational *procedures* guide decision-making, which are learnt and adapted overtime in a cumulative process as a response to various feedback mechanisms (Foxon 2010). This picture has important implications for typical patterns of system behaviour. These emerge at the micro level, in terms of technological change and at the macro-level in terms of economic growth and development. Here we concentrate on the micro-level implications for technological change. The macro-level

[12] Although we must tread with care, a certain degree of hubris means we are often want to attribute a degree of tractability and agency to a complex and uncertain world where these may frequently be epiphenomenal.

implications for economic growth and development are discussed in Chapter 3 and Annex A3.

A number of important patterns and higher-level processes appear from the micro-foundations of the evolutionary account, which have important implications for the process of technological change. These include path-dependency (and the related concepts of dominant design and technological lock-in), co-evolution of technologies and institutions and the notion of a technological regime or paradigm.

Path-dependency on the evolutionary account is a consequence of cumulative learning and the rejection of optimisation, there are three main ways in which path dependency can emerge (Dosi 1997). Firstly, as a result of cumulative learning about technologies by individuals; secondly, in behavioural routines or rules; and, thirdly, it may be a consequence of cumulative growth, the development of production processes, factor intensities etc. over time. In the evolutionary account, an important source of dynamic increasing returns and thus path-dependency and lock-in is cumulative learning (Dosi & Nelson 1994).

Running in parallel to evolutionary theory, path-dependency accounts of technological change focus specifically on the process of *adoption* of new technologies and the dynamics of their wider diffusion. The basic idea is that there are positive feedbacks from the adoption of a technology, which generate path-dependencies over time. The causal mechanisms by which these processes take place are those of dynamic increasing returns to adoption. Arthur (1989) showed in a simple model of two competing technologies, in the presence of positive feedback to adoption from unlimited dynamic increasing returns, the initial choice of one or other of the technologies will lead eventually to that technology absolutely dominating the market with a probability of one.

Arthur (1989, 1994) suggested four main types of dynamic increasing returns. Firstly, scale economies, which are present when unit costs decline with increasing output. These are typical of industrial and manufacturing processes, where the specialised division of labour and large fixed, sunk costs mean that higher productivity and lower costs are achieved at larger scales. However, these increasing returns are likely to be limited and at some point are likely turn constant or decline (Arthur 1996). Secondly, learning effects such as 'learning-by-doing' and 'learning-by-using' (see Annex A2, section A2.1). These effects are empirically well established in the literature on learning curves.[13] Thirdly, adaptive expectations, which occur as a result of increasing the general knowledge stock relating to a technology, thus decreasing uncertainty relating to the performance of the technology and therefore acting to increase adoption relative to other competing technologies. Finally, network and system effects. Network effects occur when the more a technology is utilised the greater its usefulness becomes, such as with telephones or the internet. System effects are similar, but are associated with groups of complimentary technologies. For example, power generation, transmission and distribution technology, which co-developed with end use technologies such as the electric light bulb and the rotary electric motor (Hughes 1983; Katz & Shapiro 1994). Some of these dynamic increasing returns will be more important in some industries and product classes than others (Nelson 1995). Returns to scale are likely to be particularly prominent in manufacturing industries as are learning effects, whereas, network effects are of particular importance in the software industry, for example in social media.

The implication of this process is that initial conditions, historical contingencies or otherwise random events, through increasing returns, "...can cause the economy gradually to lock itself in to an outcome not necessarily superior to alternatives, not easily altered, and not entirely predictable in advance." (Arthur 1989b: 128) A number of historical case studies support the main contentions of path dependency theory, where historical contingencies and dynamic increasing returns have led to the lock-in of inferior technologies. For example, David's study on the dominance of the QWERTY keyboard (David 1985), the so-called 'battle of the currents,' between AC and DC electricity supply technologies (David & Bunn 1988), and Cowan (1990) on the adoption of light water nuclear reactors.

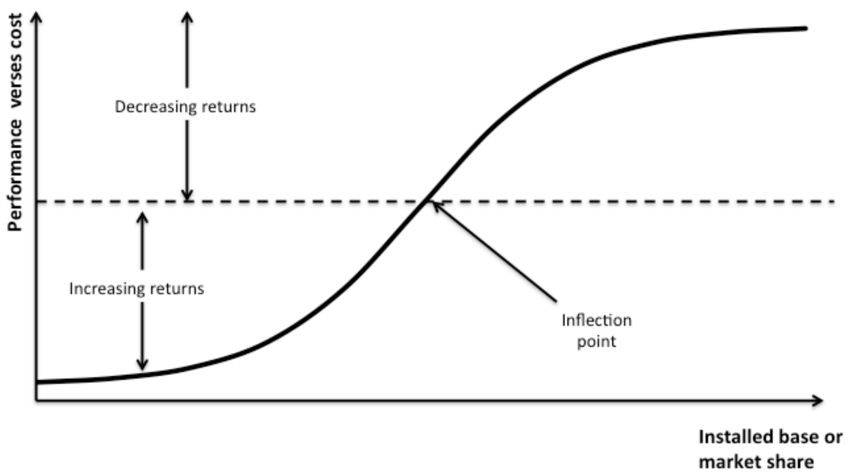
Similarities with evolutionary accounts are immediately clear, as both learning effects and adaptive expectations fit comfortably under the description of cumulative learning of evolutionary theory. Indeed, Arthur's following description of the economic system bears more than a passing similarity that of Nelson & Winter (2002: 26):

[13] For example, see Rubin et al (2004), Soderholm and Sundqvist (2007), and Jamasb (2007) for recent treatments of learning curves in renewable energy technologies.

"…in the increasing-returns world…[…]…re-everything has become necessary because every time the quest changes the company needs to change. It needs to reinvent its purpose, its goals, its way of doing things. In short, it needs to adapt. And adaptation never stops. In fact, in the increasing-returns environment …standard optimization makes little sense. *You cannot optimize in the casino of increasing-returns games*. You can be smart. You can be cunning. You can position. You can observe. *But when the games themselves are not even fully defined, you cannot optimize*. What you can do is adapt. [emphasis added](Arthur 1996: 5)

A particular weakness of path-dependency theory relates to its limited scope, in particular it does not have an answer to the question of what happens when the dynamic increasing returns to technological adoption are used up. With the exception of network and system externalities, for any particular technology or set of technologies dynamic increasing returns are likely to be limited and at some point in the diffusion of a new technology conditions are likely to revert to those of declining returns (Unruh 2000, Ruttan 1997) (as shown in Figure 2.1). [14]

Figure 2.1: The scope of increasing returns



Source: Unruh 2000

While Dosi (1997) points out that the micro-foundations of the path-dependency account and the evolutionary account differ, there is a consensus in the later literature that the two approaches are compatible (e.g. Foxon 2006, 2010). It is worthwhile remembering that evolutionary theory is a theory of the economy in general, whereas the focus of Arthur and other writers on path-dependency is specifically on technology

[14] Arthur gives tacit acknowledgement of the possibility of this possibility in his account of the ICT industry compared to manufacturing industries (Arthur 1996).

adoption. Nevertheless, it has proved to be a powerful argument in explaining the phenomena of technological change and the tendency for convergence on dominant designs and broader lock-in to particular technological systems.

The consequences of evolutionary micro-foundations go beyond path-dependency, and are manifest in the notions of 'dominant design,' 'technological lock-in' and the co-evolution of institutions. These are best illustrated by considering the dynamics of technological change at the firm, although these processes will have their analogues in other kinds of activity.

In the early stages of technological development there are typically a number of variations of a technology all meeting an expected market demand in some way. These technological alternatives compete in terms of market share and for cost reductions. At some point, one technology reaches a dominant position in terms of market share and becomes the *de facto* standard technology for meeting that particular demand, that is, it becomes the 'dominant design' (Nelson 1995; Suárez & Utterback 1995). Once a dominant design emerges from the innovation process, the risk of backing a white elephant technology is diminished and firms tend to invest heavily in refining the design and manufacturing processes, thus reducing costs. Therefore there is a shift away from product innovation to process innovation and incremental improvements to the dominant design (Unruh 2000).[15]

This in turn leads to specialisation in a firm's routines as they become adapted to the production of a particular technology. As many writers have pointed out, production and the organisational capabilities of firms, centred on the dominant design, frequently become part of firms' core competencies and the foundation of their competitive advantage (Chandler 1992; Leonard-Barton 1992; Prahalad 1993; Chandler et al 1999; Christensen 1999). Therefore, a dominant design can entail a broader technological trajectory, which will not only be composed of concrete technologies and the tacit knowledge associated with their production, but also the very organisation and management of the firm.

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[15] Nemet (2009) finds just this pattern in his study of patent data for wind turbines in the US.

More generally, drawing on Khun's notion of scientific paradigms and revolutions, Dosi (1982) suggests an analogous process in the development of technology he terms a 'technological trajectory'. He makes a distinction between normal incremental problem solving within a technological regime and non-normal problem solving associated with radical technological change. Technological lock-in may result from 'mutual reinforcement' between an incumbent technology, the process of learning surrounding it and patterns of investment in innovative activity, which have been fruitful previously. A concrete example of this comes from Christensen's (1997) observation that large firms that are the successful producers of dominant technologies, tend to invest in R&D concentrating on incremental improvements of incumbent technologies.[16] Smaller firms which are not heavily invested in the current technological trajectory, and who are unable to compete with incumbents in established technologies, are more likely to be innovators, investing in riskier new technologies, provided they are able to obtain the necessary resources.

Typically, how firms respond to technological change will depend upon the extent to which a firm's competitive advantage, core competencies, capabilities or assets are perceived as being compatible with the new technology (Pinkse & Kolk 2010). In the case where a new technology is perceived as not being compatible firms may act to intentionally supress it.[17] Therefore, it is important to stress, the positive feedbacks of evolutionary dynamics[18] are not confined to embodied technologies and low-level firm routines, as evolutionary economics sometimes seems to suggest, but can encompass strategic and political decisions. We will consider in greater detail the role of vested interests in technological change later on in this section.

Considerations of the different possible types of technological change are extremely important in determining the likely characteristics and barriers to change that can emerge. Empirical work has added to the understanding of different ways in which technological change can be elaborated within the framework above. Freeman & Perez (2000) suggested a four level taxonomy of technological change, distinguishing between, incremental innovation, radical innovation, new technological systems and changes in

[16] Dosi (1982) also notes how concentration on incremental and process innovation centring on a dominant design may effectively suppress investment in R&D for new, innovative technologies.

[17] See Sovacool (2008) on the use of IPRs to suppress environmentally friendly technologies.

[18] Lamarkian evolutionary dynamics (characterized by positive feedbacks) as opposed to Darwinian evolutionary dynamics (characterized by negative feedbacks).

techno-economic paradigms. Incremental innovations are those that take place almost continuously; these processes are the same as learning processes in the manufacture and use of technologies (i.e. learning-by doing and learning-by-using).[19] These processes are extremely important in determining productivity improvements, but they are not the result of formal R&D activity.

Radical innovations are typically the result of R&D activity in firms or other institutions. They are radical in the sense that they are a departure from incumbent technologies and processes in a way which would preclude their development from within them. For example, nuclear technology could not have evolved within the fossil fuel fired thermal industry. Such innovations tend to be unevenly distributed between sectors and over time. They also frequently entail a combination of product, process and organisational innovation. Such technologies are associated with the development and expansion of new markets and concomitant surges in investment. However, in general their individual economic impact is limited, in aggregate they can bring structural change overtime or when part of a nexus of related radical innovations they can lead to the rise of new sectors of production.

Changes of 'technology system' are wide ranging technological changes affecting a number of economic sectors and creating new sectors. These technological changes affect a number of firms and are based upon a cluster of both incremental and radical innovations that are economically and technically related. They are usually associated with managerial and organisational change affecting a number of firms.

Finally, changes in 'techno-economic paradigm' these are changes that have pervasive system-wide implications for the behaviour of an economy. They go beyond 'engineering trajectories' for particular processes to affect the cost structure, mode of production and distribution throughout the economy. These paradigms, once established, become the main influences on incumbents (engineers, designers, managers) for decades. These changes imply a painful and disruptive adjustment process for the economy, and importantly, its characteristic institutional framework. Freeman & Perez (2000) argue that

[19] See Annex A2.

these changes in techno-economic paradigm are associated with long- term economic cycles (Annex A2, Table A2.1).[20]

This taxonomy serves to highlight how different types of technological change are likely to differ substantially in their characteristics and implications. Importantly, the causes of technological change differ in each case. For example, incremental technological change might be more responsive to market demands, whereas radical technological change might be more closely associated with R&D spending. Similarly, effects are likely to differ. In the case of incremental change processes, organisations and institutions are likely to be unaffected. Radical change is likely to have a localised impact on a wider range of managerial and organisation arrangements. And shifts in the techno-economic paradigm are likely to have far reaching implications for all kinds of production, consumption - and importantly - institutional arrangements.

2.2.4 Co-evolution of institutions

Another aspect of technological change discussed in detail by evolutionary theorists has been the co-evolution of technologies with institutions.[21] On an evolutionary account, institutional arrangements and their development can be generated by similar micro-foundations as those used in the analysis of technological change (i.e. bounded rationality and uncertainty). Institutions (like firms) are satisficing, not optimising (North 1990a).[22] This implies that the characteristics of evolutionary development will also apply to institutions, variation, selection and persistence of institutions or institutional characteristics carried by satisficing routines, which encapsulate a knowledge gained through a cumulative learning process, whether it be tacit or explicit, formal or informal. The development of institutional arrangements overtime is therefore likely to be characterised by non-linear change, path-dependency and lock-in (North 1990a; Pierson 2000; Nelson & Nelson 2002; Foxon 2010).

North (1990b; 1990a; 1994) draws heavily on Simon's notions of bounded rationality, and Arthur's account of path-dependency in his analysis of long- run growth. He argues institutions imply very high set-up costs, significant cumulative (more or less incremental) learning effects can occur within an institutional framework. Network-like

[20] Kondratiev long-waves.
[21] Here we follow Foxon (2010) in defining institutions broadly as 'ways of structuring human interactions' (21)
[22] This contrasts with writers such as Williamson (1998) who see institutions as efficient ways of structuring interactions developed in response to, amongst other things, transaction costs.

effects occur in virtue of the co-ordination function institutions play, for example in ensuring contracts will be honoured. Adaptive expectations play a role in this as institutional norms define broad trajectories, which are expected to persist overtime. This not only encompasses formal, explicit institutional rules, but also a range of informal norms, which tend to be resistant to change:

> "It is the admixture of formal rules, informal norms, and enforcement characteristics that shapes economic performance. While the rules may be changed over-night, the informal norms usually change only gradually. Since it is the norms that provide 'legitimacy' to a set of rules, revolutionary change is never as revolutionary as its supporters desire, and performance will be different than anticipated." (North 1994: 366)

Once a particular path has been taken in institutional development, these positive feedbacks serve to lock-in institutional arrangements potentially, for the very long term. It should also be noted that, these positive feedbacks will be largest, not at the level of the individual firm or institution, but at a macro-level where many institutions interact in complementary ways, North (1990a) argues "…the *interdependent web of an institutional matrix* produces massive increasing returns" [emphasis added](95).

Williamson (2000) echoes this observation in his frequently cited analysis developing a four level taxonomy of institutions. This analysis identified different types of institutions in terms of their relative stability over time, in respect of the type of institution and the decision principles characterising the behaviour of individuals within these institutions. Some types of institutional arrangements, such as cultural values, social norms, customs, tradition and religion, have a tendency to persist for very long periods of time, over centuries or millennia. Although even in these cases change can be rapid, if one thinks of the Reformation in the sixteenth century or the rapid spread of Islam in the seventh century. Other types of institutional arrangements are changing almost constantly, such as transactions within markets. The characteristics of individual behaviour within these different institutions also tend to differ, within the realm of cultural norms deliberative decisions are atypical, whereas within the market direct deliberations are the norm.[23]

[23]If Williamson is correct and most decision making within these kinds of institutions is not deliberative, then we could expect to see less room for a process of positive feedback in these kinds of institutions. Although, it is not out of the question, as arguably the example of the Reformation illustrates.

Institutions can be described as developing through similar processes to technologies and productive capacities. it becomes clearer how technologies and institutions can co-evolve. On one hand, the institutional context will, to a considerable extent, determine the extent and success (or otherwise) of technological innovation and change by providing not only resources, but also more general incentives and opportunities that can facilitate technological innovation and change. For example, certain cultural norms arguably persisting since the Enlightenment have been present and played an important role in the technological change in the modern eara. The particular form of property rights and onweship patterns that developed in North-Western Europe, and the United Kingdom in particular, in the seventeenth and eighteenth centuries lent themselves to a particular type of production and the co-development of associated technologies (Myrdal 1990; Wood 2002). In this case, the form of institutions that developed provided incentives for increasing economic productivity from the application and development of new technologies (North 1990a).[24]

Private and social institutions that tend to co-develop with technological systems and are often an important source of technological inertia. For example, institutions, which develop with technological systems include schools of specialist study, professions, new academic disciplines, and unions. The interests of these institutions are often aligned with the technological system of production and consumption, which developed with them (Unruh 2000). Hughes writing on electrification at the beginning of the twentieth century describes this process:

"The momentum initially came mostly from an aggregate of manufacturers who invested heavily in resources, labor, and manufacturing plants in order to produce the machinery, devices, and apparatus required by the new system; later, educational institutions taught the science and practice of the new technology; then research institutions were founded to solve its crucial problems; and all the while a growing number of engineers, skilled laborers, appliers of science, managers, and other persons invested their experience and competence in the new...system" (Hughes 1983)

A similar story is found in Freeman's (1995) historical account of national innovation systems. Freeman stresses the role of the nation state in promoting technological change and innovation. Taking the example of German catch up to Britain in the nineteenth century, Freeman suggests that in order to catch up the Prussian (and later German)

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[24] This is a point to which we return in the review of literature on economic catch-up in Chapter 3 of this thesis.

state, amongst other things, developed technical training programmes and institutes, oversaw the acquisition and reverse engineering of British technology, waived duties on imports of industrial equipment, oversaw the distribution of technology to manufacturers, organised the employment of British craftsmen in Prussia to allow the transfer of tacit knowledge and sent officials abroad for 'tours of inspection'. Freeman also points out how the right sort of institutions can promote innovation, citing again the example of the development of in-house R&D in the German chemical industry in the 1870s, an innovation that was subsequently copied in other industries and in other sectors. The National Innovation Systems (NIS) literature is important in the discussion of catch-up in latecomer countries this is taken up in greater detail in Annex A3 and Chapter 3.

2.2.5 The multi-level sustainability transitions perspective

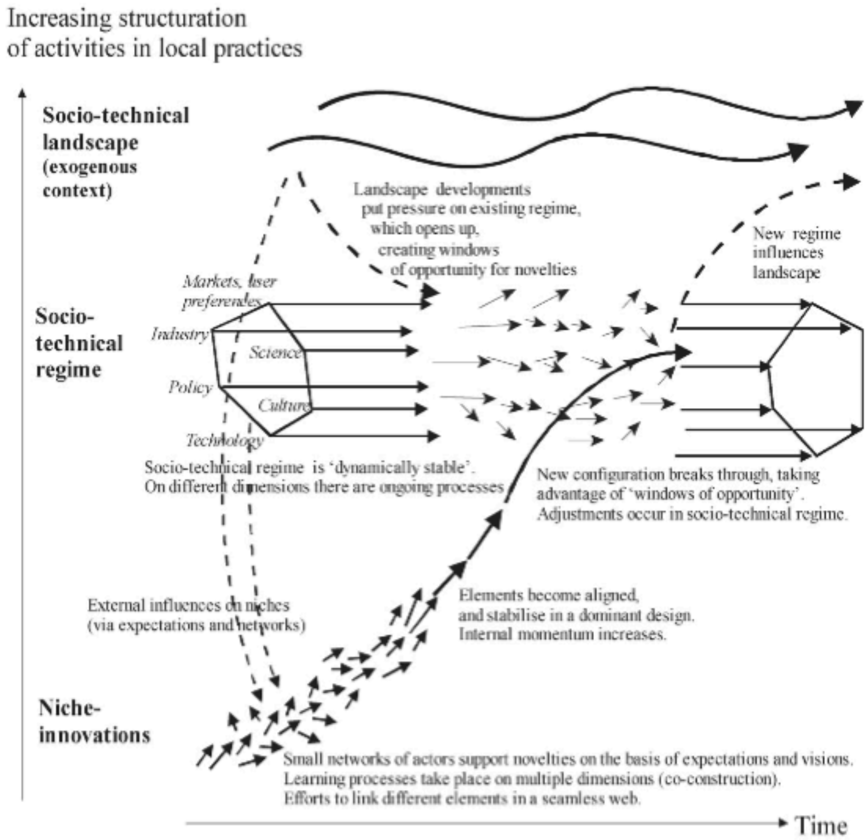
The multi-level perspective is an influential and recent approach to understanding technological change, emerging from research into policy design for managing system-wide technological change to promote environmental sustainability in the Netherlands. There is a large literature on the multi-level perspective, our purpose here is the purely instrumental one of interrogating the theory to unearth its micro-foundations.

In general the systems-wide approach of the multi-level perspective draws heavily (and often implicitly) upon evolutionary economics notions of bounded rationality, statisficing, path-dependency, dominant design, the co-evolution of institutions. Exposition of the role played by contextual contingencies in the development and diffusion of new technologies plays a central role in this approach to the analysis of technological change (Rip & Kemp 1998; Geels 2004; Geels & Schot 2007). However, the level of analysis in the literature concentrates upon the operation of social and (more latterly) governance structures, with little reference to the more fundamental casual mechanisms that determine the material distribution of resources, upon which these social structures must necessarily supervene.[25] Nevertheless, this level of analysis has enabled the transitions literature to emphasise the importance of higher-level structures at different scales of analysis, and attempt a more systematic account of the role they play in technological change. There are also close parallels between this work and that of Freeman & Perez's (2000) and their taxonomy of technological change, NIE accounts of

[25] Indeed, a fundamental criticism of the transitions account is that is pays too little attention to economic factors, and in particular costs as a determinant of technological change.

institutions (e.g Williamson 2000; North 1990) and Simonian notions of hierarchical complexity.

Figure 2.2: Multi-level perspective on transitions



Source: Geels & Schot 2007

From the multi-level perspective the development of technological systems is understood in terms of three nested systems, those of technological niches, socio-technical regimes and socio-technical landscapes (Figure 2.2). Higher levels are more stable and resistant to change and condition the direction of change at the lower levels (Rip & Kemp 1998). At the micro-level the technological niche is a localised system where new innovations become established. Niches are not stable socio-technical systems, but represent locations or spaces within which new technologies can be developed both technically and institutionally. Technologies developed within niches will only become successful if they can interact in a complimentary way with incumbent technological systems (for example, as has been the case with organic farming and wind turbines), where this is the case they can develop into technological regimes (Berkhout et al 2009).

Socio-technical regimes are thought of as an extended version of Nelson & Winter's (1982) notion of a technological regime or Dosi's (1988c) techno-economic paradigm (Geels & Schot 2007). Rip & Kemp (1998) describe regimes as follows:

"A technological regime is the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artifacts and persons, ways of defining problems - all of them embedded in institutions and infrastructures. Regimes are intermediaries between specific innovations as these are conceived, developed, and introduced, and overall sociotechnical landscapes." (Rip & Kemp 1998:338)

A technological regime is defined by a shared pattern of routines within which engineers and firms generally work, but extended beyond the supply-side pre-occupations of much evolutionary economics theory to include societal influences including interest groups, consumers and policy makers. Thus the satisficing routines, which define the institutional environment within which societal influences function take an important role in determining behaviour and influence technological change. Regimes can exist at multiple scales and are frequently nested, as in the example of various large-scale power generation technologies, which represent individual regimes nested in the boarder national power generation and transmission regime (Berkhout et al 2009). This notion of regime may seem to add little substantively to theory elaborated in the analysis of writers such North (1990, 1994) and Freeman (1995), save by making the function and importance of different forms of institutions more explicit. However, another factor which re-emerges as a result of this more detailed understanding is the importance of the demand-side. This is not demand manifest as an undifferentiated demand-pull, but as a distinctly complex social phenomenon which itself co-evolves with technology.[26]

At the broadest level, socio-technical landscapes are usually described as the contextual influences on the socio-technical regime or the selection environment for a regime (Berkhout et al 2009). These include, for example, trends in demography, culture, politics and other social trends, the bio-physical environment, resource price and income levels. In early iterations of transitions perspective the landscape is considered largely exogenous to the socio-technical regime (Geels & Schot 2007):

[26] In a way this represents a reprise for a more Veblenian understanding of demand and the socially constructed role of consumption.

"…background variables such as the material infrastructure, political culture and coalitions, social values, worldviews and paradigms, the macro economy, demography and the natural environment which channel transition processes and change themselves slowly in an autonomous way." (Kemp & Rotmans 2001: 7)

More recently, in a paper addressing criticisms of this notion of the landscape, Geels (2011) has proposed a more nuanced account of landscape trends. Firstly, landscape trends can be more or less dynamic. Bio-physical systems, for example, tend to change only slowly, other influences may be volatile and change rapidly (e.g. oil and other commodity prices) and still others can display trends over time (such as demographics). Second, landscapes can act both to stabilise and destabilise incumbent regimes. For example, high oil price could destabilise the current personal transportation regime, but on the other hand landscape elements such as higher incomes, increased globalisation and world trade could act to stabilise the regime. And, thirdly, landscapes could be treated as endogenous, rather than just a source of exogenous shocks or stabilisations. In this context, Geels (2011) suggests the notion of landscapes could be linked with that of Kondratiev long waves. Alternatively, Geels (2011) also suggests that macro-economic growth and development could be analysed as:

"…the emergence of new socio-technical systems, replacing or radically altering traditional and early-modern systems in key sectors, including energy, transport, agriculture and food, water and urban development. These new systems emerge through the interplay between new knowledge and practices on the one hand, and the prevailing institutional and social contexts on the other." (Berkhout et al 2009: 225)

Geels (2011) comments that there is scope to link transition studies to broader research on development in general. We return to linkages between economic development and technological change in Chapter 3.

The transitions literature is a fruitful elaboration of the evolutionary account, representing a broader and more systematic treatment of the interplay of societal influences on the process of technological development. This is warranted particularly in response to the challenge posed by the development of a sustainable techno-economic paradigm, which has far reaching implications beyond considerations of firm, regional or national economic performance. Nevertheless, its weakness also lies in an over-emphasis on societal factors, and a failure to give adequate weight to the material determinants of technological change. These appear in two ways, i) in terms of the costs of technology;

and, ii) in a rather less straight-forward way, in terms of the political economy which to a large extent is likely to be determined by the surplus (profits, rents) associated with a particular techno-economic paradigm.

Technology costs are something which re-emerge clearly in Chapter 4 with the consideration of the ways in which technological change is elaborated in the power sector. Linked to this, the importance of the political economy, however, emerges from the micro-foundation of evolutionary theory. This is discussed in greater detail in section 2.4.

2.2.6 Implications for policy

We have attempted to briefly present a large and rapidly growing theoretical literature that can broadly be described as belonging to the evolutionary canon. We have done this, not in order to give a comprehensive review, but to uncover the causal micro-foundations, which are elaborated through the process of technological change. What emerges is a substantially different world to that of neo-classical economics, economies emerge as dynamic open systems with no tendency to anything other than temporary, local equilibriums; economic agents are heterogeneous, only boundedly rational, with imperfect foresight and knowledge of the world, but with the ability to learn and adapt over time; agents interact not only through markets but through a variety of different structures; higher-level structures emerge from the operations of micro-level behaviour upon which they supervene; and, the evolutionary processes involved create new patterns and structures, which develop in order and complexity over time (Foxon 2011).

This account has important implications for policy to promote technological change. The conventional, induced innovation perspective would suggest that the policy imperative is to ensure that the prices are correct. In the case of environmental technologies this means through internalising external environmental costs to generate demand and correcting market failures associated with technological innovation and adoption, i.e. knowledge spill-overs to innovation and diffusion, network externalities, and financial market failures both in funding R&D and in funding the adoption of new technologies. Correcting the market failures internal to the process of technology change and environmental externalities generated by incumbent technologies would allow optimising firms to respond to the price signals and engage in the development and adoption of new environmental technologies.

We may agree with Ruttan's (2001) intuition, in common with the neo-classical inducted innovation account, that demand plays a role in conditioning the direction of technological change. We may also allow that in certain circumstances for certain types of technological change that demand may indeed be the primary driver for technological change. For example for certain sorts of non-disruptive, incremental technological change within a particular technological trajectory, such as that which Pavitt (1984) identified within production intensive firms. But, comntrary to the induced innovation account, the important policy implication of the evolutionary account, supported by much of the evidence, is that demand–side policies are unlikely to be enough, even when supplemented with additional instruments to correct market failures.[27] This is likely to be especially the case where radical technological change is concerned, and it is just this sort of change we have in mind when considering the technological response to climate change.

Unlike the neo-classical account, the policy implications of the evolutionary account do not flow directly from the micro-foundations but are dependent upon how particular technological systems are manifest on the ground. It is suffice to note at this point that the policy implications are likely to be much more hands on, imply significant industrial policy interventions and technology management to overcome path-dependencies and lock-in. As we shall see in section 2.4, it is likely that, in some cases, the co-determination of the political economy and the techno-economic paradigm will mean that the very possibility of technological change and policies to promote technological change is an outcome of the particular technological-economic-institutional arrangements that are in place.

Before going on to look at the issue of politics and political economy in greater detail in the following section we first look at the main criticisms of the evolutionary approach to technological change.

[27] See Annex A2 for a discussion of key empirical evidence on technological change.

2.3 Are the micro-foundations right? Criticisms of evolutionary approaches

Evolutionary approaches have been criticised on a number of grounds, here we address the four main criticisms; i) the evolutionary account has limited empirical support; ii) even if the evolutionary account is a better representation of the causal processes at work, the competitive fitness context in which firms operate means that we can threat them 'as if' neo-classical precepts held; iii) the theory is too heavily dependent upon dynamic increasing returns; and, iv) evolutionary theory does not treat the role of politics and power and its role in technological change adequately. As we will see there are close links between the response to ii), iii) and iv).

First, Ruttan (1997) argues that the evolutionary approach has relied too heavily on simulation models of the economy, which can produce plausible results based on stylised facts relating to the firm, sector and aggregate economic growth. An overreliance on simulation models, he argues, has led to the evolutionary approach not being productive of empirical research – it therefore "must be regarded as 'a point of view' rather than as a theory" (Ruttan 1997:1522).

Whereas a reliance purely on simulation modelling would indeed be a cause for concern, the contention that there is limited supporting empirical evidence is simply not an accurate reflection of the literature.[28] There is a wealth of empirical evidence with findings that either broadly support an evolutionary approach or are consistent with it, from economic history (North 1990a; Chandler 1992; Mokyr 1992; Mokyr 1998; Chandler et al 1999; von Tunzelmann 2003; Mokyr 2005; Mokyr 2006; Moe 2010), the history of technology (Hughes 1983; David 1985; David & Bunn 1988; Brown & Mobarak 2009; Wrigley 2011), an extensive case study literature including case studies and quantitative empirical work broadly based in the innovation systems tradition (Nelson & Langlois 1983; Lundvall 1992; OECD 1992; Nelson 1993; Edquist 2000; Dosi 2007; Marerba & Nelson 2010), including work on newly industrialising and developing countries (Johnson 1982; Amsden 1992; Kim & Nelson 2000; Kim 2001; Lundvall et al 2002; Wade 2004; 2007; Dosi et al 2009), and finally, many detailed case studies of individual technologies from the Dutch research on the multi-level perspective (Geels & Smit 2000; Geels 2002; Elzen et al 2004; Geels 2005a; Geels & Raven 2006; Geels 2006a; Geels 2006b; Geels & Raven 2007; Verbong & Geels 2007; Geels 2007; Geels et al 2007;

[28] Granted that increasing amounts of empirical work have been conducted in intervening years since Ruttan was writing.

Schot & Geels 2008; Geels 2009; Raven & Geels 2010; Berkers & Geels 2011). In recent reviews of the empirical literature on environmental technological change Kemp and Pontoglio (2011) and Gonzalez (2009) also find general support for the evolutionary account. Moreover, as mentioned above empirical research in behavioural economics is largely supportive of evolutionary micro-foundations (Simon 1986).[29] Like all theory, and especially theory in the social sciences, these accounts are necessarily underdetermined by the evidence, but the same can be said of explanations using neo-classical micro-foundations. The contention that there is no good evidence for evolutionary theory and it is over-reliant upon simulation models, if it was once true it is certainly no longer the case.

Second, some have argued that evolutionary theory is not substantively different from neo-classical economics. Competition between firms will ensure that only firms that are profit maximizers will be selected, thus even if the evolutionary micro-foundations do describe the causal processes more accurately, this does not matter as in virtue of a competitive environment, firms will behave 'as if' they operate on the basis of neo-classical micro-foundations (perfectly rational, utility maximises etc.)(Friedman 1953; Nelson 1995). However, Nelson counters this argument, suggesting:

> "Any 'optimizing' characteristics of what exists therefore must be understood as local and myopic, associated with the particular equilibrium that happens to obtain. *The heart of any explanation …[…]… must be evolutionary analysis of how the particular equilibrium, and not a different one, came to be.* Further, often there is good reason to suspect that evolution presently is going on at a relatively rapid rate, and thus equilibrium of any kind is not an appropriate concept for analysis. [Therefore]...to say that actors behave "as if" they were maximizing does not tell us much about why they are doing what they are, and provides only a start on any prediction of what they will end up doing if conditions change." [emphasis added] (Nelson 1995: 51)

Thus the contention is that this similarity produced by a competitive 'fitness' environment to the extent is approximates neo-classical equilibrium is a special case, limited in its scope and through time. Moreover, from an ontological and epistemological

[29] Simon forcefully puts it in a later work, "…I would recommend that we stop debating whether a theory of substantive rationality and the assumptions of utility maximization provide a sufficient base for explaining and predicting economic behaviour. The evidence is overwhelming that they do not." (Simon 1986: 223)

perspective there are good reasons to reject this instrumentalist argument and opt for more realistic micro-foundations.[30]

A third criticism, relating more directly to the path-dependency account of technological change (and by implication the reliance of evolutionary theory on path-dependency) was elaborated by Ruttan (1997). Ruttan accepts that technological change must display path-dependency in that it builds upon earlier technological developments, but suggests that in evolutionary theory:

"There is little discussion, for example, of how firms or industries escape from lock in. What happens when the scale economies resulting from an earlier change in technology have been exhausted and the industry enters a constant or decreasing returns stage? At this point in time it seems apparent that changes in relative factor prices would, with some lag, have the effect of bending or biasing the path of technical change along the lines suggested by the theory of induced technical change." (Ruttan 1997: 1523)

Interestingly, both Unruh (2000) and Arthur (1996) recognise that decreasing returns may kick in at some point (Figure 2.1). While Unruh does not explicitly elaborate what happens at this point, it seems to be that path-dependency switches from being a dynamic process, to a static one of lock-in, due to the installed base effect (in fixed, human capital and institutional capital etc.). Similarly, Arthur contrasts knowledge intensive sectors (such as computing, biotech, etc.) with those of more traditional manufacturing industries. Arguing that the kind of dynamic processes of path-dependency and non-linear change are more applicable to the 'knowledge' intensive sectors.

"…we can usefully think of two economic regimes or worlds: a bulk-production world yielding products that essentially are congealed resources with a little knowledge and operating according to Marshall's principles of diminishing returns, and a knowledge-based part of the economy yielding products that essentially are congealed knowledge with a little resources and operating under increasing returns…[…]… Because bulk processing is repetitive, it allows constant improvement, constant optimization. And so, Marshall's world tends to be one that favours hierarchy, planning, controls. Above all, it is a world of optimization." (Arthur 1996: 3-4)

[30] A more detailed discussion of this is beyond the scope of this thesis. However, the contention is broadly that realistic micro-foundations are likely to be a more reliable way of finding out about causal processes in complex open systems.

Arthur recognises that these worlds are not totally distinct, as for example, computers have to be manufactured, nevertheless, he contends that important differences do exist. Pavitt (1984), in his survey of technological change in the UK, also found evidence to support a similar contention, distinguishing between the kind of technological change found in supplier dominated, production intensive and science based firms. Pavitt (1984) notes that technological change in each of these firm types seems to be characterised by processes as described in the vintage model (Salter & Reddaway 1966), induced innovation and evolutionary accounts respectively. This may entail a considerable curtailing of the explanatory usefulness of the evolutionary account.

The evolutionary account, however, can accommodate both the possibility that technological change can be characterised by local equilibriums and the observation that dynamic-increasing returns can start to decrease at some point. First, dynamic increasing returns are important in explaining the notion of path dependency. Once these run out and declining returns set in other effects are likely to predominate to maintain lock-in. These include factors such as certain aspects of the physical capital, such as the life–span of installed capital (the 'installed base effect'), capital intensity etc.; network effects; cumulative learning; institutional arrangements; and, as we shall argue political economy considerations (section 2.4). Arthur's description of 'old' manufacturing industry seems to be of a fairly stable local equilibrium in a technological system dominated by just these effects. In this context, innovation is likely to be non-disruptive and incremental in nature, bound to a particular technological trajectory and concentrated on cost reduction and productivity enhancement.

Similarly, Pavitt's taxonomy can be explained from an evolutionary perspective as different sectors each of which, as a consequence of their particular characteristics, have differing levels of stability over time. This means within a given time period, the particular dynamics of evolutionary change in that sector may not have opportunity to show themselves.[31] So, the chronological scale of heavy industry may be different from that of the ICT sector. The taxonomy of different types of technological change developed in Freeman & Perez's (2000) analysis also serves as a reminder that for the more profound types of technological change (i.e. a shift in techno-economic paradigm) maybe infrequent and not always amenable to study within a short time frame.

[31] Indeed it maybe misleading to think of competition between incumbent and new technologies as frequently the latter can comprise a totally new sector in themselves and compete only indirectly with incumbent technologies.

The last criticism we address here is that the evolutionary approach takes insufficient account of the role played by politics and power in the process of technological change. A number of writers both from within the evolutionary perspective and from outside it have called for a more satisfactory treatment of politics (Nelson 1995; Meadowcroft 2009; Hall et al 2011; Meadowcroft 2011). In the following section, we take up the issue of political aspects of technological change, arguing not only that political arrangements are amenable to analysis using evolutionary micro-foundations, but that there is likely to be a close relationship between political economy influences and the process of technological change is a direct consequence of evolutionary micro-foundations. And therefore, from the perspective of the evolutionary micro-foundations, there is a *prima facie* case for a more detailed examination of the role of political economy in technological change, and in particular as regards systemic changes in the energy system. These contentions are illustrated using work by economic historians on the political economy of the industrial revolution.

2.4 Distribution, vested interests and politics

Much of the literature on technological change seems at pains to avoid the explicit treatment of politics and the political process. It may explicitly address questions of policy, but lies silent on the role political processes may play in technological development. In most of the literature politics is regarded as exogenous to the process of technological change. The treatment of economic catch-up in the USSR presented by Unruh (2000) is typical. He argues that while the 'techno-institutional complex' was able to orchestrate a process of rapid 'catch-up', from a largely feudal economy to an industrialised economy, it was ultimately unable to keep pace with productivity growth in the West as the techno-institutional regime was unable to generate the dynamic incentives for innovative activity provided by competition between firms. The issue of politics is not broached. The USSR's failure to keep pace on this account was one mediated by technology, as a result of *institutional* failures, which presumably emerged out of an evolutionary and historical process. Here political processes are relegated to the status of a 'historical contingency,' rather than as a broader consequence of the operation of the system itself.

2.4.1 Theorising politics in the processes of technological change

Similarly, writers in the broadly evolutionary economics tradition tend to steer clear of the mention of politics, other than as part of the exogenously given 'fitness environment' within which firms operate:

"In many cases the evolutionary processes at work seem to involve a blend of market, professional, and political processes, and it is likely an enormous task to sort these out and get an accurate assessment of operative "fitness" criteria and selection mechanisms." (Nelson 1995: 82)

This absence is somewhat surprising given the observation that the process of politics is very closely connected to the development and operations of institutions, and that there is a general consensus amongst writers on technological change in the evolutionary tradition that technologies co-evolve with institutions (North 1990a, 1994; Unruh 2000; Foxon 2006, 2011). Indeed, institutional variables are critical to the notion of lock-in in a number of influential accounts:

"In general, the limits on technological change lie not with science and technology, which tend to evolve much faster than governing institutions, but rather with the organizational, social and institutional changes that allow the diffusion of new technological solutions." (Unruh 2002: 318)

While criticized for their limited treatment of power and politics, it is perhaps the transitions accounts that have gone furthest in developing a systematic approach to the political issues raised by technological change. There has been increasing interest in the discussion of, getting the institutions 'right'.[32] Where politics has been considered it has frequently been conceived of, rather narrowly, as a problem related to governance, of putting the right institutions and strategies in place (Smith et al 2005; Scrase & Smith 2009). The question of policy and of governance therefore becomes a technical one. Smith et al (2005) present the question of governance in just this kind of way. Power is considered important *within* a socio-technological system, the process of governance stands somehow *outside* it and independent of it:

"The legitimate authority to push change through, or the resources available to build consent, to raise informed dissent, or even to block change, will depend on power relations across the networks of actors involved in a regime. *Governance processes can be seen as acting as an independent influence to 'manage' or modulate regime transformation for sustainable development.*" [emphasis added](Smith et al 2005: 1508)

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[32] Williamson's (2000) 'third-order' economizing.

The conception of the political process is one where politics is somehow divorced from the forces to which the rest of a system is subject. Torvanger & Meadowcroft (2011) go some way to bringing in political economy considerations, but this is limited to a more nuanced recognition of the constraints the political process is subject to. In this case, recognizing binding technological and economic constraints, and advising that policy should follow the path of 'least resistance' by promoting technologies in line with local interests and incumbent industries (Torvanger & Meadowcroft 2011). In a recent paper Meadowcroft (2011) also comments on the importance of 'getting the politics right,' rather than just the policies:

"So far sustainability researchers have focused largely on policy: what it is and what it could/should be…[…]… much less attention is devoted to the political circumstances that make the adoption of such policies likely. But behind policy there is always politics, and *getting the politics right appears to be a prerequisite to getting the policies right*." [emphasis added] (Meadowcroft 2011: 73)

This account goes a long way to recognizing the likely constraints on the policy process and the limited space to make policy decisions this implies. More recent papers by Smith & Stirling (2007; 2010) have also sought to better address issues of political power and agency, including the recognition that the political process may not be external to the particular technological system in place, and that therefore the room for the exercise of 'governance' maybe constrained:

"It cannot be assumed that existing institutions and infrastructures will afford the requisite space and resources for the kinds of continual adaptations and social learning necessary for effective transition governance…[…]...Structural change in something as pervasive as a socio-technical regime entails both losers and winners. In considering what a transition to sustainability actually means, the stakes are typically very high." (Smith & Stirling 2010: 19)

This position comes close to a recognition that politics in many cases should be treated, in the first instance as an endogenous part of technological change, but there is a deep-seated reluctance to grasp the nettle:

"The argument is not that conceptual distancing between socio-technical governance subjects and objects is always necessarily unhelpful or wrong…[…]… there needs to be greater appreciation of the internal loci of governance processes within the socio-technical systems themselves…[…]…In contrast to governance conceptualized outside the system, positioning governance inside the negotiation of socio-technical change requires processes for opening up debate and revealing technology's inherently political nature. In short, we need to move from a view of *'steering as management' to an understanding of 'steering as politics.'*' [emphasis added] (Smith & Stirling 2007: 369)

The strategy is one not of *endogenising* politics but in the creation of ever-increasing orders of meta-theorizing, from the techno-economic aspects of technological change, to institutional, to policy, to governance, to politics. On these accounts feedbacks proliferate between technology, the economy and institutions, politics may not sit entirely outside this as it is linked through budget constraints, and the process in virtue of which power to make decisions is vested in the political process. Nevertheless, the conception seems to be one of politics as somehow insulated from the workings of the technological system as broadly conceived.

We can perhaps agree with Smith & Stirling (2007) that, 'distancing between socio-technical governance subjects and objects' can be a helpful approximation. Where in Simonian terms, they may be considered 'approximately independent subsystems'. In the case where we are considering largely distributionally neutral or otherwise incremental shifts in technology, such as shifts characterized by technological change within a particular techno-economic paradigm. It is surely not the case when we are considering disruptive technological change. Nor would it be the case where institutional arrangements link techno-economic systems more closely to the accrual and articulation of political power. Moreover, while running the risk of being accused of pedantry - from a theoretical perspective it is always *wrong*, and this would seem to be a *necessary* implication of evolutionary micro-foundations.

The omission of a satisfactory treatment of politics on the part of the evolutionary economists is probably a result of the focus on firm level technological change in a relatively competitive environment.[33] It is perhaps a less forgivable omission on the part of governance and institutional theorists, as well as those writing specifically on governance issues related to technological change (Smith & Stirling 2007, 2010; Meadowcroft 2011). There is a failure to anticipate the possible extent of political capture (Lawhon & Murphy 2011). We can conjecture that this may be a result of a preoccupation with technological change in the context of relatively liberal democracies

[33] Indeed, a good proportion of the literature on latecomer catch-up; i.e. on the process of technological change outside a competitive firm level environment, does deal more of less explicitly with politics.

where government has made concrete commitments to technological change and as such at least *appears* to be relatively independent of vested economic influences.[34] This might just be a failure in neglecting to delimit the application of the theory – to the rather small set of industrialized Western liberal democracies.

More seriously, it is probably a sin of commission on behalf of the transitions account. The transitions literature is normative. It is concerned with the promotion of technological sustainability. For their normative project to the feasible, there must be space for political agency to act to seriously promote a transition to sustainable technologies. This is recognized by Meadowcroft:

"Ultimately, the most potent of the sceptical arguments is the one that focuses on the economic imperative confronting states. There is no doubt that the stability of modern societies…[…]… has depended upon the maintenance of steady economic growth. But the indictment of the state to which this points really rests on a specific claim about the modern (capitalist) economy - that economic advance can only be purchased at the expense of the environment. *And there are grounds for doubting the validity of this contention*." [emphasis added] (Meadowcroft 2005: 495)

Where we may not be as sanguine regarding the economic implications of switching away from cheap energy sources, the transitions approach *requires* the technological, economic and political feasibility of a transition to sustainable technologies. It creates this space thus by a rejection of technology skepticism, underplaying cost and the political economy context within which technology is embedded. There maybe room for a more nuanced rendering of the political economy, which may mean there is space for transitions to more sustainable technologies – but whether this space exists or not in a particular context *is a condition of the political economy and should be shown rather than assumed.*

Leaving this criticism to one side, it seems to be that this lack of interest in the political process is a significant theoretical problem. It is not only that political processes are amenable to the micro-foundations of evolutionary theory, but the implications of an evolutionary approach which conceives of technological change as embedded in institutions is likely to entail the emergence of political economy processes.

[34] For example, as in Michell's (2010) characterization of the 'regulatory state' in the UK.

2.4.2 The emergence of political economy

The absence of politics in evolutionary economics is surprising because the evolutionary account lends itself to an endogenisation of the political process, or more properly speaking, the political economy. There are two main reasons for believing this.[35] First, because political processes have been shown to be amenable to the same sort of evolutionary analysis as technological and institutional processes (Pierson 2000). This should not be surprising given that the evolutionary account of technological change is based upon a purportedly realistic account of human behaviour. Second, given the observation that technological change, and especially radical or paradigmatic technological change, is likely to have implications for institutional and political arrangements, and as a consequence the distribution of wealth, resources and power, there are *prima facie* reasons to believe that politics is likely to be an important part of the process of technological change. That is to say, there are good substantive reasons to believe that *political, institutional and technological systems co-evolve*. This contention is supported by historical research on technological development.

Firstly, considering the micro-foundations of political processes, and drawing on Arthur (1984) and North (1990a), Pierson (2000) explains how the micro-foundations of path-dependency theory (and to this extent evolutionary theory) can extend to an understanding of the causal processes involved in politics. He suggests that political processes have four characteristics, which mean that feedback effects and path-dependency are likely to be particularly strong. These are, i) the central role of collective action in politics; ii) the 'high density' of institutions; iii) the use political influence to extend unequal distributions of power; and, iv) the inherent complexity and lack of transparency of political processes (Pierson 2004; Pierson 2000).

In a political context, the impact of individual actions is highly dependent upon the actions of others. As a result, and analogous to North's (1990) account of institutions more generally, political institutions have very high start-up costs. Adaptive expectations are also important, as the perceived efficacy of a political action is highly dependent upon the actions of others. Similarly, political institutions are numerous, broad in scope and complex. They placing significant (and frequently binding) constraints on behaviour, and are frequently characterised by cumulative learning, network effects and adaptive

[35] In contrast to earlier broadly evolutionary work – in which the political process was central such as in Marx and Veblen.

expectations. Thirdly, asymmetrical power relations can be subject to positive feedback as those in political power may use their influence or authority to make (formal or informal) institutional changes that reinforce their position of power (incumbent gerrymandering of electoral constituency boundaries is perhaps the paradigm example of this type of feedback). To put it another way, those in a position of power may seek to recreate the distribution of power. Finally, in contrast to the activities of a firm in a competitive environment, where there are likely to be clear negative feedbacks in terms of changes to competitiveness through which a selection process can operate, the outcomes of political processes are frequently diffuse and ambiguous, which makes mistakes difficult to identify and rectify (Pierson 2000; Pierson 2004).

As a consequence political process and the institutions that result from them are apt to show high levels of path-dependency and lock-in. This in turn means that in understanding political processes – as with technological and institutional change - timing and sequence matter; there are multiple possible outcomes, large changes may result from small initial events; some processes are irreversible and there are pivotal moments which can shape irrevocably the course of events. Pierson (2000) also suggests that a number of additional characteristics are likely to make feedbacks even stronger.

"…the absence or weakness of efficiency-enhancing mechanisms of competition and learning; the shorter time horizons of political actors; and the strong status quo bias generally built into political institutions. *Each of these features makes increasing returns processes in politics particularly intense*." (Pierson 2000: 257)

On this account political arrangements are therefore subject to the same dynamic processes that result in path-dependency and lock-in in technological and institutional contexts. This is entailed by similar micro-foundations of bounded rationality, satisficing heritable routines, variation, the importance of environment and selection through a process of competition and feedback. Indeed a number of writers have recognised the role bounded rationality is likely to play in the political process (Forester 1984; Hafner-Burton et al 2011). In a sense, on Pierson's (2000) account, political arrangements are a special case of institutional arrangements. This is already a *prima facie* reason to believe that political arrangements are endogenous to the evolutionary development of the system, just as other institutional and technological processes are. It should be noted that although the micro-foundations and fundamental processes giving rise to political phenomena are similar at some level, how these processes are articulated given different historical contingencies, scales and causal mechanisms involved will differ dramatically.

Secondly, given these micro-foundations political dynamics that can be best described as political economy processes are likely to emerge. This is a consequence of the processes which lead to path-dependency in the political system as described by Pierson (2000) and the co-evolution of political processes and techno-economic paradigms.

Distributional outcomes and judgements relating to the significance of these outcomes are relegated to the realm of politics in most economic (neo-classical and evolutionary) theorising. However, inequality is a common feature of evolutionary models, and a direct result of the dynamics of evolutionary economics (van den Bergh 2007). Intuitively, increasing returns and path-dependency mean that some routines will be more successful than others. 'Satisficing' behaviour and the need for economic agents (firms, organisations, institutions, individuals) to search for routines suggests that optimal routines are typically not available. Some level of inequality is likely to result as some agents will be better suited to conditions than others. Therefore, it is not difficult to see on an evolutionary account how inequality could emerge.

In the account we have given of path-dependency in political processes, inequality in political power could emerge through increasing returns to political power as power is exercised by agents to change the fitness environment to benefit themselves. The strength of positive feedback to political power contrasts with the weakness of negative feedback caused by the difficulty of understanding the implications of political decisions. Relative to evolutionary processes experienced by firms in a competitive environment, these lead to much stronger processes of path-dependency and lock-in. Therefore, we could also expect to see larger inequalities in the distribution of political power in the political sphere than in the sphere of the firm.

If there is no clear distinction between access to resources afforded by (evolutionary) success in the techno-economic sphere and access to resources mediated by the political process, then economic agents would presumably seek to influence the economic fitness environment to favour themselves. This may happen as firms seek to bribe or lobby politicians, or make political donations in order to influence policy-making. More fundamentally, such processes may extend to the techno-economic paradigm and technology choice itself. The potential for positive feedbacks to this process is large, leading to concentrations of economic and political power. Particularly where economic agents are able to capture large profits or economic rents. That is, where the benefits of an activity greatly exceed costs. This is likely to occur precisely where there are paradigmatic shifts in techno-economic systems that allow agents engaged with the new technology to reap considerable profits, and in the case of natural resources where the cost of resource extraction is much less than its worth. When these contingencies have come together, the results have been a significant change not only in techno-economic paradigms, but broader institutional and political arrangements. This is therefore not just an explanation of *how political processes are important*, but *how the political economy process is endogenous to the techno-economic paradigm*.

We define the political economy very simply, first with the observation that resources are unlikely to be distributed evenly in an economy. Second, with the observation that control over resource distribution will tend to be a function of the distribution of resources. Third, that relatively resource rich agents will seek within their ability to reinforce or recreate their distributional advantage over time. Political economy processes are therefore processes by which this uneven allocation of resources is recreated. For theses reasons the distribution of resources, and the power which this implies, as well as the processes, which act to reconstitute the distribution of power over time, are likely to be particularly stable and resist change (North 1990; Pierson 2000).

As we have shown above based on the micro-foundations of evolutionary theory, there are good *prima facie* reasons to believe that political economy is not only amenable to an evolutionary approach but that political economy processes emerge as a consequence of evolutionary micro-foundations. These contentions say very little about the shape the political economy might take, its technology, sustainability or other welfare implications. At this stage it is suffice to note that given an evolutionary account, and on the basis of the micro-foundations it implies, we have good theoretical reasons to believe that political economy dynamics will play a central role in the functioning of a techno-economic system. How this is articulated in any particular context will differ and this is something we will explore with respect to economic and institutional development in the rest of this thesis.

2.4.3 Two important criticisms and two responses

In consideration of an evolutionary account of the emergence of the political economy, two fundamental criticisms emerge, i) the account is over deterministic and leaves little room for agency; and, ii) the account implies a similar functionalism or instrumentalism to that implied by neo-classical economics.

First, addressing the criticism of the approach being over-deterministic. It is certainly true that the evolutionary account of the political economy is deterministic in that it closes down the space for exercising meaningful decisions about technology and the allocation of resources more generally. This is analogous to similar criticisms levelled at the transitions approach (see Geels 2011). Leaving aside the normative implications of the criticism, the first part of the response to this points to the observation that there is already room for positive feedback, though the search and selection of satisficing routines by the firm, organisation, group or individual. It is true that on some level the processes are deterministic but they can also give rise to systems, which create space for agency. In fact, the place where direct determination of outcomes through evolutionary processes has been superseded is precisely the place where negative feedback effects are expected to be weakest, and positive feedbacks and path-dependency strongest, i.e.in the political process. This is not to say that political arrangements either tend towards social optimality or some other particular form. But that precisely because of weak negative feedbacks and strong positive feedbacks to political economy outcomes (as described above), this is the realm in which dividends to intermediation in the evolutionary process (though the development of political institutions that allow stronger feedback to performance and delimit feedbacks which reinforce the uneven distribution of power), are likely to be the most significant.

Moving on to the second, related objection, that the evolutionary account is fundamentally instrumentalist. In a sense this represents the opposite argument, we have moved from the contention that the evolutionary account is over-deterministic, to the contention that it is empty, and that the Panglossian 'black-box' functionalism of neo-classical theory has been replaced by a slightly more elaborate 'black-box' of evolutionary theory.

The response to this criticism relies upon the observation that behaviour characterised by bounded rationality and satisficing routines that tend to persist overtime leaves room for individuals, groups, firms, organizations, countries, whole epochs to be significantly and systematically wrong about the world. Leaving space for different interpretations of the world to emerge. As we are realists about the world and the constraints this implies, we would expect negative feedbacks to kick-in at some point to reign in representations of the world (and the broader techno-economic paradigms in which they are embedded) that are particularly divorced from reality. That is to say, even though we are realists about the micro-foundations upon which techno-economic, institutional and political processes rest and the constraints of the bio-physical world, within these constraints there is space for a multitude of different human arrangements to emerge. The evolutionary approach implies very little about the content of these processes and arrangements, and the precise way in which they are elaborated over time, but it does give a framework for understanding the general dynamics involved. In this way it also relies very heavily upon empirical evidence to flesh out its account.

A case in point is the economic history literature on the political economy processes as it relates to technological change. In the following section we briefly look at some explicitly evolutionary accounts of the political economy of technological change before turning our attention to the implications of the evolutionary account for technological change in developing countries.

2.4.4 Political economy and technological change in economic history

The economic historian Joel Mokyr (1992, 1997) in his writing on the Industrial Revolution has emphasised the importance of political resistance to technological change. He suggests that the extent to which political forces can act to resist technological change depends upon three main factors. Firstly, the strength of the incentive to oppose the technological change, for example, if an incumbent experiences a large loss in welfare due to the development of a new technology. Secondly, the extent to which costs and benefits of the technological change are concentrated amongst winners and losers, the more concentrated the gains or losses the easier it would be to mobilise and organise political action on either side. Finally, the position of the political authorities as regards the technological change. Mokyr argues that if the political authorities have a vested interest in the incumbent technology then they are likely to favour the status quo.

It should be noted that Mokyr's account while consistent with the evolutionary micro-foundations, looks simply at political resistance to technological change. It does not examine the particular outcomes of that resistance. Although it would seem to support the contention that technological change is likely to be bound up with the creation and perpetuation of inequality, in that where all three conditions are met for political opposition (or promotion) – significant incentives, concentration of costs/benefits and the role of state power – technological change would be unlikely (likely).

Moe (2009, 2010) picks-up more explicitly on this notion, finding evidence from a number of historical case studies that success in managing structural economic change (i.e. technological change) occurred when either vested interests in incumbent economic arrangements were too weak to seriously retard the process of technological change, or states were effectively able to prevent vested interests from blocking technological change. Reflecting on these historical lessons Moe suggests:

"…in describing structural change and long-term growth and development, technology and economics cannot by themselves provide sufficient explanatory leverage. For that, politics - or the political economy, with its focus on actors and decision-makers, on institutions and regulations, and on past and present interactions - must be included. And thus, technology, economics, and politics constitute a triangle, with all sides of the triangle capable of preventing structural change from occurring."(Moe 2010: 1731)

2.5 Conclusion

This chapter has argued that evolutionary theory has not gone far enough in developing the implications of an uneven distribution of resources. It is highly unlikely that radical technological change – let alone changes in techno-economic paradigms – will have neutral implications for the distribution of resources in an economy. If there are likely to be winners and losers from technological change, then we can expect to see incumbent vested interests actively seek to protect their position - through Lamarckian processes of positive feedback – to seek to prevent or retard prospective technological change. Their status as incumbents is likely to mean they have greater ability to influence the process, as heirs to the benefits associated with a successful technology. Just in the same way as technological trajectories become locked-in as investment in incumbent technologies close down the possibilies for technological alternatives, so incumbent vested interests are likely to try and close down, by investment in political means, the emergence of new technologies. Technological change will also imply a process of negative feedback, as technologies are replaced and the power of their associated vested interests eroded.

Ownership of technological assets can be quite liquid and investment fungible across a range of technologies, to the extent that technological change does not dramatically affect the behaviour of an economy, vested interests, in this case capital, may not necessarily oppose the development of new technology. Just as large land-owners were able to shift their accumulated capital into new manufacturing enterprises in the nineteenth century, so equity investors can shift investment between different sorts of technologies. In this way, relatively liquid, 'deep' capital markets can act to spread risk. Although, it has to be said, this will be of little impact in a structural crisis of adjustment driven by technological change. The question is, what kind of technological change is the change necessitated by the climate crisis?

This question leads to another under-theorised relationship, which is also of potential importance here, that of the interrelationship between natural resources, technology and the political economy. In the schema sketched above the possible interrelationships between technology and the political economy are fairly clear. When we examine the possible candidates for techno-economic paradigms the importance of natural resources also becomes clear. In the five 'long-waves' identified by Freeman & Perez (2000) (see Table A2.1, Annex A2), each techno-economic paradigm is associated with a particular energy carrier. The association of fossil fuels with the Industrial Revolution is of particular concern when considering the issue of cliamte change.

Fossil fuels, with a high energy density and high ratio of energy returned over energy invested, have been an essential element in the facilitation of the process of industrial development and the gradual rise in labour productivity. The combination of these energy sources and new technologies has allowed the generation of extremely large resource rents (Wrigley 2011). These rents, are not evenly distributed, by sector, nationally or globally. Geographical contingencies are important. Perhaps of greater importance have been the techno-economic paradigms and the institutional structures within which they reside (firms, nation states, etc.), which have mediated generation of consumables from these resources. The interests vested in fossil fuels are inextricably linked to the techno-economic paradigm. Not only this, the rents generated through this process are very large, meaning both in technological terms and political terms, the inertia demonstrated by this configuration is likely to be extremely large. Its stability equally is likely to be dependent upon adequate cheap fossil fuel resources. Economic power expressed through the political, production and consumptive processes is likely to be extremely hard to displace. Particularly when the benefits, which accrue to the alternatives are generally less concentrated or when many of the benefits are in the future and are therefore difficult - if not impossible - to appropriate through the political economy process. Meaning that the dynamic increasing returns to the political power generated through the ownership of an emerging technology (and especially one that can generate significant natural resource rents) are not likely to be available in the case of fossil fuel alternatives.

In the following chapter we go on to look at how the insights of evolutionary economics have influenced accounts of technological change and catch-up historically and in emerging economies, with a particular focus on the role of the political economy.

Chapter 3: Catch-up, institutions and political economy

3.1 Introduction

Neo-classical economics is ambivalent regarding the role of the state, with a tendency to regard it as essentially parasitic on an otherwise efficient allocation of resources realised through the operation of markets. This comes as no surprise, there is a strong normative current in neo-classical economics which, to paraphrase Veblen (1900), uncritically assumes a 'meliorative trend' in the course of events, expressed autonomously of the 'conscious ends' of economic actors. If the central tenets of the orthodox economic canon are correct then properly functioning markets deliver the best possible outcome, realising 'the greatest amount of good for the greatest number'. According to the orthodox account, extra-market institutions have - at best - a limited role where markets are not functioning correctly. At worst, they actively distort market allocations and reduce the greater good. And the risk of 'government failure' is almost always thought to be much larger than the risk of 'market failure' (Rodrik 2008; Helm 2010).[36]

The account of technology policy to address climate change given by orthodox economists continues to reflect these preoccupations (see Annex A2). According to static partial equilibrium analysis, market based policy to address the environmental externality is always best. Positive externalities associated with technological innovation and adoption may warrant additional interventions, such as subsidies for R&D or underwriting some portion of technology risk for early adopters. In spite of equivocal empirical evidence for both the orthodox account of technological change and the primacy of market based environmental policies, the policy prescriptions have remained indissolubly wed to the static analysis, and therefore substantially the same. Recent World Bank papers on the possibility for 'green growth' in developing countries point to similar policy implications, involving an overwhelming (if not exclusive) emphasis on 'getting the prices right' (Popp 2011b; Dutz & Sharma 2012).[37]

[36] While neo-classical economics recognizes market failures, problems relating to uncertainty, collective action, externalities etc., which may necessitate government intervention, these are introduced to explain deviations from an ideal.

[37] Popp's (2011b) paper is typical in its narrow focus on market failures, there is no mention of industrial policy, or recognition of a large and complex literature on technology transfer which clearly presents itself as highly relevant in the case of environmental technological change. We should also note that it is perhaps unfair to pigeonhole the perspective of the World Bank, it is home to a wide divergence of opinion. Official policy pronouncements are highly constrained by political interests, and as such show a significant status quo bias. Despite what Rodrik (2006) dubs the "Washington Confusion", conceptually and institutionally the Bank is still wedded to the orthodox canon and privileges scholarship within this canon over other approaches.

The prescribed technology policy approaches for climate change in developing countries stand in a marked contrast to more nuanced approaches to technological change emerging from the literature on economic development. Influenced by New Institutional Economics (NIE) and historical developments which have served to highlight the importance of institutional factors in economic change and development, the research on economic development has taken a distinct 'institutional turn' placing much greater emphasis on the role of institutions. And, as a direct consequence of this, an increased interest in the political economy context (Rodrik et al 2002; Acemoglu et al 2005; Evans 2006).[38] Theoretical disagreements aside, in their substantive implications at least, these approaches go a long way towards embracing a more nuanced account of economic development and the process of technological change. This represents a move away from a neo-liberal 'market fundamentalism' and the universalism this implies, and towards an understanding of development processes as contingent and particular (Rodrik 2010a).[39] And a reprise for what Krugman (1997) rather disparagingly described as 'high development theory' - or at least - for something very like it.[40] More substantively, the literature on technological change and catch-up in developing countries implies an important role for more intrusive policy, institutions, and explicit analysis of the political economy context in understanding the conditions for technological change.[41]

Notwithstanding the revealing insights of the emerging institutional and political economy literature, it is still hobbled by theoretical roots in neo-classical economics and what are essentially rational choice frameworks. The piecemeal analysis of 'market failure' and 'government failure' - that characterises much of the literature - fails to articulate a convincing account of the dynamic processes involved in technological change and economic development (Nelson 2008; Dosi 2011). As a consequence the treatment of political economy remains somewhat shallow, frequently presupposing the causal primacy of institutional arrangements (such as property rights and markets) and by implication the political economy arrangements that enable them in explanations of economic development and technological change (Khan & Blankenburg 2009). An

[38] This literature is broadly consistent with the argument presented in Chapter 2.
[39] The growth diagnostics literature has already been taken up by the OECD, although in a rather crude form, in assessing barriers to Green Growth (see OECD 2011)
[40] For example see Levy & Fukuyama (2010), Khan (2010), Robinson (2011), Acemoglu et al (2005), and perhaps most influentially, North (1990a, 2005).
[41] Even the World Bank now recognises the need for an analysis of political economy analysis in addressing issues of growth and 'green growth' (e.g. World Bank 2012). However, as we argue below the approach taken is highly constrained, shallow and is essentially an elaboration of the notion of government failure.

inability to take history, contingency, path-dependence and lock-in seriously in much of this analysis leads to an account that is theoretically unable to appreciate the systemic causal processes that lie behind technological change and economic development, and that constitute the context within which climate change mitigation efforts will need to bear fruit.

In this chapter we argue that technology policy should attend more carefully to the historical experience of structural technological change in developing countries (Berkhout et al 2009; Rodrik 2010b). This involves a fuller engagement with institutional explanations, and by implication, the political economy. We find that political economy processes emerge as crucially important in making the process of technological change, in this case in the form of economic catch-up, understandable. Based on insights from economic history and recent scholarship on the political economy of economic catch-up, we develop a framework to allow the analysis of the political economy of technological change.

In the following section we look in greater detail at the 'institutional turn' in development economics. Following the arguments made in Chapter 2, we argue that current mainstream thinking on institutions is constrained by its reliance on neo-classical micro-foundations leading to the emergence of an unwarranted unilinear causal narrative and limiting its ability to place adequate emphasis on the political economy process. Although recent scholarship in development economics has again propelled political economy considerations into serious contention, we argue that the understanding of the process is still stymied by a narrow focus on market enabling institutions. Section 3.3 presents an alternative framework based upon an evolutionary understanding of the political economy emphasising the close association between the processes of production and the distribution of power. Based on these observations we describe and develop our analytical approach for understanding how political economy considerations can influence environmental technological change. Section 3.4 concludes.

3.2 The 'institutional turn' and the (re)emergence of political economy

Much of the understanding of institutional arrangements in the debates surrounding the economics of catch-up (see Annex A3) have been influenced by New Institutional Economics (NIE). Research in NIE has placed a stress upon the institutional and political conditions for the development of markets, and shown a greater appreciation of their historical genesis and the likelihood of market failures. Importantly NIE approaches typically emphasise that effectively functioning markets neither emerged automatically, nor, where recognisable markets did emerge, did they necessarily function particularly well.[42] This theory has been supported by an expanding body of empirical evidence and an emerging consensus on the importance of institutions for development (Rodrik et al 2002; Acemoglu et al 2005; Evans 2006):

"...perhaps only one broad conclusion emerging from the wealth of growth regression results commands universal support. This is that *'institutions matter' for growth and development and that they matter decisively* …[…]…The implication is that to understand the historical and spatial patterns of growth and development it is necessary to understand the role and functioning of the 'deep' determinants of development, *those institutional or political factors that ultimately shape the proximate determinants of growth*: factor accumulation, technology adoption, and policy choices." [emphasis added] (Adam & Dercon 2009: 174)

The 'institutional turn' thus identified institutional and political arrangements as the fundamental determinants of economic development and by implication (and importantly for our argument) technology adoption. While the 'right' sort of institutional arrangements were perhaps not sufficient for development, they are certainly regarded as necessary (Khan & Blankenburg 2009). There remains, nevertheless, a great deal of debate on the precise role of government, the state, and the implications for political economy. At one end of the spectrum sits the paradigm notion is of a minimalist regulatory state working to ensure the effective functioning of markets through ensuring, amongst other things, third party contract enforcement and property rights (e.g. Kaufmann et al 2007; Kaufmann et al 2009; Savoia et al 2010). Towards the other end of our notional spectrum are the statist explanations, which stress the potential efficacy of the state in guiding technological change and development, property rights are deemed instrumentally useful, but not sacrosanct, and there is no unilinear path to development, a view typical of the literature on the developmental state (Chang 1994; Leftwich 1995; Khan & Jomo 2000; Haggard 2004; Leftwich 2005).

This distinction also relates to the causal role institutional arrangements are deemed to take in the process of economic development. Paldam & Gundlach (2008) distinguish between advocates of a minimalist 'good governance' approach to the state who tend to

[42] A foundational assumption of much neo-classical and neo-liberal scholarship see Annex A3.

treat institutional arrangements as exogenous and the fundamental cause of economic development (North 1990a; Acemoglu et al 2000, 2005), and proponents of a more activist state which tend to view institutions as endogenous to what is a political economy of development (Myrdal 1968; Evans 2006; Andrews 2008; Khan 2010; Chang 2011; Khan 2012). In the following sections we look at the debate surrounding the role of the state and the political economy of development in greater detail to enable the development of an adequate framework to allow us to start understanding the relationships between the process of technological change and the political economy.

3.2.1 From institutions to good governance

The theoretical roots of the 'institutions first' perspective are in NIE including the work of writers such as North (1990a, 1990b), Olson (1997), and Acemoglu et al (2005), amongst others.[43] This approach, based on an analysis of the historical experience of industrial development in Europe (and Britain in particular). It suggests that efficient market institutions may not spontaneously emerge as much of the neo-classical theory seems to assume (Nabli & Nugent 1989; Khan 2012). The failure of catch-up economic growth and the attendant technological change to emerge is not in general related to the market failures characterised as intrinsic to the process of technological change (Chapter 2 and Annex A2), which are associated, to a greater or lesser extent, with technological change in developing countries and developed countries alike.[44] The market failures implicated in the failure of economic development to emerge are *existential*. That is to say, they are related to the fundamental conditions for efficient markets emerging in the first place, i.e. property rights and contract enforcement. On this account, the problem of development is the second-order condition of the institutional arrangements necessary for the functioning of markets. The notion is that without a third party actor effectively enforcing property rights and contracts, market transactions cannot take place and markets cannot exist.

Importantly, in putting the institutions for markets in place there is a role for the state, although one that is circumscribed with stress placed upon just those factors that are

[43] Although this also draws on earlier institutional economist such as Veblen (1998) and Commons (1931).

[44] The possible exception to this is the case of intellectual property rights that in principle incentivize innovation by creating formal right to technology rents. But in the case of developing countries the role of IPRs is unclear. As developing countries are frequently relying upon foreign IPRs, an effective IPR regime may indeed retard development. Poor IPR may act as a disincentive to invest for foreign companies but this is not necessarily the case. For example, it has not really acted as a disincentive for investment in China where the loss propriety technology to weak de facto enforcement of international property rights is seen as an inevitable cost of investing there (e.g. see Sawdon 2011).

deemed important for productive investment and a market allocation of resources to take place:

"….the key challenge for most developing countries is to create the basic legal and institutional infrastructures that protect property rights, enforce private contracts and allow individuals to freely take advantage of market opportunities. In principle there are many more things that governments could and should do: provide public goods, correct market failures, reduce inequalities in income and opportunities, stabilize excessive economic fluctuations. *But these other government activities are not what make the difference between success and failure in economic development. The real difference is made by the basic institutional and legal infrastructures that protect property rights, enforce the rule of law and prevent abuse by governments*." [emphasis added] (Tabellini 2005: 283)

It is not so much that the state could not be active elsewhere, but the *essential cause* of economic development is a state that acts to enable the market, and given the essential economic institutions which undergird the operation of the market, otherwise refrains from interference in the economy (Tabellini 2005; Savoia et al 2010). The message is twofold, that institutions are the fundamental cause of development, and that a minimalist state can do the job. The logic of this stress on economic institutions in promoting economic growth and development is clear, property rights and contract enforcement are essential for the conduct of transactions and the development of effective markets. In the case of technology, the particular institution of IPRs plays an important role, in line with the conventional neo-classical story (see Annex A2):

"…the rate of technological change depended on the inventor's ability to capture a larger share of the benefits of his invention. Only the patent system created a set of systematic incentives that raised the private rate of return closer to the social rate." (Mokyr 2009: 349)

But once we have taken the crucial step away from the *Wunderursprung* of markets and introduce, instead, key institutions that are the cause of economic development, we have also necessarily introduced a role for extra-market players. That is to say we have introduced a polity. But, there is nothing in the polity of itself to ensure that it will not seek to influence the operations of economic processes to favour its members. The state can be as much a threat to property rights as it can be a guarantor. Indeed, all other things being equal, given the fundamental assumptions of economics relating to the utility maximising behaviour of individuals, we would *expect* to see rent-seeking behaviour emerge from the state, which will in turn retard investment. As Weingast (1997) observes:

"The more likely it is that the sovereign will alter property rights for his or her own benefit, the lower the expected returns from investment and the lower in turn the incentive to invest. For economic growth to occur the sovereign or government must not merely establish the relevant set of rights, but must make a credible commitment to them." (Weingast 1997 cited Haggard et al 2008: 213)

Therefore, the theory suggests, there is need for another level of institutional arrangements, which ensure that the state does not use its power over otherwise efficient market allocations in rent-seeking behaviour. For example, concerns relating to state predation on private property, mean that protection from the state is one of the key functions of the legal institutions, explaining the stress often placed upon 'the rule of law' (Haggard & Tiede 2011).

It is interesting to note that the essential logic of the position developed from NIE - that property rights and contract enforcement are important in ensuring markets can function properly - is transformed from an assertion of the positive role the state could play in promoting economic growth (and indeed the acknowledgement that the state *could* do a lot more), to the predominantly negative caricature of the predatory state, and the role of a set of additional institutions in curtailing what is seen as an inevitable consequence of administrative fiat.

The 'institutions first' account has attracted a significant amount of criticism. Critics point to the partial reading of history, which has placed the development of property rights at its centre (Ogilvie 2007; McCloskey 2009; Khalil 2012; Khan 2012). In North's canonical formulation, property rights (including the development of IPRs) and supporting institutions were something that uniquely emerged on the eve of the Industrial Revolution and played *the* causal role in its emergence in the 17th and early 18th centuries, as North & Thomas put it:

"Efficient economic organization is the key to growth; the development of an efficient economic organization in Western Europe accounts for the rise of the West. Efficient organization entails the establishment of institutional arrangements and property rights that create an incentive to channel individual economic effort into activities that bring the private rate of return close to the social rate of return…If a society does not grow it is because no incentives are provided for economic initiative." (North & Thomas 1973: 2-3)

Critics argue that the historical record does not support this assertion. Well-developed property rights, contracts and markets existed in many places at many times in history prior to the industrial revolution that did not lead to the same sustained economic growth, McCloskey (2009) writes:

"The long perspective is why North's is an exceptionally poor argument for explaining the Industrial Revolution or the modern world. The choice to escape from growth-killing investing in swords or in influence at Court rather than investing in good textile machinery to make good woolen cloth, and in good organizations to administer the good machinery, has happened repeatedly in history - in China for whole centuries at a time, in Rome in the second century C.E., in much of Europe after the eleventh century. Something was radically different about the case of eighteenth-century Britain. *But the difference was not the rearrangement of incentives beloved of economists, those rules of the game. The incentives had already been rearranged, long before, and in many places*." [emphasis added] (McCloskey 2009: 20-21)

Other critics such as Khan (2012) and Ogilvie (2007) concur. The picture of economic development that emerges from the NIE account is one in which economic development - and technological change - takes-off as a more-or-less automatic consequence of the emergence of efficient markets, once the barriers created by feudalism and inefficient institutions are removed.[45] But in common with McCloskey (2009), these writers point to the emergence of a much broader range of specific conditions, which lead to the emergence of modern capitalism in Britain. A new structure of property rights and institutions associated with new modes of production, as Khan & Blankenburg (2009) put it, 'forced productivity growth', in ways that did not happen elsewhere (Wood 2002; Adam & Dercon 2009; Khalil 2012). This points to a more complex understanding of the process of industrialisation, one in which requires both a better understanding of the role of political, and technological conditions, and perhaps as Mokyr & Nye (2007), McCloskey (2009), Hickey (2012) and Evans (2006) argue an understanding of human motivations that goes beyond the reductive assumption of utility maximisation:

[45] It should be noted that this reading of North, while correct in its criticism of the substantive and empirical aspects of his work tends to obscure the elements of his method, which sit uneasily with this reading. In particular, North's commitment to bounded rationality and path-dependency, the centrality of beliefs in determining human behaviour and his criticisms of the neo-classical canon more generally. Nevertheless, the criticisms of North's earlier work (pre 1990) and of North how he appears in the subsequent mainstream economics literature is probably accurate.

"An institutional analysis that takes goals and interests for granted would be intellectually impoverished. The better part of human needs and desires are culturally constructed. Enabling people to construct and reconstruct their aims is a basic task of institutions as enabling people to satisfy the needs and desires that have been constructed. Just because this complicates linear explanatory logics does not give us an excuse for ignoring it." (Evans 2006: 41)

Turning back to the criticisms of the 'institutions first' perspective, even if we were in agreement with North's account of the genesis of modern capitalism resting on the creation of a stable property rights regime, it does not follow that, in the case of contemporary development we can necessarily expect this pattern to be repeated. The world is changed, it remains an open question whether or not in the contemporary context a reliance on a stable property rights regime alone would lead to sustained economic growth.[46]

3.2.2 A critical review of the empirical evidence

A large empirical literature has developed seeking to test which institutions are important in promoting economic growth. The empirical method of choice is that of cross-country econometric analysis, which attempts to test the correlation between economic performance and variables standing as proxies for various institutional arrangements, in order to establish a causal relationship running from the latter to the former. It is a large literature, here we review a few influential studies to illustrate the difficulties the work faces.

On the issue of property rights there is little dissent concerning their importance in realising long run economic growth. For example, Knack and Keefer (1995) found a significant association between property rights institutions and economic growth, not only in terms of encouraging aggregate levels of investment but by enhancing the efficiency with which those investments have been made. Other studies have found similar evidence of the association of long run growth with the strength of property rights in the cross-country data (e.g. Porta et al 1996; Mahoney 2001; Keefer & Knack 2002; Keefer 2007; Asoni 2008) and in micro-level studies (e.g. Kaufmann 2004; Bazzi, & Clemens 2009; Malesky & Taussig 2010).

[46] Indeed the discussion of the Gerschenkronian account of latecomer catch-up suggests otherwise, see Annex A3.

Studies linking more general conceptions of good governance or broader policy with economic growth have been more equivocal in their findings. In *extremis*, broader governance institutions ensuring freedom from the threat of violence are important. As Haggard et al (2008) point out security of the person clearly has priority over security of property rights or contract enforcement. This observation is reinforced by Collier et al (2003) who clearly illustrate the disastrous economic consequences of armed conflict.

Leaving these considerations aside to focus on the larger set of more stable developing countries, and particularly emerging economies, the empirical question of the extent to which the right kind of institutions are associated with - let alone are the identifiable cause of - economic growth remains an open one. The originators of the World Bank's World Governance Indicators, Kaufmann, Kraay & Mastruzzi (2004, 2009) argue strongly for the relevance of their composite indices, and the causal role played by institutions in enhancing growth outcomes.[47] Aidt (2009), however is more equivocal, in a review of the literature, noting, for example, that while there are good reasons to think corruption is growth retarding there is little robust empirical evidence to indicate that the rate of GDP growth is significantly affected by corruption. Flachaire et al (2011) find that political institutions do matter for growth, but not decisively as in some circumstances regimes which are relatively authoritarian, or perform badly in terms of institutional or governance indicators have shown high levels of growth. This finding is supported by a diverse range of writers such as Przeworski & Limongi (1993), Khan (2005; 2007a), Rodrik (2007a) and Gerring et al (2012).

Notwithstanding, the equivocal evidence on political institutions and growth outcomes, which itself points to the need for a better understanding of the linkages between political arrangements and economic outcomes, the general policy prescriptions which continue to be taken away from this debate are not only that institutional arrangements are important for growth, but that a specific set of institutional arrangements that characterises the small set of modern capitalist liberal democracies is generally the best for promoting growth. Hence, the overwhelming emphasis on the normative grab-bag of 'good governance' reforms that continue to be emphasised by donor agencies (Andrews 2008; Gisselquist 2012).

[47] Even arguing that there is a negative feedback from income levels to governance measures (Kaufmann & Kraay 2002).

This large body of empirical literature has come in for extensive criticism, with the empirical support for 'good governance' particularly contested. Criticisms centre on both methodological issues[48], and the veracity of the empirical claims.

Criticisms of method centre on the use of proxy variables for institutional arrangements, the ontological implications of universalism this entails, and issues of endogeneity and establishing the direction of causality. Firstly, the widespread use of proxy indicators to represent complex institutional arrangements is criticised. The notion that nebulous, ill-defined proxies can somehow aggregate and capture a range of varied institutional structures is questioned. It is not clear what institutional arrangements are signified by the composite proxy measures used in the cross-country analysis, for example in the World Bank Global Governance indicators or Political Risk indicators compiled by ratings agencies. But these proxy indicators, available for a range of countries over an extended period of time, are essential for the very possibility of the empirical analysis. Evans (2006) questions the plausibility of arranging property rights, which are dependent upon specific historical context, and reflect a complex of institution and political arrangements, on a 'simple ordinal scale':

"Any initial allocation of rights to different kinds of property…[…]…is disputable and somewhat arbitrary. Enforcement of rights once they have been allocated is equally so. Sending the National Guard to evict peasants growing crop's on a landlord's unused land is enforcing property rights. So is shutting down a factory whose pollution is making the surrounding neighbourhood unliveable. Development almost certainly depends on how property rights are allocated and what kind of property rights are enforced for what segments of the population. Exactly how these complex patterns of allocation and enforcement are related, positively or negatively, to development can hardly be taken for granted." (Evans 2006: 37)[49]

Andrews (2008) makes a similar point, asking what the proxy indicators actually represent. Countries with high governance scores have in common are strong governance outcomes and high levels of economic development.[50] But the underlying governance structures are quite different. Moreover, contemporary governance structures did not emerge in their current form in some common linear fashion, the paths to better

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48 Addressed in greater detail in the discussion of the problems facing cross-country growth regressions in Annex A3.
49 Mokyr makes a similar point: "Indeed, one could argue that to some extent the reverse was needed for rapid technological change: some property rights had to be extinguishable when they got in the way. This was true not just for such concrete matters of eminent domain used the expropriate land…but also to extinguish a host of monopolies and other rent-generating exclusions and privileges that had been regarded as assets in an earlier age but were effectively used to block technological progress" (Mokyr 2009: 349)
50 As he notes with no little irony, "…like Denmark or Sweden on a good day, perhaps."

institutional and economic outcomes were extremely varied, effective governance structures in successful countries when they started out on their path to development did not resemble the institutional arrangements we find today. Indeed, given the high costs of effective governance, it is difficult to see, materially, how this could be possible (Khan 2012).

Secondly, the empirical claims that right kind of institutional arrangements cause growth is not well founded. Indeed causation could quite easily run the other way. As we noted earlier, the presence of complex, contingent causal conditions in open-systems means that causation is extremely difficult to pin down (see annex A3). In the case where we are seeking to link two variables, one of which is extremely ill defined, with events that are not contiguous in space or time, but linked by a complex series of interactions, the possibilities for confounding variables are dizzying. Absent the respectability offered by the historical account, the argument begs the question. The argument that good institutional arrangements are associated with good economic outcomes, therefore good institutional arrangements are necessary for good economic outcomes, only makes sense if we assume that good institutional arrangements are necessary in the first place (McCloskey 2009).

These two criticisms are related to a third, that of the assumption of an epistemic universalism (Kenny & Williams 2001). That is, the assumption that the experience of economic development, and the role institutions play in it can be reduced to a notional relationship between two aggregate indicators which captures the essential causal dynamics of the relationship between institutional and economic change seems far fetched. Nevertheless, the ahistorical normative implication of this logic has been extremely influential in policy fields.[51]

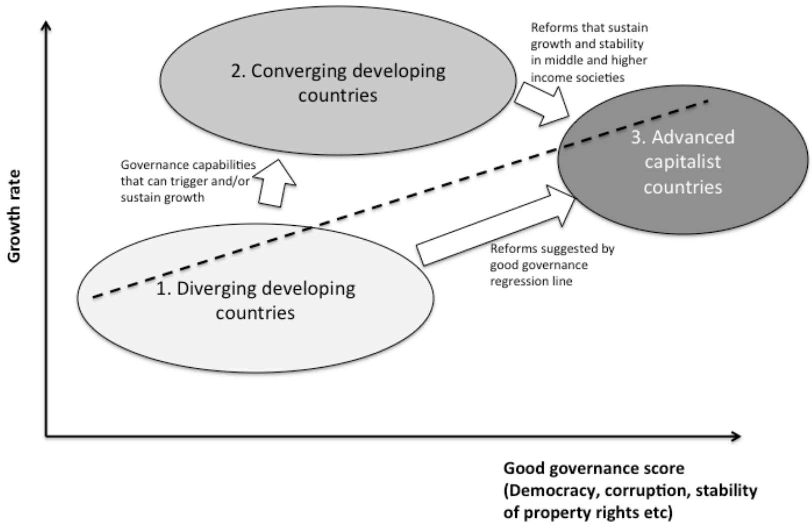
Khan (2007b) has made related criticisms of the veracity of the empirical evidence. Firstly, he argues that the relationship between the indicators of good governance and economic performance is generally weak anyway. Without the high-income countries, the statistical relationship between good governance and good economic performance disappears. Secondly, unpicking the empirical analysis, he points out that there is little difference in the governance scores, even related to core economic governance indicators

[51] Again, discussed in greater detail in Annex A3.

(such as property rights), between developing countries that have good growth records and those with poor growth records. Moreover, the outliers to the analysis are precisely those high-growth developing economies that have managed to realise significant economic catch-up, i.e. those with poorer governance scores but high levels of economic growth.

In short, the interpretation of the regression results as supporting the causal primacy of good governance institutions, and by implication the likely efficacy of good governance reforms is misleading (Figure 3.1). The alternative interpretation of the data in Khan's analysis stresses that institutional arrangements *other* than those of the good governance paradigm are found in converging developing countries (such as those in East Asia).[52] This view is broadly supported by an increasing number of writers including Grindle (2004, 2007), Evans (2006), Adams (2008), Levy (2010) and Fritz (2007), as well as writers on the developmental state (Leftwich 1995; Haggard 2004; Wade 2009; Routley 2012).

Figure 3.1. Governance characteristics of growth economies



Source: (Khan 2007b)

Attempts have been made to support the case for the primacy of property rights through the use of instrumental variables and historical data. Acemoglu, Johnson & Robinson (2000) in an oft cited paper use the exogenous variable of settler mortality rates as an instrument for property rights (proxied by average expropriation risk for 1985-1995)

52 What these institutions may look like is discussed in greater detail in section 3.3.2 below.

which they find is correlated with better growth performance. The argument is that in settler colonies with initially high settler mortality rates were more difficult to settle and as a result developed extractive institutional arrangements and weak property rights. Settler colonies (such as Australia or New Zealand) on the other hand, were easier to settle, thus settlers engaged in productive activities demanded propriety rights similar to those enjoyed in the home country. The historically persistent institutional form of a strong-stable property rights regime has been associated in the long term with better growth performance.

Khan (2012) argues that the perception that this analysis has, once and for all, proved the association of property rights regimes with economic performance, is wrong. He suggests that the research shows that settler colonies performed better in the long run, controlling for other factors, than non-settler colonies – but that this is not controversial. He challenges the link between the instrumental variable (settler mortality rates) and the associated strong property rights regime, pointing out it relies on a particularly partial reading of the historical narrative, one which omits the violent expropriation of long-standing, stable indigenous property rights regimes. Indeed, that the low density of indigenous populations, which is used as an instrument in a follow-up paper by Acemoglu et al (2001), was a condition of development through the violent expropriation of indigenous rights. In short, what seems like the best effort to prove the causal efficacy and primacy of the property rights accounts in the mainstream account, as with the story told by North is based upon a partial understanding of the historical record, which serves to obscure what is a more complex process.

3.2.3 Embracing the political economy

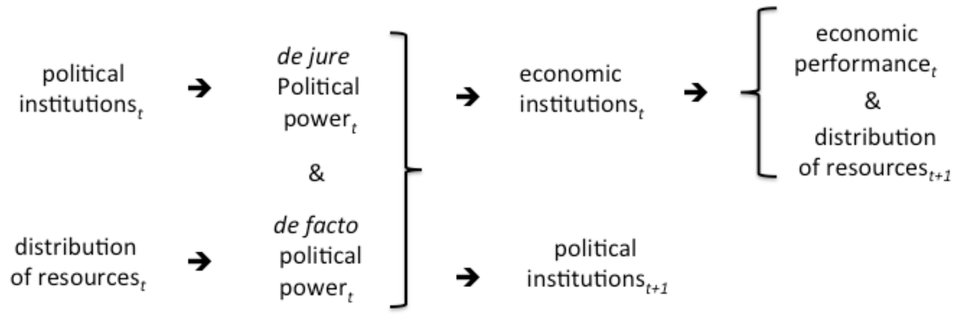
Evans (2006), and Adam & Dercon (2009), while to varying degrees harbouring doubts about Acemoglu, Johnson & Robinson's conclusions, credit the account with influencing the re-emergence of political-economy considerations in understanding the process of development. Despite the partial reading of the historical narrative in Acemoglu et al's account, what does emerge from the argument is the importance of an understanding of history, and through this an understanding of the particular 'political equilibrium' or 'political settlement' in determining the conditions for economic growth. That is to say, even if we accepted that property rights institutions are the cause of economic growth, that these institutions emerge is a condition of a political economy process:

"…property rights and the integrity of contract are not simply the result of "getting the law right" in any narrow sense. Rather, property rights come out of a complex causal chain that includes a variety of complementary institutions and political bargains - with respect to security, appropriate checks on private capture of the state, institutional checks on state power, and the more discrete features of the judicial and legal system. In simplest form: Property rights and contracting rest upon institutions, but these in turn rest upon *deep coalitions of consenting interests*." [emphasis added] (Haggard et al 2008: 221)

Drawing on their empirical work Acemoglu et al. develop a pared down conceptual framework illustrating the dependence of institutions on essentially exogenous political and distributional factors (Figure 3.2). In this framework economic institutions determine both economic performance in the present and the future distribution of resources. Economic institutions themselves are chosen based upon political power. *De jure* political power is that held and exercised by formal political institutions, and *de facto* political power is political power exercised outside formal institutions. Essentially the definition of political power in this framework is the capacity to decide upon institutional arrangements (both political and economic). Political power in the current period is determined by incumbent political institutions and the current distribution of resources. These are the two 'state variables', which change slowly overtime and determine the state of the rest of the system. The upshot of this model is that those who possess political power will seek to choose economic and political institutional arrangements, which will recreate this distribution of resources and power. Political institutions and the distribution of resources in the initial period are effectively exogenous and determine economic outcomes, crucially through the choice of economic institutions. While this elaboration of the theory is helpful in stressing the importance of the political economy and the distribution of resources, by suggesting that political conditions are effectively exogenous, the critical policy variable remains economic institutions.

Conceptually, the account developed by Acemoglu et al moves the mainstream position closer to an account whereby the process of economic development and technological catch-up is understood as a political economy process. Substantively, the account remains one wed to a belief in the efficacy of markets, although now the account is mediated through a long causal chain - markets require suitable institutional arrangements, which in turn require suitable political arrangements. It is this substantive account that we have rejected. It relies either on a partial and misleading interpretation of the historical record (which in any case may be of limited relevance to the contemporary context), or on shaky cross-country evidence.

Figure 3.2. A simplified political economy relationship



Source: (reproduced from Acemoglu et al 2005) Note: Subscript ‘*t*’ denotes the current period, and ‘*t+1*’ the future period.

On the other hand, the suggestion that the political economy context is likely to be an important determinant of economic growth and technological change, is one with which we agree. The question remains if, as we contend (along with writers such as North (2005) and Nelson (2008)), the mainstream framework is inadequate for this task, how can we understand this relationship? The micro-foundations developed in Chapter 2 provide only a basic ontology within which our processes must be framed. It is this question we turn to in the next section.

3.3 A conceptual framework for understanding political economy of economic growth and technological change

This section draws upon the analytical work done on the political economy of economic development and seeks to articulate an analytical framework explicitly linking political economy processes to technological change in the process of economic catch-up. This framework will serve as a basis for understanding the political economy context for environmental technology choice.

Managing the transfer, acquisition and diffusion of technology and the organisational and institutional arrangements within which they are embedded is at the heart of the problem of economic development. A general consensus amongst practitioners and academics has developed over the last 15 years that a ‘hands-off’ regulatory state is not likely to be sufficient to do the job (e.g. see Commission on Growth and Development 2008).

Important 'externalities' mean that government (or other extra-market players) are likely to have to use systematic intervention through various sorts of policy to support the acquisition and diffusion of new technology (i.e. the governance capabilities to trigger and sustain growth in Figure 3.1). The point we wish to stress here, drawing on the arguments made in Chapter 2, is the importance of the links between *technology* and the political economy. A point which is not articulated particularly well either in the emerging literature on the political economy of development, or indeed the evolutionary account of technological change. The analysis of Mokyr (1992, 1997), and Moe (2009, 2010) of the relationship between technological change and the political economy in the context of the Industrial Revolution discussed in Chapter 2 suggests a useful conceptual starting point.

3.3.1 Technology and political economy

Both Mokyr (1997) and Moe (2010) stress that vested interests have been an important determinant of the pace and direction of economic and technological change. They point out that the history of technological change is one in which the interrelationships between the political economy and technology have been extremely important. Technological change not only changes aggregate economic performance, it changes the distribution of material benefits, particularly so in the case of technological and economic changes that precipitate wide-scale structural or disruptive technological change. Mokyr (1997) points out, technological change can elicit significant political resistance, as the beneficiaries of incumbent technologies (be they artisanal craftsmen, industrial workers or oil companies) seek to preserve and further the benefits they enjoy, or reap new benefits. An individual or group's ability to mobilise and articulate political power will be dependent upon a number of factors including the difficulty or otherwise of mobilising collective action, the extent to which interests are aligned with those of politically powerful groups, the extent of the perceived change in welfare, and above all their own political power in the first place.

It would be a mistake to think that historically, the links between technology and power have only, or predominantly, been exercised through economic means, coercive power and ideological power have also been extremely important in this interplay between technology, economics and politics (Galbraith 1983). For example, throughout history the pursuit of political power through military means has been a key driving force behind technological acquisition and advancement, technological advancements (in material technologies as well as tactics), in the pursuit of ancient bronze-age warfare through to the development of nuclear weapons in the twentieth century (Lipsey 2009). Similarly, the pursuit of political power through ideological means has also been articulated in technological development as in the 'Space Race' in the 1960s and 1970s, or as we will argue in Chapters 4, 5 and 6 in the ideology surrounding electrification and the construction of hydropower dams (Ruttan 2001; Williams & Dubash 2004). Similarly, while we may harbour some fundamental doubts about North's story, we can certainly agree that important institutional arrangements have themselves been both cause and effect of military, ideological and economic changes, just as in other cases they are constitutive of inertia (North et al 2009).

What is important then about the emergence of a capitalist mode of production, is not as on the NIE account stable property rights *per se*, but the particular form of institutions that emerged in the Industrial Revolution, and importantly their relation to the means-of-production, and of interest to us here, the technology of production.[53] Khan & Blankenburg (2009) and Wood (2002) are correct to point out that the particular institutional forms were instrumental in the emergence of capitalism and the Industrial Revolution:

> "Rapid productivity growth in England was associated with the emergence of a new system of property rights (a 'mode of production') that required the imposition of a new structure of rights and institutions that forced productivity growth in England in a way that did not happen elsewhere." (Khan & Blankenburg 2009: 340-341)

However, the technologies that were an intrinsic part of this change do not get a mention. Khan & Blankenburg's account of technological change while broadly consistent with evolutionary economics, largely overlooks the implications of the technological changes taking place during the Industrial Revolution. The supposition seems to be that it was the form of property rights that emerged that spurred entrepreneurship and innovation. But we contend that the story is more complex than this. Incentives for innovation were in part a condition of institutional and political

[53] It should be pointed out that there is no inevitability about this process. The historical antecedents for these institutional forms came about as much through the capricious vicissitudes of history as they did through the beliefs and actions of individuals and groups.

arrangements, but were also a condition of the *type* of technological advance that was taking place.

As we argued in Chapter 2, technologies and institutions co-evolve, institutional change and technological change are different facets of the same process. A key feature of the Industrial Revolution, compared to other technological changes in the past was the massive increase in labour productivity, enabled by technology that allowed cheap energy to be applied to the process of production (Smil 2010; Wrigley 2011). This in turn generated hitherto unseen increasing returns to scale (Lipsey 2009). The point to take away from this is, while cheap energy resources were available elsewhere in the world, the availability of the requisite *technology* was a necessary condition for the industrial revolution.

Our contention is supported by Mokyr's (2009) analysis that shows that the alternative notion, that the development of property rights institutions for intellectual property spurred invention and technological change (essentially an induced innovation account), is not supported by the evidence. The IPR regime during the Industrial Revolution was weak and often ineffective, and to reduce the incentives of inventors to simple benefit seeking does not accord with the historical record, in common with McClosky (2009), Evans (2006), Ogilvie (2009) Mokyr (2009), and Mokyr & Nye (2007) see this as misleading. Other motivations such as honour and even altruism were important incentives.[54] Moreover, as Allen (2012) points out much innovation took place informally as part of a collective learning process – part and parcel of those positive externalities to technological innovation and diffusion.

Our position on the importance of technological change in the industrial revolution, and in general for sustained economic growth approaches that of Lipsey (2009), who suggests that the Western Scientific method was a critical condition for technological advance.[55] This in turn may have been the result of historical contingencies, but it provided for the systematic development of knowledge about the world, which enabled industrialisation to take place. This is in accord with writers in the evolutionary economics tradition,

54 Keynes' General Theory and the later works of Douglass North also place some emphasis upon the role of ideology and beliefs in explaining human action.

55 To cite Lipsey (2009) "A necessary condition for the Industrial Revolutions was Western science whose roots lie as far back as the scholastic philosophers and the medieval universities. Its absence elsewhere is a sufficient reason why no other place developed its own indigenous industrial revolution."(259)

which repeatedly stress the importance of the means of invention and innovation, in terms of funding for education, basic and applied research, and the development of institutions such as R&D labs within firms and university systems (Freeman 1995; Lall 2000; Nelson 2004; Mowery et al 2009).

The important thing to come out of this story is not so much how the Industrial Revolution was put in motion. Although this too is important both in a rebuttal of the accepted wisdom of NIE, and an illustration of how intricate the articulation of these processes is in complex, open systems. Rather, our interest is in how we can understand the processes that emerged in this colossal structural change in the social order. We suggest it is precisely at this period in history that because of the dynamic increasing returns to the application of capital to productive processes, this is where power articulated through economic means comes to predominate, where the technology rents are used to enable further transition:[56]

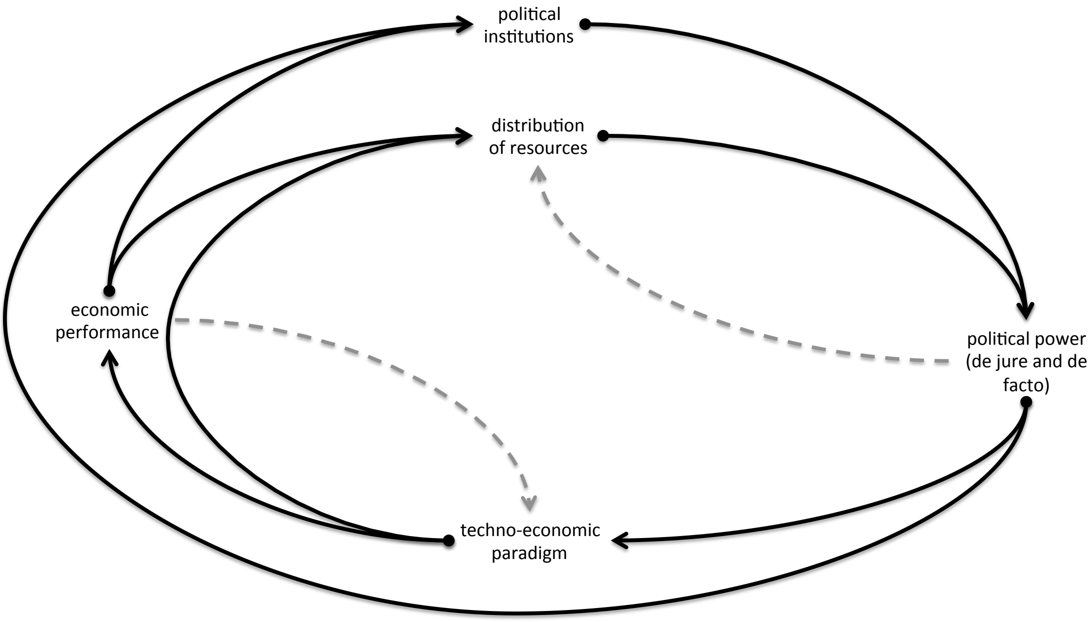
"The success of the British experiment was the result of the emergence of a progressive oligarchic regime that divided the surpluses generated by the new economy between the large landholders and the newly rising businessmen, and that tied both groups to a centralized government structure that promoted uniform rules and regulations at the expense of inefficient relics of an economic ancient regime. Wealth - inherited or earned - remained the source of political power, but as its base broadened, its political objectives shifted." (Mokyr & Nye 2007)

There are two important elements to the dynamic we wish to highlight here. First, the massive increasing returns to scale allowed by the new technologies. Second, the way in which this means that power shifted from being articulated primarily through physical coercion or ideology, to power generated and articulated primarily, if not exclusively, through economic means. This is not to suggest other forms of power are not important, or indeed to afford any causal primacy to economic power (Marx 1867; Heffer 2011). Ideology and coercive power have been and remain extremely important both in their own right and in the articulation of economic power. But, we maintain that the change in the social order that emerged as the Industrial Revolution is uniquely characterised by the scale of generation of economic power articulated through the political processes, and that this was enabled by technology.

[56] Or at least technology-enabled rents, such as those associated with new energy realted technologies.

Thinking about this conceptually, we can start to see an alternative framework emerging which modifies that offered by Acemoglu et al (Figure 3.2) in some significant ways (Figure 3.3). First, the process is cumulative and circular rather than linear, meaning that the endogeneity problem cannot be assumed away. Second, while the distinction between *de jure* and *de facto* political power remains important (as we shall see in section 3.3.2) for the purposes of this exposition it is assumed that both types of political power perform similar functions *vis-a-vie* the techno-economic paradigm and political institutions. Similarly, the reference to political institutions extends to encompass formal and informal institutional arrangements. Third, and perhaps the most significant departure from the framework in Figure 3.3, is that economic institutions are replaced by the notion of a techno-economic paradigm, highlighting the co-dependency and co-evolution of technologies and institutional arrangements (as stressed in Chapter 2). Fourth, the link between economic performance and the political institutions and distributional implications is made more explicit, economic performance enables political institutions by providing the material wherewithal to support opperations. Fifth, two important positive (Lamarckian) feedbacks are indicated (the discontinuous grey lines), these are direct feedbacks not mediated through the broader political economy process. One arrow, links economic performance with the techno-economic paradigm, and represents the operation of firms, for example, in their search for more effective routines, or alternatively as they seek directly to supress institutional forms and technologies that are perceived not to be in their interests directly (such as in warehousing patents). The second feedback is from political power to the distribution of resources, as for example, states may actively seek to alter the distribution of resources though redistributive taxation policy. These economic and political feedback pathways would tend to be stronger and more important in advanced economies and liberal democracies respectively.

Figure 3.3: Linking politics and the techno-economic paradigm



In common with Acemoglu et al's framework, the main point of this framework is to illustrate how the particular configuration of economic institutions, and in our framework the techno-economic paradigm, is closely related to the particular configuration of political power. For Acemoglu et al institutions need to be feasible from the perspective of the particular configuration of political power. This is true in the case of this framework too, although, in this case the relationship between political power and the techno-economic paradigm is one best characterised as co-evolutionary. Moreover, as with Acemoglu et al's framework, this framework is suggestive of inertia as a particular distribution of economic power is created through this process.

Nevertheless, the similarity is superficial. Whereas Acemoglu et al see the particular political settlement as an equilibrium, suggesting static inertia, in our case we see a political settlement emerging from a dynamic process and one that is constantly evolving. Dynamic increasing returns would serve to quickly reinforce an emergent distribution of power, this settlement is not a precarious balancing act between competing interests, but a system where inertia, lock-in and increasing inequality in the distribution of power are intrinsic characteristics.[57] At the same time, the system is intrinsically unstable.

[57] It is interesting to note that for all the reliance of the Acemoglu et al/NIE account of institutional development on North, his ontological commitments to significant dynamic increasing returns leading to institutional inertia, sits uncomfortably with the notion of an equilibrium, something which his neo-classical acolytes seem to be oblivious. We

Exogenous shocks are as likely to be important here as in Acemoglu et al's framework. But incompete understanding and uncertainty about outcomes means the system will never be in equilibrium and always prone to unforeseen contingencies. This too gives greater play to other expressions of power not incorporated here such as ideological and coercive power.

This framework serves to emphasise the broad conceptual direction in which we are going, and our contention that the techno-economic paradigm is part of a broader political economy process, but it is not adequate to explain or examine how the political economy of technological change is articulated in a particular context, and in particular in the context of economic catch-up. To understand this we need to turn to the analysis of the political economy of technological change in latecomer catch-up, and the work on developmental states in particular.

3.3.2 Drawing on the experience of developmental states

In common with our argument, an influential and comprehensive review of the institutional literature on East Asian economic development by Haggard (2004), stresses the role of an understanding of the political context in an explanation of institutional and economic outcomes. Haggard argues that a variety of institutional forms were able to perform important developmental functions such as ensuring requisite property rights, making credible and effective policy commitments, formulating effective policy and constraining rent-seeking behaviour. In common with other writers including Acemoglu et al (2005), Khan & Blankenburg (2009), Chang (1996) and Leftwich (1995, 2008), emphasis is placed upon the understanding of functional outcomes not as an inevitable consequence of some uniquely optimal institutional form, but as a consequence of the motivations of those in positions of power, that is, as a consequence of politics. What emerges as important from the analysis of East Asian development, is not that the institutions played the function they did, other institutions may have performed equally well or better, but how they were acatually able to do it:

"… to the extent that dictatorial regimes faced credible commitment problems, representative institutions did not appear to be a necessary condition for solving them. Authoritarian governments established their credentials with private actors through other commitment technologies: industrial policies, subsidies, rents,

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may note, in support of North, that institutions are frequently shot through with anachronisms, frozen hard fast into the structure of our social arrangements.

corruption, particularistic ties, and simple 'repeat play.' Through non-predatory behaviour and restraint, sustained over time, governments signalled that the property rights of favoured groups were assured. *Institutions were not necessarily important, and to the extent that they were, they rested on more fundamental political coalitions and exchange relationships*."[emphasis added] (Haggard 2004: 62-63)

Leftwich (1995) offers a more detailed political account of the role of East Asian states in the process of economic catch-up in his discussion of developmental states. In developing an 'ideal-type' of developmental state Leftwich highlights key characteristics of the political context in these states that allowed them to play an effective developmental role. First, the presence of a narrow political elite committed to national economic development, typically with close links to the military and administrative organs of government. Second, these states were able to achieve relative autonomy from competing special interests. Historically, this has been a consequence of the state's ability to consolidate its power without the interference of other interests. The paradigm contrast is between states in East Asia and ostensibly similar states in South Asia, Latin America and the Philippines. In the former, the political power of the *Ancien Régime* was weakened by violent conflict and colonization allowing the emergence of a politically autonomous developmental elite, in the latter, long standing economic and class interests were able to capture the political process and effectively ensure that the state served their interests, thus retarding development (Khan & Blankenburg 2009). Autonomy has also been a consequence of the broader geo-political context, providing both the external threat, which necessitated development, and external material (money and know-how) from politically allied states (Stubbs 2008). Third, Leftwich notes the autonomy, competence, and power the economic bureaucracy in developmental states enjoyed, which in particular enabled them to effectively implement important policies. Fourth, the relative political weakness and subordination of civil society. And, fifth, as a result of a combination of the preceding factors, the ability of the state to effectively manage non-state economic interests. State power was consolidated in such a way that it was able to avoid capture by the interests of capital. On one hand, the closeness and denseness of formal and informal linkages between state and the emerging industrial sector played an instrumental role in the relative success of industrial policy (importantly through reducing knowledge asymmetries between policy makers and firms). On the other hand the state was able to maintain its autonomy to effectively implement and monitor industrial policy, a characteristic often referred to as 'embedded autonomy' (Chang 1994; Evans 1998; Khan & Jomo 2000).

Importantly, this points to a broader political settlement, which enabled the emergence of states that were actively able to pursue economic catch-up. These regimes depended on the subordination of other interests to the goal of national economic development. This entailed the suppression of possible competing interests, enabled by the relatively high degree of legitimacy these states enjoyed. This was, in turn, a function of their actual performance, in terms of the delivery of developmental goods, such as jobs and rising income levels as a consequence of economic growth, but also the delivery of services and essential infrastructure (Leftwich 1995). The suggestion is that developmental states represent a particular type of implicit political trade-off between the suppression of popular political power and developmental performance (Fritz & Menocal 2007; Levy 2010; Levy & Fukuyama 2010).

Similarly, Khan & Blankenburg (2009), in their comparative study of the political economy of industrial policy in South Korea, Thailand, Malaysia, India, Bangladesh, Pakistan, Brazil, Colombia and Peru contrast the relative success of industrial policies for technological catch-up in South East Asia, and the relative failure of industrial strategies in South Asia and Latin America. They explain this based upon the incompatibility of the particular political economy configuration with the successful implementation of technology policy, and in particular the management of resource flows or rents.

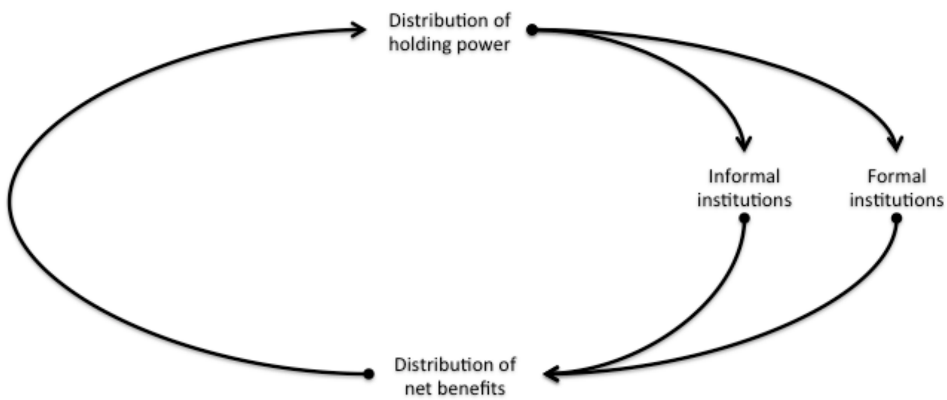
It is not our purpose to understand the details of the process of economic catch-up in developmental states, rather we are interested in explaining the importance of political-economy processes to allow an understanding of technological change, and potential for environmental technological change in particular. More specifically, drawing on the experience of both successful and failed political settlements, the question is, how can we articulate the political economy process in a conceptual framework that is at a sufficiently general level to allow of application in this research? In order to enable us to do this we turn to recent work by Khan (2010, 2012) Levy (2010), and North, Wallis & Weingast (2009) and their work on political settlements.

Khan (2010) suggests that at the most general level a political settlement is one in which the distribution of net benefits in a system is consistent with the distribution of what he calls 'holding power', defined as:

"Holding power refers to how long a particular organization can hold out in actual or potential conflicts against other organizations or the state. Holding power is a function of a number of different characteristics of an organization, including its economic capability to sustain itself during conflicts, its capability of inflicting costs on competing organizations, its capability to mobilize supporters to be able to absorb costs and its ability to mobilize prevalent ideologies and symbols of legitimacy to consolidate its mobilization and keep its members committed." (Khan 2010: 20)

Control over material or economic resources is likely to be an important determinant of holding power. As we argued above, economic power is likely to become much more important with the development of capitalism, both due to the scale of capital accumulation needed to invest in modern industrial production, and once underway as a consequence of the massive dynamic increasing returns to scale enjoyed by new forms of production. When the distribution of benefits and the distribution of holding power are consistent with one another the system will be relatively stable as the distribution of resources, power and institutional structures are mutually reinforcing. The relationships and the system will however evolve overtime through the evolutionary processes outlined in Chapter 2. Institutional arrangements, both formal and informal mediate this relationship. In a capitalist settlement formal institutions predominate, but in the context of most developing countries informal, patron-client relationships are likely to be of significance (Figure 3.4).

Figure 3.4: The interdependence of power and institutions



Source: Based on Khan 2010

The distinction between formal and informal institutions is key for Khan. Khan (2010) contends that in the early stages of economic catch-up politically powerful groups are unlikely to be able to capture benefits through formal capitalist institutions of property rights and the rule of law, or indeed have the technological wherewithal to enable them to effectively exploit the new techno-economic paradigm. And even when they do, the capabilities needed to succeed in competitive markets are unlikely to be present from the get go. Therefore, informal institutions can play a role in ensuring benefits are aligned with holding power in a way that formal institutions could not. That is to say, if there is to be institutional stability the mismatch between the structure of power and the structure of formal emerging capitalist institutions needs to be met by informal institutions, and in particular patron-client networks. The economic and technological outcome of these resource flows are ambiguous and depend on how the process of economic development is articulated *vis-a-vie* the particular political economy context, but in all cases, resource flows mediated through both informal and formal institutions have an important role to play in maintaining political stability through the process of transition (Khan 2000; North et al 2009; Levy 2010). This argument is broadly in line with the evolutionary approach we adopted in Chapter 2, and illustrates how this is likely to play out in the context of a developing country.

Importantly for our purposes, the political settlement and the distribution of holding power is likely to be related closely to the possibility of promoting structural change in techno-economic systems. Conversely, inertia in the political economy settlement could in some important cases be associated with inertia in techno-economic systems. The extent to which technological change is either resisted or promoted by powerful groups will depend upon the perception of the implications of the technological change for those groups. Again, it is worth stressing that uncertainty and exogenous factors are likely to play important roles meaning that particular settlements maybe more or less stable over time.

The final component of Khan's account that is utilized in this analysis is the notion of rents. Here the term rent is used in a similar way to the notion of classical economic surplus. That is the income accruing to the owners of property after the direct costs of production have been paid for (Khan 2000a). The main types of rents and the institutional structures sustaining them are identified in Table 3.1. Khan (2000a) takes care to distinguish these rents from both classical economic surplus and in terms of neo-classical economic theory. As opposed to the Khan's (2000a) more ontological concerns, for our purposes a looser explanatory characterisation of these rents as economic surplus will suffice. The import thing to note is the institutional arrangements or structure of rights sustaining these rents and the source of the rent. Rents and rent-seeking are the main means by which holding power is articulated.

Table 3.1. Rents and the rights sustaining them

Type of rent or surplus	Structure of rights sustaining it
Classical economic surplus	Property rights of capitalists over capital equipment and of landlords over land
Monopoly rent	Indivisible rights over lumpy assets or legal right to be sole supplier in a market
Natural resource rent	Exclusive rights over natural resources
Rent based transfers	Transfers of rights through the political mechanism
Schumpeterian rents	Rights over intellectual property
Rents for learning	Transfers conditional on learning
Rents for monitoring	Rights over residual earnings

Source: Khan 2000a

In terms of technology policy, rents may be allocated (by the state) to firms to promote learning or innovation. This opens up the possibility for 'government failure'. This framework gives us a tool to understand where government is likely to fail and why. Policies to promote technological change are technically demanding and require constant monitoring. Rents will need to be put in place to incentivise technological learning and better economic performance, but will need to be removed over time as firms become more competitive, otherwise infant industries will face no incentive to grow up. However, the optimal rent pathway (if there is such a thing) cannot be known *ex ante*. Therefore, rents will need to be closely monitored and modified on a trial and error basis. This in turn requires the technical capacity to perform this task, and the political power to reduce rental allocations as performance improves, or where firms are not performing, to reallocate assets and rents. In short, this requires a set of political capabilities, which must be compatible with the broader political settlement (Khan & Blankenburg 2009):

"...managing rents for technology acquisition is not just constrained by state capacities, but also and often primarily by political constraints that prevent specific strategies of rent management from being implemented…[…]…rent-management strategies… can themselves vary significantly given different internal political configurations of power, and their relative success depends on the 'compatibility' of these institutions with these pre-existing distributions of power" (Khan & Blankenburg, 2009: 348-349)

Similar arguments are applicable to natural resources, and in particular fossil fuel exploitation (Khan 2000; Kolstad & Wiig 2009). Given the features of a political settlement discussed above, it becomes clearer to see how lock-in can emerge where large rents are available. In the case of fossil fuel exploitation, the returns from investment can be significant - as we have argued elsewhere this is a key characteristic of modern capitalism which is frequently overlooked. It is likely that most of the rents associated with these resources are dispersed throughout the productive and consumptive sectors (including not just extractive industries, but processing and transformation, distribution and with end users). This distribution of resource rents will be mediated by both formal and informal institutional relationships. These rents, in turn, create vested interests with the material and economic wherewithal and holding power to influence the development of formal institutional structures.

Effective policy for climate change mitigation in the energy sector is likely to be subject to just these types of political economy constraints. Just how constraints are articulated in any given context will depend upon the distribution of holding power, the distribution of material resources and the formal and informal institutions that mediate this relationship. This in turn will depend on the more concrete considerations of resource availability, the structure and relative power of energy sector firms and institutions on the supply-side, the political power of the demand side, and the evolving national political settlement within which this dynamic creation and recreation of the political economy takes place.

3.5 Conclusion: political economy and technology for 'green growth'

We started out this chapter with the observation that broadly neo-classical economic thinking continues to predominate in questions of climate change mitigation policy in the context of advanced industrial economies, but also and perhaps more explicitly in the policy prescriptions doled out to developing countries. The simple answer is get the prices right. At first glance this stands in some contrast to the substantively more nuanced explanations of technological change and economic development which now predominate in thinking on development.

On closer analysis of the theory, however, we find the repeated retrenchment of the neo-classical paradigm in the face of conflicting empirical evidence. Far from falsification, neo-classical theory has ironically extended its reach from prices, to institutions, to governance, to politics. And produced policy prescriptions to match. If it is not the prices, then it is getting the institutions right, if not the institutions then the governance, if not the governance then the politics. And what are the 'right' institutional, governance and political arrangements? Precisely those which will allow us to get the prices right, and this goes for environmental governance as much as it does economic governance.

Recent research performed under the auspices of the World Bank, focuses on, in order of merit, considerations of internalizing knowledge and environmental externalities (preferably through market based mechanisms such as the CDM), trade liberalization and FDI, addressing financial market failures, and developing absorptive capacity in recipient countries (Popp 2011b; Dutz & Sharma 2012). Even political economy and behavioral issues get a mention, although there remains a strong aversion to the *bête noir* of selective industrial policy (e.g. World Bank 2012). On closer analysis, the account of both behavior and political economy is very narrow. Political economy emerges as a consideration only due to government induced market distortions such as fuel subsidies, not as a more fundamental condition of the system. Behaviour is also characterized in terms of individual motivations, broader social structures are not considered.

As regards our concerns here, the treatment of the political economy of climate mitigation is inadequate if not wholly absent. Political economy considerations are likely to be critical for understanding the context for the implementation of mitigation strategies, from the perspective of institutional arrangements to foster environmental technology adoption and development, the implications for natural resource rents, and from the more general perspective of capital accumulation and redistribution.

The process of industrialisation or economic catch-up is a process of structural change that is unlikely to be distributionally neutral. This itself is likely to mean that changes may be destabilising and face political inertia. This may be overcome through the redistribution of political power managed through economic rents or other means, and the formal and informal institutions that mediate this process. Moreover, the creation of rents is likely to be central to the possibility of technological change in the shape of rents for learning. Both redistributional rents and rents for learning may coincide, but they may not. Whether they do or not depends upon the political economy context. It is not only that in the board sense that there will need to be some concordance between economic and political power. But at the micro-level the configuration of political power will need to be such that it can foster technological catch-up through the effective management of rents, and address the vested interests emerging from incumbent sectors.

When considering the possibility of environmental technological change, the implications for rents (whether they be technology rents, natural resource rents or something else), and the extent to which the scale and distribution of rents is likely to change will be important. Indeed, considering the scale of fossil fuel rents and the dramatic change in the distribution of rents a more sustainable techno-economic paradigm may imply, considerations of rents, their distribution and the political economy context, which determines this is likely to be central to the possibility of this type of change occurring. It maybe that in some contexts there is greater political space for environmental technologies than others, but as we suggested in Chapter 2, this needs to be shown it cannot be assumed.

We are now in a position to start to answer the first research question raised at the end of Chapter 1. Our question asked to what extent systematic environmental technological change was likely to be affected by the political economy, and what were the best ways of understanding this relationship. In response to this Chapters 2 and 3 (and supporting annexes) agrued that there are strong grounds for adopting an evolutionary approach to understanding processes of technological change and economic development. This seems to be the case for both an understanding of the micro-foundations for technological change (Chapter 2), and an understanding of the broader process of economic development (Chapter 3). We have also agrued that a direct implication of this is that we can expect political economy processes to be directly implicated in structurally significant technological change. Further, that the scope for structural technological change to take place will be dependant upon the political economy context. An analytical framework for elaborating this process (Figures 3.3 and 3.4) which stressed the interlinkages between the disposition of holding power, the techno-economic paradigm, economic performance, and distributional and institutional outcomes.

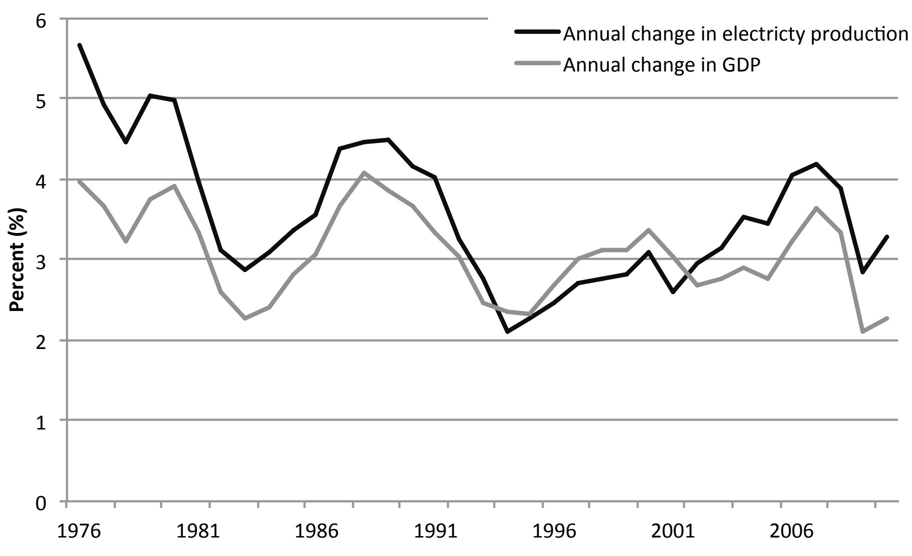
The development of this framework also represents a step towards answering the second, empirical research question, namely "*To what extent have political economy factors influenced the choice of technology in the electricity services industry of Vietnam?*" This question both serves to test the utility of the analytical framework we have developed and generate substantive understanding of a particular country context. Before testing the research questions through the development of the Vietnam case study (Chapters 6 and 7), we first need to understand how the techno-economic constraints fced by a particular technological system interacts with the political economy. The next chapter looks at how the political economy is likely to be elaborated in the context of the electricity sector though an examination of the technological, economic and political aspects of the sector.

Chapter 4: Political economy and technological change in the electricity supply industry

4.1 Introduction

It is difficult to over-emphasise the importance electricity has acquired in the modern world. Electrical light, power and heat have come to perform ubiquitous and critical roles in all modern economic and social systems. Electricity has been a key driving force in productivity growth and structural economic change since before the beginning of the twentieth century (Devine 1983; Freeman & Perez 2000; Steiner et al 2000; Stern 2011). And in terms of social welfare, electricity provision is associated with improved health and educational outcomes, as well as improvements in household productivity (Winkler et al 2011). The importance of reliable and affordable access to electricity supplies means that power sector development is regarded as an integral and essential part of the broader process of industrialization and economic catch-up (Williams & Dubash 2004; Victor & Heller 2007).

Figure 4.1. Annual change in global electricity production and real GDP (5 year moving average) 1972 - 2010

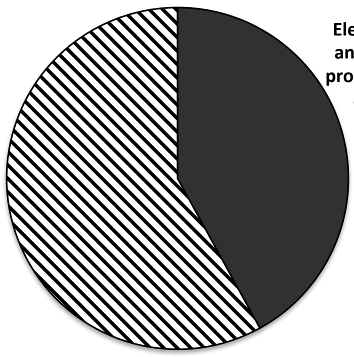


Source: IEA 2013, World Bank 2013

If anything, the relationship between economic performance and the use of electrical energy has been strengthening. Empirical studies have found a strong relationship between both increased electricity consumption and economic growth, and increases in the proportion of energy consumed as electricity and economic growth (Ferguson et al

2000; Yoo & Lee 2010; Payne 2010). These trends have been even clearer in countries undergoing the process of industrialization, where both historically and in the contemporary context, growth rates in electricity consumption have, with very few exceptions, seen growth in electricity consumption outstrip economic growth considerably (Figure 4.1) (Victor & Heller 2007; Hausman et al 2008).[58]

Figure 4.2. Global carbon dioxide emissions by source 2009



Source: (IEA 2012a)

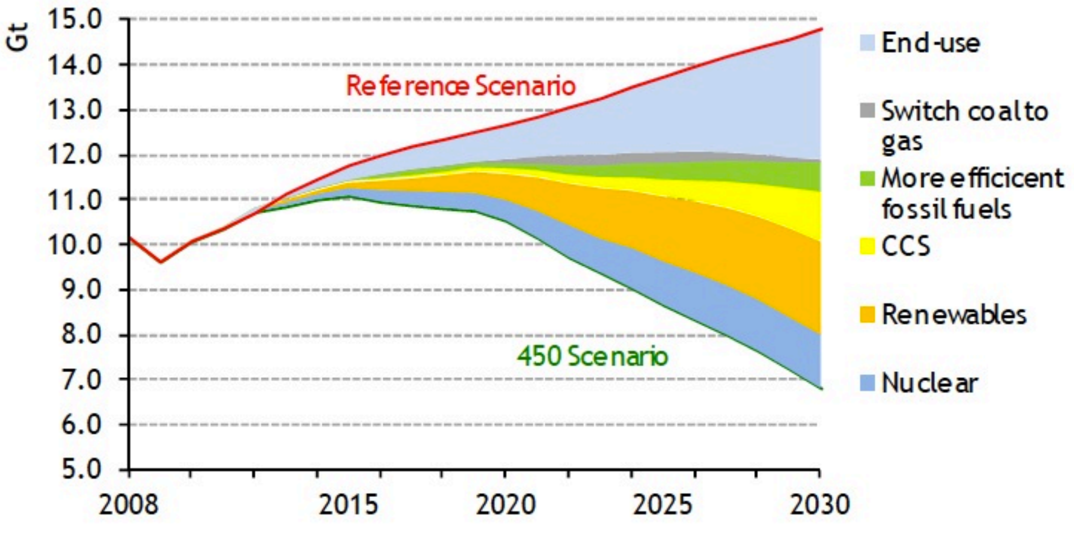
Electricity, however, is also the largest and fastest growing source of carbon dioxide emissions (IEA 2012a). The imperative of climate change implies the need to achieve significant emissions reductions through technological change in the global electricity supply industry (ESI) (Metz et al 2007; Ferrey 2009; IEA 2010; IPCC 2011). If we are to be able to achieve emissions reductions sufficient to avoid the risk of dangerous climate change, nothing short of a shift in the prevailing technological paradigm in the power sector will be needed.

Changes to supply side practices and technologies could include switching to fossil fuels with lower carbon intensity (e.g. from coal to natural gas), the roll-out of carbon capture and storage (CCS), and similar end-of-pipe (EOP) carbon sequestration technologies, expanded use of renewables and possibly nuclear generation, and improved operating

[58] A crude indication of these trends, global growth in electricity consumption has consistently outstripped growth in GDP, at a rate of 5.1% between 1960 and 2010, compared with real GDP growth of around 3.5% (IEA 2012, World Bank 2012). In more recent years, global electricity production has increased about 82% from around 11,800 TWh in 1990 to over 21,500 TWh in 2010, and despite the global financial crisis, over the last decade production growth has once again accelerated to around 3.5% between 2000 and 2010 (IEA 2012). Much of this resurgent growth has been driven by rapid capacity expansion in emerging economies. The glaring exception to this being India, which during its high-growth period between 1994 and 2006, saw average annual real GDP growth of 6.7% compared to electricity consumption growth of around 5.0%. This is in part explained by India's large service sector which has been a more important driver of growth than in many other countries, and in part, by India's notoriously dysfunctional power sector which has extreme difficulties in meeting demands placed upon it (Victor & Heller 2007; Szirmai 2011; IEA 2012)

efficiency in generation, transmission and distribution. Greater emphasis on demand side management measures (DSM), and in particular on energy efficiency amongst end-users are also likely to play an important role (Figure 4.3).[59] Changes in the nature of generation technologies, the mix of generation technologies, and the need for demand reduction measures may, in turn, imply concomitant change in the technological and institutional organization of electricity systems, such as greater levels of distributed generation and the development of so-called 'smart-grids'. Meeting these challenges also implies the need for significant investment in RD&D in energy technologies (Metz et al 2007; IEA 2010; Schleicher-Tappeser 2012). As yet the implications of these changes for the future development of the sector remain unclear (Künneke 2008; Kessides 2012b). But the scale of the requisite changes should not be under-estimated (Unruh 2000; Sioshansi 2009; Smil 2009; Solomon & Krishna 2011; Tainter 2011; Fouquet & Pearson 2012). Nor should, if our previous analysis is correct, the scale of the barriers that are likely to stand in the way of such a transition.

Figure 4.3. Energy related CO_2 abatement from the electricity sector of major economies



Source: IEA 2010

The arguments in the previous chapters sought to establish a *prima facie* case for incorporating political economy considerations in the analysis of technological change. In the case of developing countries and technologies that allow the production of large

[59] Renewables by convention includes wind, solar, wave and tidal energy, geothermal, biomass and waste to energy as well as small hydropower. Large scale hydropower is excluded, usually defined at plants exceeding 30MW in installed capacity are excluded.

economic rents, distributional outcomes and therefore political economy considerations are likely to be significant. In this chapter we argue that based upon a critical review of the history of the sector and in the case of the technological changes needed to promote low carbon development in the ESI, there is similarly a strong case to expect political economy considerations to be important.

That the political economy is, in some sense, 'important' for outcomes in the power sector, is uncontroversial and commonplace (e.g. Williams & Dubash 2004; Besant-Jones 2006; Victor & Heller 2007). The treatment of the political economy, and *how* it emerges as important, however, differs considerably between writers. Advocates of power system liberalisation and market-based reform, in common with the proponents of the neo-liberal view of governance, have tended to treat political economy considerations as potential sources of interference in otherwise rational techno-economic decision-making processes, and as an exogenous barrier to otherwise desirable reforms (Bacon & Besant-Jones 2001; Besant-Jones 2006; Jamasb 2006). Similarly, as noted in Chapter 2, and in contrast to the more historical bent of the long-term energy transition studies, much of the recent writing on technological change in the sector seeks to abstract from the political economy context, placing a stress on individual behaviour, non-cost barriers or market failures (Lewis 2007; Sovacool 2009; Smits & Bush 2010; Solomon & Krishna 2011; Wüstenhagen & Menichetti 2012; Negro et al 2012; Schleicher-Tappeser 2012; Sovacool 2012).[60] This literature tends to downplay the importance of real material costs associated with low carbon technological change, which in turn means that the implications for the change in the distribution of material wealth, and thus political economy considerations are not taken seriously enough.

By contrast, historical treatments of ESI development and reform have tended to focus upon the interaction between technological, economic, institutional and political economy aspects of the sector (Hughes 1983; Hirsh 1999; Hirsh 2003; Williams & Dubash 2004; Williams & Ghanadan 2006; Hirsh 2007; Victor & Heller 2007; Hausman et al 2008; Clifton et al 2011; Hausman & Neufeld 2011; Millward 2011a; Millward 2011b). In these accounts, political economy processes emerge, not as some adjunct to

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[60] One common approach is not to mention increased costs at all. For example, a recent paper by Schleisher-Tappeser (2012) much is made of immanent grid parity of solar PV with other sources of electricity in Germany. It forgets to mention that cost parity is only achieve thanks to a subsidy to solar PV. Another approach is to calculate costs including externalities or insist that costs are otherwise lower than fossil fuels (Sovacool 2008). Unfortunately, these are profoundly optimistic estimations of cost. Such advocacy is misplaced in the academic literature, and may have unforeseen negative consequences for the roll out of renewables, for example see Mints (2012).

the functioning of a techno-economic system, but as an intrinsic part of the system. Drawing on this work, and in a similar vein to Moe (2010), Mokyr (1997, 2006) and Lipsey (2009), it is our contention that in common with the energy sector more generally, a more systematic understanding of the importance of political economy dynamics will be central to identifying the potential for technological change in the ESI, and that an approach based upon Khan's (2000a) notion of rents can serve to elaborate this process.

The task in this chapter is broadly three-fold; to investigate the key factors driving change and development (technological, economic and institutional) in the power sector; to understand how political economy dynamics have entered into and influenced these changes; and, to elaborate what implications political economy considerations may have for technological change in the ESI.

To achieve these objectives we first draw on the history of the ESI. In a discussion of the early development of the sector we investigate the motive forces behind the emergence of the relatively stable techno-economic paradigm in the ESI during the 1930s, around a dominant system design of large scale centralized electricity grids. We move on to look at the development of institutional arrangements in the ESI (namely vertically integrated monopolistic state owned or controlled regional grids) and how these arrangements emerged through interactions between the incumbent techno-economic paradigm and the broader social, political and economic context. Lastly, we move to more recent developments and look at the post 1980 period of ESI liberalization. Appealing to this evidence we go on to develop an analysis of political economy dynamics within the ESI and characterize them as a fundamental response to the presence of significant economic rents (or opportunities to generate rent-like transfers). Finally, we examine what the presence of these rents (appropriable though the exercise of political power) is likely to mean for different technologies and develop a taxonomy of rents associated with the sector.

In what follows, section 4.2 starts with a discussion of the history of the ESI. Section 4.3, looks at the emerging pressures facing the sector, while section 4.4 draws on this analysis by elaborating rents likely to be associated with different technological options, and section 4.5 concludes.

4.2 Understanding the dynamics of power sector development[61]

The ESI is *sui generis*, the nature of its technology and the resulting economic, institutional and political dynamics that characterize the sector and condition its development differ substantially from other industrial sectors, and as well as other superficially similar network, utility and energy sectors (Grubb et al 2008; Hausman & Neufeld 2011). In the case of the power sector, its particular technological characteristics mean that the dynamic increasing returns resulting from economies of scale and scope are particularly strong. This has, in turn, had significant implications for the development and structure of the sector.

The objective of this section is to draw out the broad technical, economic, institutional and political factors that have shaped power sector development. Roughly following Hausman et al (2008), we breakdown the historical development of the sector into three overlapping periods, i) the period of emergence and rapid technological development from the early 1880s to the 1930s, by which time a relatively stable dominant system design had been established; ii) the long period from the 1920s until the 1980s characterized by continuing expansion of the sector, incremental technological change within the dominant system design and increasing public ownership and/or control of the sector; and, iii) from the 1970s to the present, characterized by important changes in technological dynamics, sector liberalization, and the large scale re-entry of private and foreign capital into the sector. In this discussion we do not seek to give a detailed account of ESI development, rather our emphasis is on teasing out interactions between technological change in the ESI and the political economy of the sector.

4.2.1 Electrical utilities and the emergence of a techno-economic paradigm

In understanding the emergence of a dominant system design in the ESI, Hughes (1983) offers a useful three-stage chronology of the development, i) development of the small utility; ii) development of a universal system and diversification of load; and, iii) diversification of supply. Each stage is associated with particular technological and economic advantages over the preceding arrangements. The transition between these

[61] The reader should note that this section on the early development of the power sector draws on relatively few available academic sources. Despite the importance of the sector, as Morton (2002) and Hughes (1987) have both noted, the academic work on the sector remains relatively sparse, and in most cases concentrates on the development of the power sector in North America and Europe. Nevertheless, in terms of development of the power system this was to serve as a blueprint for development elsewhere. As a consequence this section draws heavily on the comprehensive historical works of Hausman et al (2008) and Hughes (1983) supplementing these sources with other authors where possible.

stages overlapped and was not always smooth (see section 4.2.2), the advantages of these developments proved influential and resulted in the gradual emergence of ESI utilities and regional or national electricity grids that now dominate the ESI (Hughes 1983b; Hausman et al 2008; Hausman & Neufeld 2011). By and large, these advantages also represent fundamental technical and economic characteristics of power generation and supply which have continued to influence the shape of electricity provision to the present day (Morton 2002).

Electricity has been used for commercial purposes since the beginning of the nineteenth century. In its earliest commercial applications electricity was supplied from isolated sources, initially chemical batteries and later in the nineteenth century, with the development of electro-mechanical generation technologies, steam powered generators rapidly became the dominant form of electricity supply. Electricity supply was typically owned and operated by consumers in the form of isolated generation plants built on site to meet on site consumption needs, usually for lighting or industrial purposes (Hughes 1983; Hausman et al 2008).

Initially, the largest potential market for electricity was deemed to be for lighting. In the late nineteenth century, this market was largely served by gas companies operated on a utility basis, owning both supply infrastructure and distribution networks through which they supplied gas lighting to customers. Electricity entrepreneurs, most famously Thomas Edison, saw an opportunity for electrical lighting utilities to compete with gas using a similar model (Hughes 1983).[62] But it was not until the 1870s, with the invention of the incandescent light bulb, that the prospect of a competitive electricity supply utility became technically feasible.[63][64] The first electricity utility with centralized generation, distributing electricity over a geographically dispersed area to household and business customers started operations in 1882 in New York (Hughes 1983; Hausman et al 2008).

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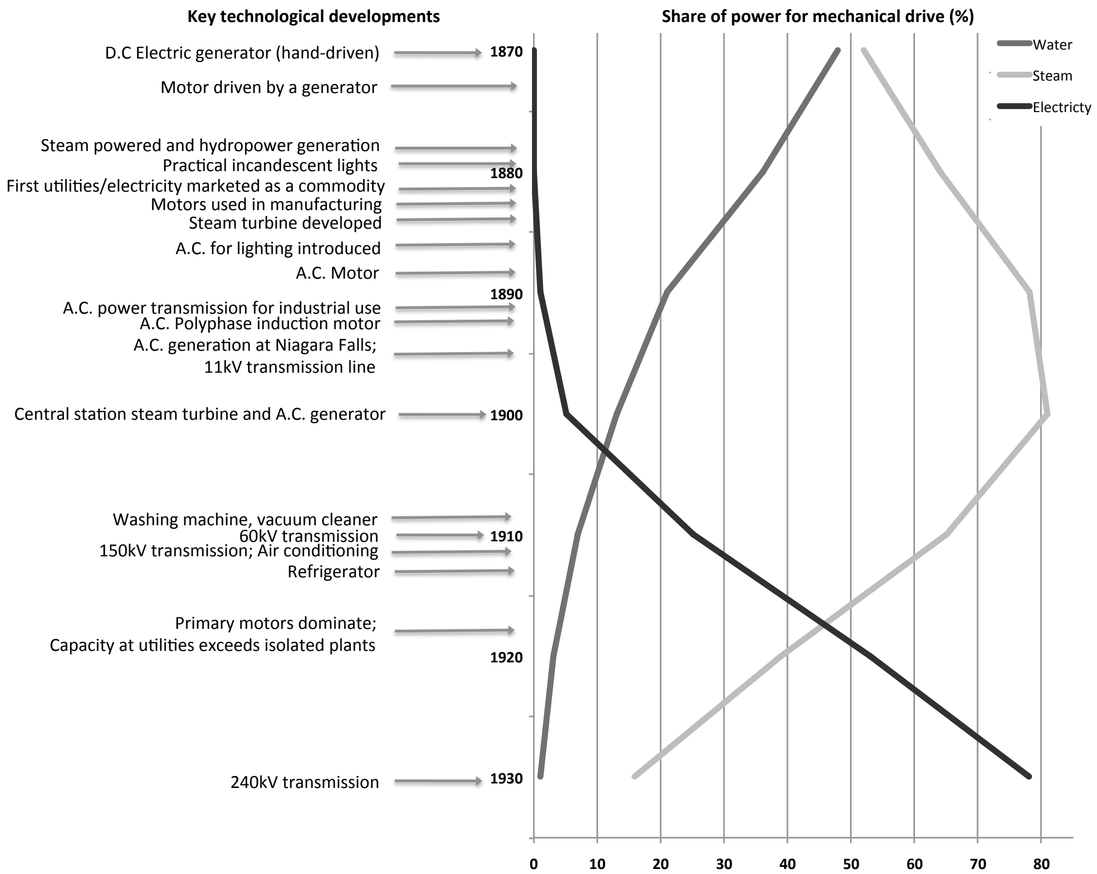
[62] Gas for street and domestic lighting provided from centralized plants through a distribution network to customers over a geographical area were the first example of utilities, and presented the largest competitor to electricity utilities (Hausman et al 2008, Hughes 1983). Neufeld (1987) comments, "Electric power companies historically faced stiff competition from substitutes for centrally generated electricity. For example, the market for artificial lighting was originally served by gas companies, and Edision's initial pricing policies were based non on his production costs but on the cost to his potential customers of gas lighting." (693)

[63] In contrast to the previously available arc lighting, incandescent bulbs could be connected in parallel to a high-voltage network allowing both individual customer control of the lighting and the provision of a level of light that was suitable for domestic use.

[64] Themselves a consequence of the development of more effective technologies for creating vacuums.

Figure 4.4. Key technological developments and the expansion of electrical power use in US industry 1870 – 1930



Source: Devine 1983, Hughes 1983, Hausman et al 2008

In the years after development of the first utilities, a series of inventions made electricity cheaper, more reliable and easier to distribute at scale (Figure 4.4). At the same time, innovations in end-use technology meant that wider-use of electricity could be made by consumers in manufacturing industry, the commercial sector and amongst households (Devine 1983; Hughes 1983a; Hausman et al 2008). Exmaples include, the development of the steam turbine greatly increased the overall efficiency and efficient scale of electricity production over reciprocating generators. Improved transmission and distribution technologies allowed larger grids to be developed and allowed access to more distant generation sources, such as hydropower and coal-fired thermal plants at mine-mouths. The development of relatively cheap, reliable electric motors to drive machinery offered unprecedented flexibility to manufacturers, which were able to capture significant productivity gains as a result. Household devices such as washing machines, refrigerators and air conditioners also added to the increasing demand for electrical power (Devine 1983; Hughes 1983).

These technological changes enabled the rapid expansion of the power sector globally, in cities, industrial and suburban areas and in more isolated locations such as plantations and mines, gradually towns and rural users were incorporated into networks. The geographical spread of electrical energy use was rapid, and by the turn of the century, in urban areas it was already becoming ubiquitous. Hausman et al (2008) comment on the dynamics of these developments:

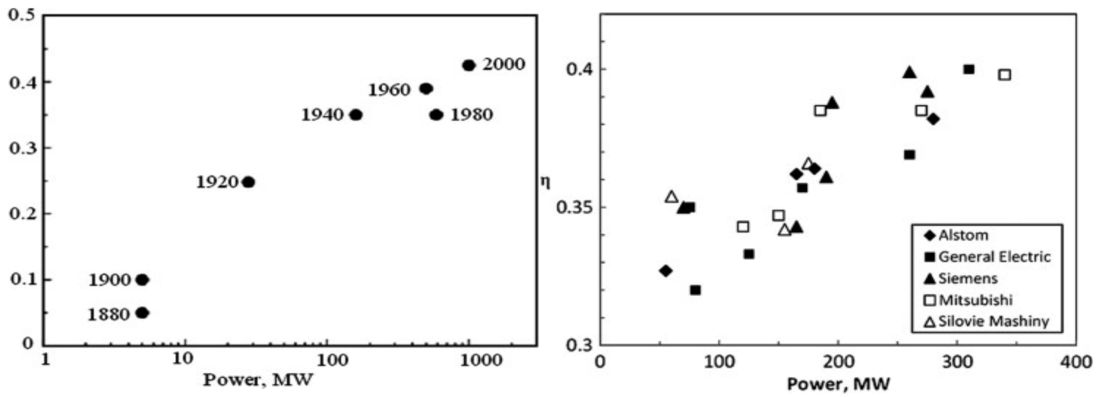
"While the story in each country had unique aspects, the process of electrification followed certain patterns. Globally, urban areas became electrified before rural ones. There was a strong preexisting demand for light, power, and transportation. Over time, new devices to connect to the system were invented or adapted, including products such as electric irons, fans, heaters, ranges, vacuum cleaners, shavers, toasters, hot plates, and refrigerators. Every city and town in the world wanted electricity service. By the turn of the century, or shortly thereafter, with the exception of the least developed areas of the world, nearly every city and most of the larger towns had electricity service of some type…" (Hausman et al 2008: 18)

Small electrical utilities spread quickly aided by technological change, which rapidly enhanced their viability. However, up until 1917 in the USA and considerably later in Great Britain, most electricity generation capacity was still installed in the form of isolated generation units at industrial plants (Devine 1983; Hughes 1983; Hausman et al 2008). Initially, isolated plants had key cost advantages over utilities. They did not need to develop an expensive distribution network over an extended geographical area to supply customers as power was consumed in situ, nor did they have the administrative or billing costs of utilities, and if steam were produced as part of the industrial process or for heating, electricity could be generated as a by product (Neufeld 1987). Nevertheless, the utility model enjoyed a number of important technological advantages that lead to increasing economic returns to scope and scale, and resulted in the eventual emergence of the utility as a core element in the design of electricity systems.

The first advantage that utilities enjoyed over isolated generation plants was their ability to separate decisions about the citing of generation plants from considerations of customer location. The first utilities had rather small distribution networks, and were constrained by available transmission technologies. But with the development of technologies that allowed the relatively long-distance transmission of electricity at higher voltages (Figure 4.4), these advantages came to the fore.[65][66] This allowed generation plants to be cited away from city centres in locations with cheaper real estate. In later years, it also allowed greater flexibility in the citing of factories, which had previously sought geographical locations with easy access to energy resources such as coal or hydropower (Devine 1983; David & Bunn 1988; Hirsh & Sovacool 2006; Hausman & Neufeld 2011).

Generation technologies available at the time also enjoyed considerable economies of scale. In the case of thermal and hydropower generation technologies, larger generation units tended to have more efficient operational attributes. This allowed utilities, which supplied larger loads to realize returns to scale that were not available in smaller, isolated generation units (Chao et al 2007; Hausman & Neufeld 2011; Severnini 2012). As with transmission technologies, technological innovations in the sector gradually increased the efficient scale of power generation equipment, further reinforcing the advantage of ever-larger utilities (Kunneke 1999; Bejan et al 2011)(Figure 4.5).

Figure 4.5. Thermal efficiency and power plant size over time (left) and for gas turbines (right)



Source: (Bejan et al 2011)

Note: Thermal efficiency (η) differs from considerations of the optimal plant size in respect of cost per unit of installed capacity. The latter cost curves for units of installed capacity measure only capital investment costs, not variable costs. Nevertheless, between 1880 and 1980 (left) the large increases in thermal efficiency seem to have been closely related to increases in the economically efficient scale of

[65] The resistance of an electrical conductor is a function of the current and the inverse of the cross-sectional area of the conductor. To transmit power over long distances without requiring prohibitively expensive transmission cables with a large cross-section area, electrical power needed to be transmitted at high voltages and low currents. This effectively precluded long distance transmission and constrained the geographical areas utilities could serve. Development of transformer technology to allow voltages to be stepped-up for transmission, and stepped-down to be safe for domestic consumption made larger scale transmission and distribution systems, and utilities economically viable (Hughes 1983a; David & Bunn 1988).

[66] In the so-called 'battle of the currents' between competing systems based upon alternating or direct current, both of which could be produced by available generation technologies, in the end rested upon relative cost advantages and a more simple technology from transforming AC compared to DC (Hughes 1983, David & Bunn 1988, Hausman et al 2008).

power plants.

Third, electricity is not easily storable and requires that demand and supply be matched in real time to ensure the stability and reliability of the network. As a consequence, the generation capacity[67] requirements of a power system are not determined by average, but peak level demand (similar considerations apply to other network industries such as ICT and transport) (Kunneke 1999; Grubb et al 2008).[68] For a plant that supplies a diversified consumer base, whose individual peak demands differ over time, there is significant opportunity to achieve higher utilization rates of generation capacity and, as a result, much better returns on generation investment (Neufeld 1987; Chao et al 2007; Hausman et al 2008; Hausman & Neufeld 2011).[69] What is more, larger networks with a diversified consumption base tended to require lower reserve margins and enjoy higher load factors, and hence were able to earn a better return from their assets.[70] While these returns to scope were not unlimited, in the early stages of system expansion they proved to be significant. Expansion in demand was also being promoted through innovation in end-use technologies for household, industrial and public use. The expansion in scope and variety of demand allowed dramatic improvements in load factors and consequently returns to investment for larger utilities (Hughes 1983, 1987).

Fourth, a larger supply and distribution network allows a greater number of generation units in the network. Given that generation equipment periodically requires maintenance and may sometimes breakdown, to ensure supply at these times back-up generation capacity needs to be available. Spreading this back-up capacity over a larger network effectively lowers the proportion of capital costs that need to be invested and increases the average load factor for generation assets (Hausman et al 2008).[71]

[67] Peak loads will also be determinate of the size of transmission and distribution equipment. However, the actual capacity needs for T&D will depend on the portion of the load flowing through that section of the grid which depends upon the particular way in which the grid is configured.

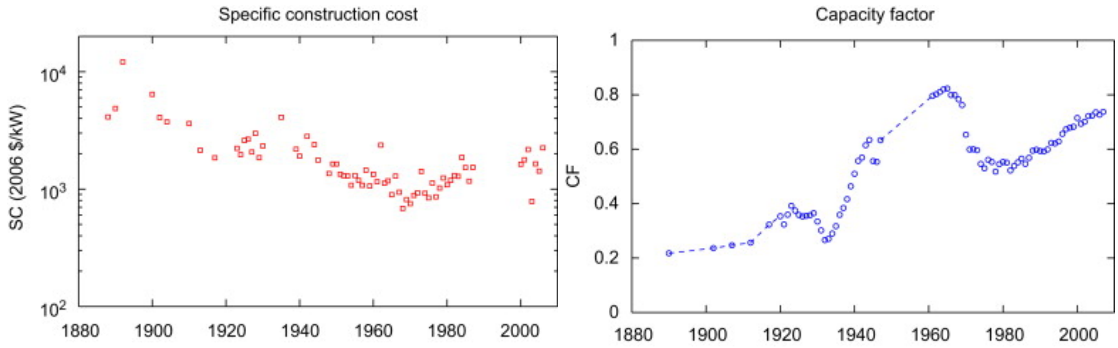
[68] For example, intuitively, for an isolated plant serving a factory, demand may be intermittent, demanding a peak capacity of 20 MW for 5 hours a day (in other words demanding 100MWh of electricity), potentially the plant operating at full capacity could produce 480MWh per day, so the plant would be running at approximately only 21% of its capacity.

[69] The rate of utilization of generation equipment is known as the load or capacity factor. This is measured in terms of the proportion of which its rated capacity is used over a given period of time.

[70] The reserve margin is usually defined as the total available capacity divided by peak capacity demand, load factors reflect the proportion of the time overall capacity is used. For example, a load factor of 80% means that 80% of generation capacity is fully used.

[71] Intuitively an isolated plant would require 100% back up capacity in case of breakdown or when regular maintenance is required, a network with two plants, if each were likely to be out of action 10% of the time, would require a back up of only 50%, for 4 equivalently sized plants 25% and so on – up to the point where we may expect 100% of the back-up plant's capacity to be used.

Figure 4.6. Construction cost declines, capacity (load) factor increases for coal generation in the US 1882 - 2006



Source: (McNerney et al 2011)

Note: the Capacity or load factor measures do not only reflect the relative operating efficiencies of technologies, they also reflect capacity needs relative to demand. Declines in the capacity factors in the figure can therefore be explained in part, in the 1930s by the Great Depression, and in the 1970s by the Oil Crisis and resultant economic problems.

Fifth, differing generation technologies have different cost attributes that lead to significant economic benefits when operated together in the same network. Some generation technologies have high up-front costs but relatively low operating costs, whereas other technologies have lower capital requirements but large operating costs. For example, in the early stages of ESI development improvements to generation technologies meant that for a large expanding network with more efficient generation capacity being constructed, capacity of an older vintage could be used in times of peak demand only, again offering opportunities not available to isolated plants or smaller networks. The relationship between the efficiency of generation and the load may differ for plants of different scales. Large generation networks employing a variety of different types of generation asset can run those with low operating costs continually to provide a base-load supply, and generation assets that are more costly to run to provide power at time of peak demand (Murray 2009). In the early years of power sector development, the possibility of incorporating hydropower offered just such advantages (Hughes 1983; Hausman et al 2008).

In addition, there are also a number of advantages that larger systems can enjoy through the incorporation of hydropower resources.[72] Due to the relative efficiency of hydraulic

[72] The first hydropower station was developed in the 1870s and the first documented use of hydropower for electricity supply was in 1878 by Sir William Armstrong, which used a small hydropower plant to generate electricity to power arc lighting in his Northumberland home. Other early examples of hydropower stations in the US were at Grand Rapids in

turbines and the availability of cost-free energy, hydropower is generally cheap relative to thermal power (WCD 2001; Kumar et al 2011; Severnini 2012).[73] Hydropower was also generally more reliable than thermal plants in the early days of the ESI when emerging thermal plant technologies were prone to breakdown. These cost advantages meant that in the early years of ESI development wherever there were adequate water resources and a demand for electricity, hydropower plants proliferated (Electricity Today 2006).

Most, but by no means all, the early hydropower plants were small by modern standards with small storage reservoirs relative to their capacity, meaning they were particularly vulnerable to seasonal variations in water availability. This seasonal intermittency in hydropower availability meant it was much more valuable when part of a diversified portfolio of generation assets including coal fired generation which was available year round. Coordination of several hydropower plants operated as a cascade (i.e. a series of hydropower plants on the same river system where the discharge of one plant becomes the inflow to another) could also be optimized to maximize the value of electricity output. The ability of larger utility networks to integrate and effectively utilize relatively low cost hydropower therefore also represented a significant advantage (Hausman & Neufeld 2011).[74]

Hydropower offers a number of additional ancillary benefits that can improve system stability when operated as part of a varied generation portfolio (Kumar et al 2011). With the exception of run-of river plants, most hydropower plants have the capacity to store water in an impoundment area behind a dam.[75] Notwithstanding seasonal variability, this means hydropower plants can effectively store power and to be used at peak times. What is more, from a purely technical perspective, hydropower is particularly well suited to this role as is can be brought on-line and off-line relatively quickly, plants can vary their

Michigan which was used to power arc lights for store fronts and a theatre in 1880 and at Niagara Falls which was used to power machinery at a flour mill as well as street lighting in 1881, and later as part of a long distance AC transmission line to supply load in Buffalo.

73 Severnini (2012) also claims that hydro's cost advantage was maintained in the US until around 1950, when improvements in transmission technology and the thermal efficiency of coal fired plants lead meant it lost its advantage. It should be added, that each hydropower plant differs, it is also likely that the best, most accessible, cheapest hydropower sites had been used up by the 1950s.

74 The importance of long distance transmission technology for enabling the effective utilization of hydropower (which is frequently in remote locations away from load centres) is illustrated by the observation that in 1914 of the 25 highest voltage transmission lines outside the US 23 were servicing hydropower plants (Hausman et al 2008). It seems the potential benefits of hydropower were both an important factor in influencing the development of long distance transmission technology and also had influence on the development of regional grid systems.

75 The size of the reservoir impoundment and 'live storage' capacity varies considerably with the design of the dam. Run-of river hydropower plants typically have no impoundment, or very little live storage, whereas very large dams can have a storage capacity which represents a large proportion of annual in-flows.

production in real time in response to variations in load, and work efficiently at different generation loads (Kumar et al 2011). This contrasts with coal generation technologies, which require time to be brought into operation, and cannot be turned on and off quickly to meet changing demand. This necessitates the operation of 'spinning reserves' to maintain system stability. This in turn implies a significant cost as plants are effectively running but producing no power (Murray 2009). Hydropower's flexibility in managing variable system loads and maintaining the quality of power supplies is extremely valuable in maintaining overall system reliability (Altinbilek et al 2007; Kumar et al 2011).[76] This was particularly the case in the early years of power sector development when other technologies more flexible than coal (i.e. such as fuel oil, diesel and gas turbine generation technologies) were not available at scale.

It is worth noting that due to the cost advantages enjoyed by hydropower, in countries where significant hydropower potential is available it has frequently been a key technology in the early development of the sector. For example, in the USA, over 40% of electricity produced was from hydropower by the early 1900s, a figure which had dropped to about a third by 1940, but in areas such as the North and Northwest of the country where hydropower resources were abundant approximately 75% of power was generated by hydropower (Bureau of Reclamation 2008; IEA 2011). The dominant role of hydropower has tended to change once the best hydropower resources become fully utilized and power systems come to rely on what are generally initially more expensive thermal generation technologies (Electricity Today 2006). This remains the case today and can be seen clearly in the gradual decline of the share of electricity produced by hydropower overtime, as well as the greater reliance on hydropower in developed countries with smaller less developed ESIs (Figure 4.7).

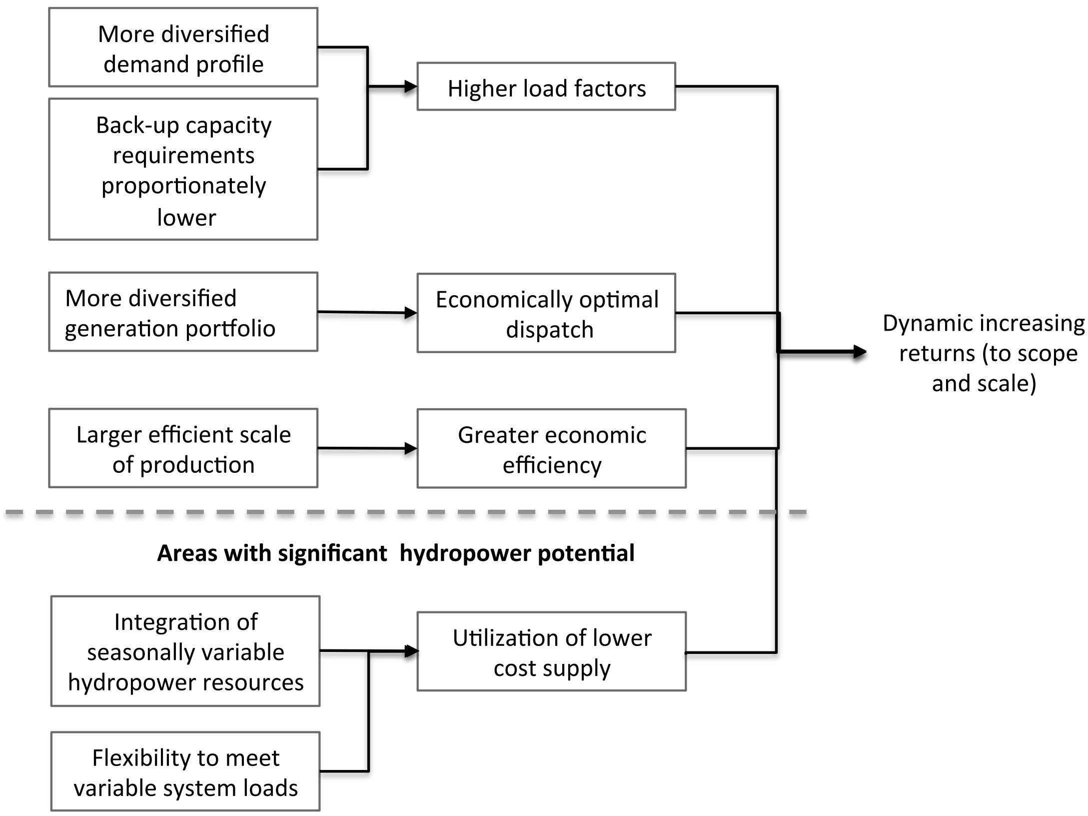
These advantages combined firstly to favor utilities over isolated plants; secondly to favor systems with a more diversified and larger demand (pointing to the co-evolution of demand and supply side technologies); and, thirdly, to favor systems with a more diversified supply. These all represented returns to scale resulting from the emerging techno-economic characteristics of the ESI. These are summarized in Figure 4.8.

[76] Conversely hydro-heavy electricity systems are vulnerable to hydrological risks, such as droughts.

Figure 4.7. Share of electricity production from hydroelectric sources by country income group 1960 – 2010

Source: IEA 2013

Figure 4.8: Systematic techno-economic advantages of electrical utilities and their increasing scale in the early stages of power sector development



Source: Author

The strength of increasing returns to the scope and scale of networks meant that systems relatively rapidly converged towards what can be considered a dominant system design (Chapter 2, section 2.2.3), which has since seen little fundamental change.[77] Until relatively recently, significant technological changes in the ESI that have taken place since the 1930s such as ever-larger coal-fired thermal and hydropower plants, higher-capacity long-distance transmission technology, improvements in the management of scheduling, dispatch and capacity expansion in large networks, and, in the 1950s, the development of commercial nuclear power, have been technological changes along the same technological trajectory and have continued to enhance these returns to scale and as a consequence lock-in a dominant system design in the ESI.

Despite the dominance of techno-economic factors in determining the emergence of this technological paradigm, as pointed out in Chapter 2, we should be cautious about arriving at to overly reductive conclusions relating to the emergence of the paradigm. Learning effects leading to improved technologies and falling costs also played a role in the expansion of the system (Grubler 2004; Wilson 2012). As the historical scholarship indicates evolving behavioral routines, in terms of emerging socio-cultural influences added to the momentum of the developing techno-economic paradigm. This is illustrated by the focus of R&D efforts, as well as the broader engineering approaches to the ESI.

As suggested by Dosi (1982) and Unruh (2000), this pattern of technological development has likely been influenced by feedbacks between the technological trajectory set in motion by these economies of scale and the process of defining the research agenda.[78] Hughes (1983) comments on the emergence of the technological form of the large-scale regional utility towards the end of this period of intense innovation and technological change:

"In the 1920s, however, engineers, managers and financiers realized that a technical form – the regional system – had fulfilled inherent implications and could be considered conceptually mature. This realization was manifested in engineers' and managers' conceptualization of underlying technical and economic relationships; their deft identification of critical problems and efficacious solutions; and their introduction of institutional forms that were suited to expansion; and their development of organized knowledge

[77] Although as Kunneke (2008) notes we may now be on the verge of a significant change in these arrangements, discussed below.

[78] Using Freeman and Perez's (2000) taxonomy and from the point of view of incumbent fossil fuel and hydro based generation technologies, the development of nuclear technology may be regarded as a 'radical technological change', but from the point of view of the power system in general it represents only a incremental innovation. See the discussion of individual technologies below.

(science of technology) about regional power systems." (Hughes 1983: 363)

Evidence suggests that other influences such as national security and fuel availability also influenced R&D choices and consequent technological trajectories (e.g. on nuclear technology see Cowan 1990; and on energy efficiency see Reddy 1991). These efforts did not seek to fundamentally change the techno-economic paradigm, but essentially concentrated on solutions within it. The technological trajectory and associated R&D activity that took place within the power sector, is best understood using Dosi's (1982) characterization as 'normal incremental problem solving' within a technological regime, a process from which non-disruptive technologies tend to emerge. As such, these technological changes have acted to further consolidate the dominant design and, in most cases, its organizational attributes.[79]

A further consideration is the co-development of a particular engineering ideology also associated with the system design. Hughes (1976, 1983, 1987), Morton (2002), and Hausman et al (2008) note that the emergence of an engineering 'ideal' acted to further entrench the focus on achieving scale economies:

"…owing in part to the economies of scale made possible by building large power plants and transmitting the resulting electricity over increasingly longer distances. Soon municipalities were linked into single systems, then regions and states…[…]…the engineers who were making it possible were *simultaneously establishing a technological ideal of great importance* - the goal of a single, unified system covering a huge region, an entire nation, or perhaps someday a whole continent (or, indeed, the entire world). The obsession with increasing scale dominated both the engineering effort and the publics' debate over its results for the next half century."[emphasis added] (Morton 2002: 60)

These examples serve to illustrate the role non-technological, non-economic factors likely played in adding to the momentum of the dominant system design, and the global diffusion of the ESI. Indeed, engineering visions of large-scale electricity grids may occasionally have outpaced the technological capacity to realize them, as seems to have been the case with the Heinemann-Oliven project announced at the Second World Power Conference in 1930. This proposed a regional high voltage grid in Europe, stretching from Oslo in the north to Rome in the south, and from Lisbon in the west, through Bucharest to Rostov in the east (Hausman et al 2008).

[79] While nuclear power from an energy technology perspective could be classed as a radical technology, from the perspective of the ESI it did not affect the dominant design of the sector see Markard & Truffer (2006)

This techno-economic paradigm was not confined to the relatively developed parts of the world, but was quickly spread globally through the transfer of technologies and engineering know-how. Western engineering institutions trained cadres of engineers from all over the world, leading to the rapid global propagation of these ideas (Hughes 1983; Coopersmith 1993). The dominant system design has been (and in many cases continues to be) influential in the development of the power sector throughout the world, with significant influence on the development of the sector in the former USSR, Latin America, Asia and parts of Africa (Singer 1988; Coopersmith 1993; Williams, & Dubash 2004; Yeh & Lewis 2004; Williams & Ghanadan 2006; Victor & Heller 2007; Tafunell 2011). While economic growth and the associated expansion of the ESI was slower to get going in these regions, the technological objective and the techno-economic rationale guiding the development of the sector has been essentially the same.

4.2.2 Co-evolution of institutions: ownership and control of power systems

At the same time as the gradual emergence of the dominant system design, the institutional arrangements of the ESI were evolving. The institutional corollary to the technological ideal of the centralized regional grid was that of a state owned, or at least very tightly regulated, vertically integrated monopoly. This was based upon considerations relating to the likely depredations of monopolistic electricity suppliers, issues relating to raising finance for the sector and the role of ESI in the provision of public goods. These all represented considerations stemming from the basic technological and economic characteristics of the sector. The rational response to these issues was deemed to be one of state activism through direct ownership and tight regulation of the ESI (e.g. see Jaccard 1995). A review of the historical development of these institutional arrangements, however, shows them not to be a product of rational design, but the outcome of complex historical processes in which political economy considerations played an important role.

In the early years of ESI development in the USA and Europe, power utilities tended to be privately owned and operated by relatively small companies operating in discrete command areas, usually centered on an urban municipality or location of industrial activity (e.g. a plantation, mine or close to a hydropower source). In much of the early global expansion of the power sector through late nineteenth century and the early decades of the twentieth century, this pattern was repeated, private companies and their financial backers were the prime movers, electricity systems were often fragmented, with separate utility networks of limited scope based close to large load centres (e.g. see Yeh & Lewis 2004; Victor & Heller 2007; Clifton et al 2011; Hausman & Neufeld 2011; Millward 2011a; Tafunell 2011).

At the same time more extensive regional transmission and distribution grids using ever-larger generation technologies were emerging. These started to answer the technological and economic imperatives of the increasingly dominant engineering paradigm. By the 1930s in Germany's Ruhr valley, North Eastern USA, the USSR and Great Britain to name a few, large scale grids were being developed interconnecting varied loads with a range of generation sources over large areas (Hughes 1983a; Coopersmith 1993; Hausman et al 2008). While the private sector still dominated electricity production, the substantial capital requirements of the ESI (Table 4.1), especially in the early years of expansion and transmission system development required the mobilization of financing from a range of different sources.

The capital requirements of a rapidly expanding ESI necessitated a means of financial intermediation that could act to pool and mobilise the kind of investment capital needed.[80] Specialist banking institutions and holding companies developed that were able to draw on broad financial networks. These institutions were able to spread risks that could be involved in providing finance to individual utilities, and their understanding of the sector better placed them to assess investment risk in what were technically complex undertakings. They were also better able to access capital markets than smaller companies. In addition, they enjoyed advantages related to access to accumulated technical expertise and management know-how, upon which smaller firms were unable to draw (Chandler 1992; Chandler et al 1999; Hausman et al 2008). Public investment was also important in some locations with municipalities, regional and national governments engaged in ESI investment. This was particularly the case with the development of transmission grids and large-scale power plants (such as the Tennessee Valley Authority (TVA)) (Hausman et al 2008; Hausman & Neufeld 2011). Generally, the pattern of ownership and control in the global ESI was extremely complex:

"Electric and gas utilities in the various countries have developed in a variety of ways. In some countries

[80] Similar to the processes involved in latecomer catch-up suggested by Gerschenkron (1962) (see Annex A3).

foreign capital has played a major part, in other nations public ownership and operation has been entirely or almost entirely responsible for their growth and development, while in still other lands private companies, municipal plants, State or Province ventures, and mixed public and private schemes have each contributed in building and operating these industries." (England 1936, cited Hausman et al 2008: 23)

Notwithstanding this complexity, a key emerging trend in the sector was the importance of private and foreign capital in the ESI, a trend which continued up until the Second World War (Annex A4, Table A4.1).

Table 4.1. Capital output ratios for selected utilities and manufacturing industry in the USA 1900 - 1937

	Electric light and power	Steam railroads	Telephones	Street and electric railways	All manufacturing
1900	12.48	6.43	4.12	6.85	0.79
1904	10.26	5.15	3.25	6.61	0.89
1909	10.27	4.49	2.77	6.16	0.97
1914	10.83	4.59	2.16	5.06	1.01
1919	5	3.52	1.77	4.29	1.02
1929	3.55	3.57	1.57	3.21	0.89
1937	2.76	4.27	2.01	3.52	0.74

Source: Neufeld 2008

State involvement also came in the form of granting franchises to utility operators – who were dependant upon access to public rights of way for their distribution networks. Price regulation to reign in monopoly profits was adopted in most jurisdictions based on some calculation of service costs allowing for what was deemed a fair return on capital, or a so called 'cost-plus' tariff. This was gradually replaced by pricing regulation based on the long-run marginal costs of supply in the 1970s. Nevertheless, between the early 1900s and the last quarter of the century, cost-plus price regulation was an important feature of the institutional arrangements of the ESI.

The ESI was also starting to see a gradual institutional change, the expansion in scale and scope of the sector, the emergence of national electricity grid systems, and the development of a universal service as supply networks extended to rural areas, generated greater political interest in the sector, a concomitant rise in state regulation and in some cases state ownership of the sector. This in turn meant the gradual withdrawal of foreign and private capital from the sector (Victor & Heller 2007; Hausman et al 2008; Clifton et al 2011; Millward 2011a). These changes happened at differing paces and to differing extents in different parts of the world, with public ownership of the ESI in continental Europe taking off in the interwar years, and globally in the post war period. This coincided with the view of an increased role for the state in mobilizing capital to enable the realization of the 'big-push' externalities particularly associated with investment in public infrastructure. By the 1970s, in practically all countries' power sectors were publicly owned monopolies, with the major exceptions of West Germany, Japan and the USA – although even in these countries the sector was heavily regulated (Bacon 1995; Gratwick & Eberhard 2008). In countries with sufficiently developed power sectors, vertically integrated regional or national grids were the norm. In general, the role of international finance had diminished and power sectors were domestically owned and controlled (Annex A4, Table A4.1).

This shift in organization, ownership and control, while taking place in highly idiosyncratic ways in different locations over the period, are typically explained in the economics literature as a response to three salient techno-economic features of the sector, i) its status as a natural monopoly; ii) the presence of significant transaction costs associated with large sunk costs and slow turnover of capital stock in the sector; and, iii) the provision of important public goods associated with managing a grid system and operating power generation technologies (Jaccard 1995; Chao et al 2007).[81]

First, the power sector was generally regarded as a natural monopoly (Gratwick & Eberhard 2008). As costs tended to decrease with the scale of production, it was cheaper for one firm to supply electricity than two or more competing firms. Intuitively, duplicate distribution networks and larger efficient scales of power generation (discussed in section 4.2.2 above) are lower cost than multiple distribution networks in one area and smaller competing generators (Bacon 1995; Chao et al 2007). Complete control of the market would in the first instance allow the generation of monopoly profits. Additionally, because monopolistic firms do not face a competitive market for their goods, they are potentially able to generate *supranormal* profits. The ability to engage in price discrimination by charging higher rates to consumers with greater demand inelasticity, allows monopolistic electricity providers to capture a greater share of consumer surplus

[81] Jaccard (1995) mentions a range of other potential public goods (provision of employment, up-stream and down-stream linkages). These have not been included here as these are not directly associated with the essential technical and economic characteristics of the ESI, rather they are contingent, and frequently used as political and ideological arguments for state ownership and control. These 'public goods' are discussed below in greater detail, but as elaborations of political economy processes.

and generate greater profits. For example, monopolistic firms may supply electricity at much higher tariffs to households than energy intensive firms. Households tend to display low price elasticity of demand, where as energy intensive industries tend to be sensitive to changes in the price of what is a key input.[82] The justification for government intervention in the sector in terms of ownership or regulatory control, is given by the potential for electrical utilities to generate high levels of monopoly profits (or monopoly rents) (Neufeld 1987; Jaccard 1995; Neufeld 2008).

Second, the cost structure facing an electricity utility means that it is particularly vulnerable to transactional risks (Neufeld 2008; Hausman & Neufeld 2011). The electricity sector is particularly capital intensive and capital in the electricity sector is relatively long-lived.[83] Because much of the capital is invested in transaction-specific stock, for which there are limited alternative uses, there is a large difference between the value of the stock realized as a consequence of use for its design purpose, and the next most valuable use (Williamson 1985). Indeed, in many cases, the next best use for capital stock in the power sector is as scrap metal. To guard against the risk of not being able to sell their electricity, investors enter into long-term supply contracts. But, there is always the possibility that the other contracting party may renege on the contract. Alternatively, as the contact cannot possibly cover every eventuality, contractual arrangements are likely to require periodic renegotiation, at this point the electricity purchaser is in a stronger bargaining position and may seek more favorable terms. In both cases, the high level of sunk costs means that once invested the owner of the capital stock stands at a clear disadvantage in negotiations. The high level of capital intensity and the long-lived nature of the capital stock compound this risk (Chao et al 2007; Hausman & Neufeld 2011).[84] As a result the investor may be reluctant to undertake the investment in the first place. Vertical integration of utilities can act to mitigate some of these risks as all transactions within the sector would take place within a single firm. State ownership or control of the sector could also effectively internalize these risks (Besant-Jones 2006).

Third, the power sector provides a number public goods, which would be difficult to internalize into the costs of a privately owned and controlled firm, therefore justifying

[82] For large scale industrial users it may also be feasible to switch energy supply away from electricity to other energy sources (e.g. in steel production).
[83] According to recent EIA (2010) estimates between 25 – 80 years for generation assets.
[84] This is closely related to the notion of the 'obsolescing bargain' discussed below.

public ownership and control (Jaccard 1995; Gratwick & Eberhard 2008).[85] The narrow public goods provided by the sector include the coordination of planning and ensuring capacity requirements are met, maintenance of a plant mix by fuel and type reducing energy security risks, and the need to fix responsibility for maintaining the security of the system (Murray 2009). To this we may also a unified operational control of the systems to ensure grid reliability and prevent cascading failures (Chao et al 2007).[86]

Jaccard (1995) points out that the public good rationale covers a broader range of different arguments that have been deployed covering different characteristics of the sector which have been important in different times and different places. Broader 'public goods' include provision of employment in the ESI itself, employment in fuel and equipment input providers, employment in sectors which receive subsidized electricity, cross-subsidization of strategic or otherwise favored sectors, and cross-subsidization of supply to rural locations and poor households.

These arguments offer a first-order rationale for, what was by the 1970s, almost ubiquitous state ownership and control of the ESI globally.[87] However, to portray the ostensibly stable institutional arrangements that had emerged, as a rational response to the considerations of monopoly, transaction costs or public goods is misleading. A review of the historical literature on the development of the ESI shows that these changes were not only, or even primarily, a prudential response of rational states, but the outcome of often-complex *political* processes (Williams & Dubash 2004; Hausman et al 2008; Neufeld 2008; Hausman & Neufeld 2011; Millward 2011a; Millward 2011b).

Instead notions of efficiency and public good appear along-side the play of vested interests, and geo-strategic considerations. Often they appeared as part of a justification for government action, sometimes as window-dressing, sometimes as genuine ideological commitment. Notions of public good were extremely broad and open to interpretation, reflecting commitments to objectives such as employment generation, universal service, energy security, modernization and economic growth. The gradual development of monopolistic national utilities was uneven and contested, and illustrates the importance of political economy dynamics in understanding the development of the sector.

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85 Although these may not be 'pure' public goods in the textbook sense of goods, which are non-excludable and non-rivalrous, they do have public good attributes.
86 For example, in maintaining synchronized frequencies in different parts of the grid.
87 We look at how this rationale may have been succeeded by that of sector liberalization in section 4.2.5

4.2.3 Politics and the coevolution of institutions

In spite of the available returns to scale enjoyed by large networks, writers such as Hughes (1976, 1983) and Hausman & Neufeld (2011) point out that the development of large scale grids and interconnection of municipal utilities in the 1920s was often resisted in the USA, Great Britain and Germany as they threatened vested political and economic interests. For example, in the case of the proposed Giant Power project in Pennsylvania, long distance transmission lines from mine-mouth plants threatened a range of interests. These included municipal governments who would no longer be able to exercise the degree of control they enjoyed over generator revenues and rail firms that were threatened by the potential loss of custom from the transportation of coal from mines to power generation plants (Hughes 1976). Another example is the 'Superpower' project proposed in 1921 to develop an integrated system transmission grid system between Boston and Washington. This promised a 40% reduction in total costs, but also floundered in the face of opposition from utilities operating in the area who could not be convinced that the benefits to them would outweigh their loss of control (Holland & Neufeld 2009). In these cases, inertia emerging from the political economy context slowed the realization of the engineering ideal and the formation of institutional arrangements to facilitate that.

In 1930s Britain and the USA, state involvement in the power sector and the promotion of larger regional grids was in part as a response to the exigencies of the Great Depression (Hughes 1983; Hausman & Neufeld 2011). In the case of federal government investment in hydropower in the USA such as the TVA and associated developments, the ability of government to mobilize finance to cover the high upfront costs of the generation plants and associated transmission lines, the public ownership of land where these projects would be cited, and the significant public good of cheaper electricity, rural electrification and industrial development in an economically depressed region of the US provided significant justification for state intervention (Hughes 1983). Even with this significant technical and economic advantages, public good rationale, and federal backing, the development of these hydropower projects encountered significant resistance from private utilities and parts of government hostile to federal government involvement. Similarly, in Great Britain, the development of the National Grid despite its technical and economic advantages also faced opposition from private ESI utilities and was only enabled by the prevailing political climate during the depression (Hughes 1983).

Notwithstanding increased public investment in the ESI in the USA and Great Britain in the interwar period, private sector generation utilities continued to dominate. This was in contrast to the situation in continental Europe, where public ownership developed earlier (Millward 2011). Again, the evidence points to the predominance of political concerns related in this case to national security. Millward (2011; 2011a) suggests the actual reasons for public ownership of utility industries in continental Europe up to 1939, were related primarily to geo-strategic considerations of territorial integrity and industrial-military capabilities amongst competing, geographically contiguous states:[88]

"….public ownership was not the prime instrument for dealing with natural monopolies and related dimensions of market failure (for which arms' length regulation was the most common instrument); nor can its occurrence be found in government policies to avoid worker exploitation…[…]…public enterprise was often an instrument for promoting social and political unification, securing national defense and related strategic considerations, in some instances for promoting economic growth, with regulatory failures and socialist pressures playing a more subsidiary and/or occasional role." (Millward 2011b: 377)

Techno-economic and public good considerations did seem to get greater purchase when the political environment was favorable. Such as in times of national security or economic crises, or when in the interests of the nation state, private sector vested interests could be more easily overridden. The paradigm example is perhaps the radical upheavals caused by the Russian Revolution in October 1917 and subsequent civil war which led to the opportunity for wholesale reform of the sector:

"Where Russia differed was the collapse of the old regime and its replacement by a new government whose leadership viewed science and technology as essential components in their quest for a socialist society. Only in revolutionary Russia, when the old tsarist power structure and techno structure had been discredited and a revolutionary government explicitly desired to transform society, did the goals of large-scale electrification and of the new political elites successfully converge" (Coopersmith 1993:14)

[88] In contrast, as Yergin and Stanislaw (1998) point out, British military power was perceived as being dependent upon sea power, which motivated the public acquisition of a controlling stake British Petroleum, as oil was the energy resource seen as essential to maintain military supremacy.

In the case of the USSR, Coopersmith notes that the electrification plan was out of synch with conventional economic logic, which may have favored a more incremental approach to improving on existing supply arrangements and a greater concentration on large urban load centres. But the engineering ideal of a large-scale centralized system, was aligned with the new structure of political power. The New Economic Plan (adopted in 1921) and subsequently the First Five Year Plan (1928 – 1932), with the objective of promoting rapid industrialization had electrification at its heart (Dobb 1949; Coopersmith 1993). The technocratic bent of socialism, the ideology of common ownership and modernization, the strategic vision of industrialization and perceived need to bolster military power, propelled wholesale reform of the ESI's technological, economic and institutional arrangements. Within the Soviet sphere of influence, this pattern of ESI development was to have a lasting effect on the structure of the industry (Williams & Dubash 2004).

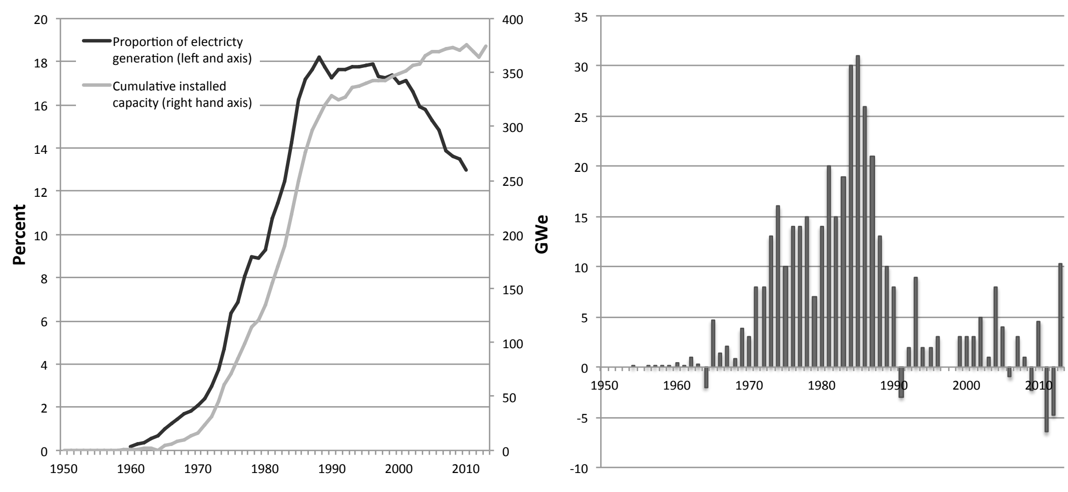
Faith in the private sector as a means of achieving social well being had been shaken by the Great Depression. The post war period (1945 – 1970s) was marked by an increased state intervation and public ownership, and the withdrawal of private capital from the ESI. The perception was that state control of the strategic 'commanding heights of the economy' was justified by practical and ideological considerations. Yergin & Stanislaw's (1998) account of the rationale for nationalization of industries in the case of post war Britain is illustrative:

"…that as private businesses, these industries had underinvested, been inefficient, and lacked scale. As nationalized firms, they would mobilize resources and adapt new technologies, they would be far more efficient, and they would ensure the achievement of the national objectives of economic development and growth, full employment, and justice and equality. They would be the engine of the overall economy, drawing it toward modernization and greater redistribution of income." (Yergin & Stanislaw 1998:26)

Appeals were thus to technical considerations of efficiency and resource mobilization, but also to the broader public goods of economic growth and modernization, and considerations of social equity. Arguments relating to private monopolies seemed to play a less important role. Again in this case, the dislocation of the political settlement caused by the war and its aftermath, shifted the balance of political and economic power, allowing institutional change in the ESI to take place. In other cases, despite the disruption of war, ESI institutions remained relatively intact, and private regional utilities continued to operate albeit under tight regulatory control and as part of a regional transmission grids (e.g. in the USA) (Pond 2006; Hausman et al 2008).[89]

At the same time, these institutional developments were accompanied by the development of civil nuclear power in France, the UK, the USA and the USSR, which served to reinforce both the dominant system design and role of the state in the ESI (Cowan 1990). In many ways nuclear power technology embodied the institutional and techno-economic paradigm that had emerged in the ESI in the 1930s, comprising of large generation units supplying relatively inflexible base-load (Thomas et al 2007). Large upfront capital costs, the risky nature of investments in a new and complex technology, important safety and security aspects, and the perceived strategic nature of the technology necessitated intensive state intervention in the mobilization of capital, and in the development and diffusion of this technology (Damian 1992; Thomas 2010).

Figure 4.9. Global nuclear power fleet cumulative installed capacity and proportion of global electricity consumption (left), and annual change in capacity (right) 1950 - 2013



Source: Worldwatch 2004, 2005; IAEA 2005, 2009, 2010, 2011, 2012, 2013; WNA 2007

There are a number of different factors driving the adoption and relative success of nuclear programmes in different countries. The initial impetus to develop nuclear power was for military purposes, only later did technical and economic considerations come to the fore (Cowan 1990). Many of the countries that adopted nuclear technology, such as

[89] Indeed, White et al (1996) comment: "Since passage of the Federal Power and Public Utilities Holding Company Acts in 1935, the electric power industry has remained one of the most tightly regulated sectors of the U.S. economy. Through lengthy and litigious proceedings, state and federal regulatory commissions adjudicate the prices, capital investments, financial structure, and corporate organization of the 250 investor-owned electrical utilities that principally operate as de jure or de facto franchise monopolies." (201)

France, Korea and Japan had relatively limited domestic energy reserves and did so in response to energy crisis of the 1970s (Kessides 2009). But the literature also points to important socio-cultural and political differences in determining the degree to which this technology was deployed in different countries. In France, a more fundamental belief in the role of the state, close collaboration between government and the ESI, was influential in determining the relative success of the nuclear program there. Similar points have been made about Korea, Japan and latterly China. (Jasper 1992; Hadjilambrinos 2000; Grubler 2010; Valentine & Sovacool 2010). In states with a less powerful central government and poorer coordination between the ESI, technical experts and government such as in Sweden, the UK and the US the nuclear industry fared less well (Cowan 1990; Jasper 1992; Hadjilambrinos 2000; Thomas et al 2007).[90]

4.2.4 Development of the ESI in developing countries

It was only in the post war period that electricity demand growth really took-off in many developing countries (Williams & Ghanadan 2006). This period in the developing world saw state lead development of the ESI become the norm, this accompanied the process of decolonization and the nationalization of strategic industries (Williams & Dubash 2004; Victor & Heller 2007). At the beginning of the period ESIs in many former colonies were wholly or partly foreign owned (Annex A4, Table A4.1).[91] Independence brought a range of pressures on foreign owned and private utilities, which lead to their withdrawal over a number of years. Although the details of each case were different, the literature identifies a number of general trends that commonly characterized the process.

The arguments for state ownership in developing countries, like those proffered in the industrialized world, drew on the rationale that the sector was a natural monopoly, suffered from important investment risks that necessitated vertical integration and had a number of important public good attributes. However, in the developing world these considerations were articulated through different political processes than had been the case in the development of public utilities in industrialized countries.

[90] It should be added that the USA and UK probably suffered from being early adopters of nuclear technologies. By the time France started pursuing nuclear generation at scale reliability had improved significantly with capacity factors up from around 60% in the 1960s to 80-85% in the 1970s (Grubler 2010).

[91] Although as Nellis & Kikera (1989) point out colonial administrations tended to be more 'economically intrusive' than they were at home, meaning that in many cases a president was already set for state involvement.

Firstly, there was a public perception that monopolistic electrical utilities had the opportunity to generate a high level of profits from what was regarded as an essential public service. Where these profits were generated for foreign shareholders this was especially unpopular. This perception was also fueled by the lack of understanding of ESI costs. A focus on operational costs, rather than the capital costs that utilities needed to recoup, also lent to a sense that utility operators enjoyed excess profits (Hausman et al 2008; Victor & Heller 2007; Williams & Dubash 2004; Nellis 1989).

Secondly, state control of the sector, allowed the politicization of decisions, and the channeling of resources to politically important groups. There was a realization of the political benefits the provision of 'public goods' could afford, including subsidized electricity supplies to favored sectors and the generation of employment from large construction projects such as dams (Nellis & Kikeri 1989; Victor & Heller 2007). Thus State control over the ESI had the potential to allow a politically expedient allocation of resources.

Thirdly, political allocations aside, in general the strategic role of the ESI deemed was important in promoting modernization and nation building, as described by Williams & Dubash (2004):

"[The power sector] played an important role in national ideology, symbolizing a new type of social compact between state and citizen. For post-colonial developing countries, electricity represented the good life - well-illuminated homes and workplaces, modern factories and transportation, escape from the drudgery of manual labour - that had been denied the majority of people in the first half of the twentieth century. In propaganda and popular consciousness alike, images of a society with universal and affordable electricity became important tropes for state-led development." (Williams & Dubash 2004: 413)

From the perspective of investors the withdrawal of private and foreign capital had its own particular dynamic. Private and foreign investment faced an increasingly hostile environment. Alternative sources of capital became available for governments. The Cold War fueled competition between Western and Soviet powers for influence in newly independent states. Concessional loans and technical assistance were granted, frequently for large ESI projects as a means to garner influence. At the same time, the belief at the time in the efficacy of lending to address capital shortages to fund public utilities influenced lending policy at donor institutions.[92] The increasing unpopularity of foreign and private sector ownership and increasing reluctance of foreign owned firms to invest, coincided with declining requirements for foreign capital (Williams & Dubash 2004; Hausman et al 2008). With adequate access to capital, governments did not perceive foreign owned ESI utilities to be adding any value, and felt they had adequate trained staff and technological know-how to manage the sector domestically. They thus came to see private sector investments in terms of an obsolescing bargain. Without the perceived need for foreign know-how, or technology transfer, the sunk capital costs of the ESI meant that the bargaining power of foreign private investors was diminished (Woodhouse 2006; Victor & Heller 2007).

In the face of tightening electricity price controls foreign firms were also forced to bear exchange rate risks. The gaps between long-run and short-run marginal costs left a short-term opportunity for the host government to appropriate these funds though price controls, taxation or other means. In the long term, this led to declining service standards as firms were reluctant or unable to replace worn out capital stock or expand generation capacity to meet needs. Declines in service provision, for which utilities were blamed, further added to political pressure upon them. Gradually increasing pressure made foreign investment in ESIs unattractive. This was part of a wider process as nationalist and socialist governments came to dominate in the developing world making conditions unattractive for foreign investment (Nellis & Kikeri 1989). More attractive investment opportunities existed elsewhere. Over a period of approximately one turnover of the capital stock, foreign private sector investment had all but disappeared from developing country ESIs (Harris 2003; Victor, & Heller 2007; Hausman et al 2008; Annex A4, Table A4.1).

4.2.5 A universal techno-economic paradigm?

At this point it is worth noting three points salient to our more general argument. First, techno-economic and (*de jure*) institutional outcomes are marked by a considerable degree of uniformity. By the 1930s, the dominant system design of large-scale grids reaping increasing returns to scale was becoming almost universal. Large positive feedbacks from scale and scope efficiencies, learning externalities in terms of both manufacture of ESI technologies and their operation in complex systems, their institutionalization, though

[92] Influenced by the success of the Marshall Plan and influential writers such as Rostow.

bodies of scientific, engineering and managerial practice, and propagation through schools of study and the development of specialist firms (electrical equipment manufactures, utilities, holding companies and specialist banks). By contrast, the relatively weak feedbacks and strong lock-in effects that characterize institutional and political arrangements meant that a partial convergence on institutional arrangements for the ESI was not reached until the 1960s and 1970s. Convergence was typically achieved not as a result of rational policy choices but through external disruption of incumbent institutional and political arrangements.[93]

Second, that convergence did take place is indicative of the *fundamental technological and economic characteristics of the ESI*, which gave rise to significant returns to scope and scale, these in turn lead to positive feedbacks to the dominant system design, and the consequent emergence of the techno-economic paradigm. Conversely, the IRS also can serve to explain the inertia facing the political and institutional arrangements in the system. It is not only that feedbacks to political and institutional performance tend to be weak, and especially so if performance is deemed adequate.[94] But, that given large IRS and resulting appropriable benefit streams, the political power accruing to a particular set of institutional arrangements is likely to show inertia as the beneficiaries of those arrangements seek to preserve their position using the wherewithal the appropriable benefit streams entail. Thus inertia is likely to be large and convergence on institutional forms that are better able to serve their purpose has been slow.

Thirdly, the purpose of the techno-economic paradigm is frequently subordinated to political ends through the development of particular institutional arrangements. Positive feedbacks to technological and economic performance may result in the emergence of technological arrangements that are optimal. Similarly, the interests of those in a position of power to ensure their position (which in most cases is maintained in virtue of public consent), will in a large part depend upon the effective delivery (or the perception of capacity to do such) of 'public goods'. Given the central importance of the ESI in the provision of these goods, it has generally been in the interests of those in power to ensure adequate technical performance of the sector. The subordination of the sector to

93 For a discussion of the theory behind the notions of learning externalities, feedbacks and lock-in as regards technological, institutional and political systems see chapter 2.

94 In this regard the reader will recall we rejected the notion that people are optimizers, and instead adopted a characterization of them as only boundedly rational satisficers, see Chapter 2.

political ends therefore may also tend towards the adoption of performance enhancing technologies and institutional arrangements in the longer term.

On the other hand, the political control of the sector could result in outcomes that are dysfunctional from a welfare perspective, such as the favoring of particular interest groups or technologies that served broader political purpose. The size and capital intensity of the ESI gave ample room for machinations of just this sort – particularly in developing countries where feedback in the form of rents or other benefits to those in positions of power tended to be highly concentrated, and feedback to the performance of those in power tended to be weaker. In section 4.2.6 we look at how political and consequent macro-economic failings featured in the movement to reform the ESI in developing countries.

Finally, the IRS enjoyed by the sector meant that *negative* feedbacks to sector performance tended to be weak. Poor performance, in terms of the efficient use of resources and delivery of least-cost service could be effectively hidden. The reduction in long-run marginal costs in virtue of technological improvements and IRS swamped signals about the efficiency of the ESI, which would otherwise have been passed on in consumer prices or failures in service provision. Negative feedback would only be visible if the IRS and technological improvements ran out, and performance underwent a marked deterioration in terms of cost or service. Only then would political pressure for performance improvement be likely to emerge. This is essentially what happened in industrialized countries during the 1970s, and to which we turn next.

4.2.6 Dynamics of ESI liberalization in the industrialized world

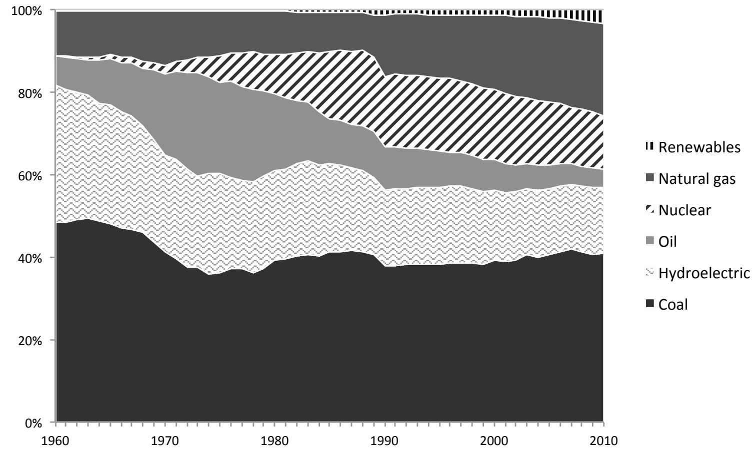
By the middle of the 1970s, a number of important trends were starting to undermine established institutional arrangements in the ESI's of industrialized countries. These included supply-side pressures, changes in generation technology, and perceived shortcomings in institutional arrangements, as well as broader macro-economic and political considerations. All this was underpinned by the emergence of a strong neo-liberal ideological current, which endorsed a greater role for private ownership and market allocation mechanisms throughout the economy and a concomitant withdrawal of the state (e.g. see Önis & Senses 2005). These pressures lead to significant global institutional change in the ESI led by reforms in the USA during the 1970s, Chile in the

1980s, and the UK in the 1990s. These changes in many ways set the global reform agenda for the next 20 years as they were subsequently taken up by many developing countries at the behest of the IMF, World Bank, and other multi-lateral and bi-lateral donor institutions.

As with the emergence of the techno-economic and institutional paradigms that came to dominate the ESI in the post war period, the dramatic changes in the ESI in the last quarter of the twentieth century had important (if not entirely determinate) technological precursors. The fundamental and systematic technological characteristics of the ESI and their economic consequences had not really changed between the 1930s and the 1970s. For the most part, the dominant system design driven by IRS of large centralized generation plants, and regional or national transmission and distribution grids persisted. Coal and hydropower generation technologies were still the predominant technologies, with oil-fired generation important in some countries (Figure 4.10). ESI utilities were publicly owned or tightly regulated regional monopolies operating on a cost-plus basis. However, the technological and economic dynamics that had characterized the ESI were changing. Stagnation in performance of scale technologies, the development and deployment of nuclear power generation from the 1950s onward and the economic implications of this, the emergence of smaller-scale efficient generation technologies, a growing of awareness of environmental problems related to electricity generation technologies and increasingly acute energy supply constraints, all served to undermine the incumbent techno-economic paradigm, and lead eventually to profound institutional change in the sector (Hausman & Neufeld 2011; Hirsch 1999, 2007; Williams & Dubash 2004; Jaccard 1995).[95]

[95] The CCGT combines a gas turbine generating electricity, the exhaust gasses from which are used to heat water and drive a steam turbine which generates additional electrical power, hence a combined (gas and steam) cycle turbine, as opposed to an open cycle gas turbine (OCGT) which does not incorporate a steam cycle.

Figure 4.10. Share of global electricity production by fuel (%) 1960 - 2010



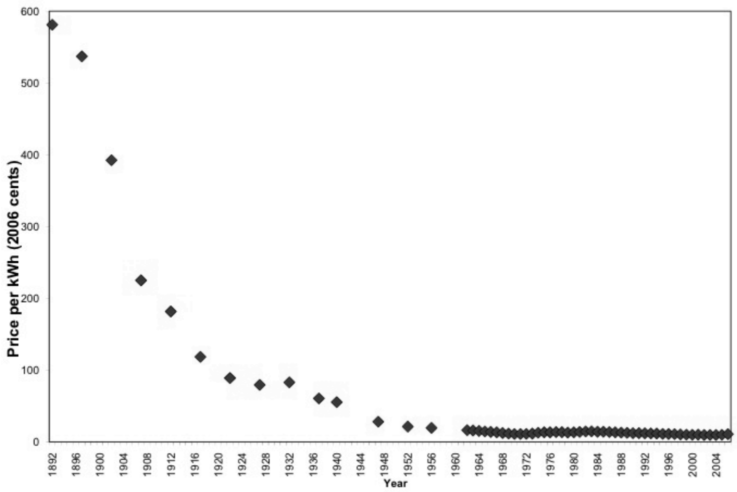
Source: IEA 2012

By the 1970s there was an emerging consensus that the returns to scale and scope enjoyed by the utilities had run their course (Christensen & Greene 1976; Joskow 1987; Victor & Heller 2007). Hirsh (1999, 2003, 2007) points out at this stage the ESI in the USA (and elsewhere) was characterized by 'technological stasis', in which the potential for incremental marginal improvements to technologies had run out:

"Despite the desire to attain increased economies of scale, especially in light of the industry's inability to reach higher thermal efficiencies, managers stepped back from the largest units and settled for smaller, proven units...[…]…In previous decades, the improvement of power-producing technologies had mitigated increased costs in building materials and labor, allowing the industry to reduce the price of its product. But because of technological stasis - along with greatly increased borrowing rates for an industry that consumed vast amounts of capital - power companies soon found themselves uncharacteristically requesting rate hikes from utility commissions." (Hirsh 2007:76)

As a consequence electricity prices, which had seen continual decline since the early years of the sector, had by the late 1960s stopped falling (Figure 4.11).

Figure 4.11. Price of residential electricity in the USA 1892 - 2006



Source: Reproduced from Hirsch 2007

Other emerging problems from within the industry and external to it would put upward pressure on costs in the 1970s. Following the Yom Kippur war in 1973 and the Arab Oil embargo the price of energy increased dramatically (Yergin 1996). At around the same time it emerged that ESI utilities across many industrialized countries had over-invested in capacity. The economic downturn had led to falling demand for electrical power. In the past planners had relied upon a rule of thumb estimating demand growth at about 7% per year, but by the 1970s with falling economic growth and rising inflation demand growth fell dramatically across industrialized countries (Patterson 1983) (Figure 4.12). As a result electricity utilities were lumbered with excess capacity and increased pressure on costs and tariff levels (Boston Pacific Company 2000).[96]

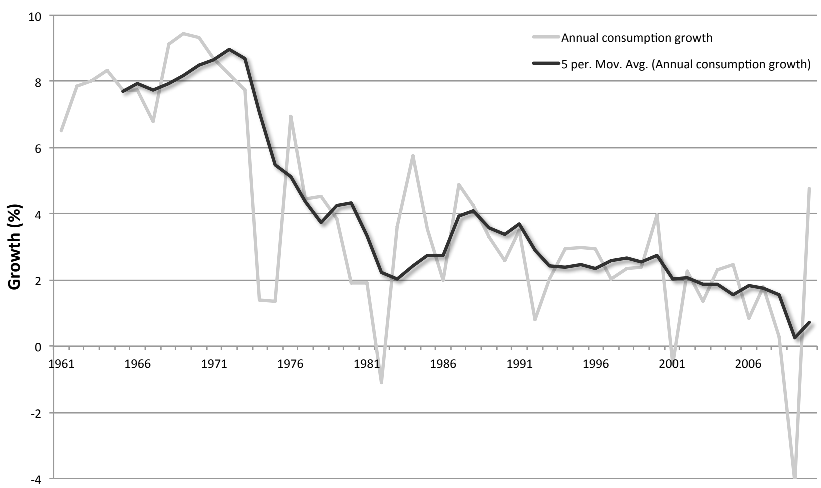
In some countries such as the USA and UK, much of the over investment in capacity had been made in nuclear plants during the 1950s and 1960s. Due to large capital requirements, construction and cost overruns this left utilities with large borrowing requirements. Ballooning nuclear costs coincided with dramatically increased interest rates, leaving the private US utility companies in particular with huge a huge debt problem (Hausman & Neufeld 2011; Damian 1992).

[96] To quote from the US FERC, "…expensive large base-load plants for which there was little or no demand, came onto the market or were in the process of being constructed. Accordingly, between 1970 and 1985, average residential electricity prices more than tripled in nominal terms, and increased by 25 percent after adjusting for general inflation. Moreover, average electricity prices for industrial customers more than quadrupled in nominal terms over the same period and increased 86 percent after adjusting for inflation." (Federal Electricity Regulatory Commission cited Boston Pacific Company 2000:3)

Addtionally, during the 1960s and 1970s there was a rising awareness of the potential environmental consequences of power generation. These included air pollution from fossil fuel combustion at thermal plants, the risks associated with the uncontrolled release of radioactive substances and the disposal of radioactive waste at nuclear plants, and environmental costs associated with hydropower development, particularly to fisheries (Jaccard 1995). Increasingly stringent environmental regulations for generators meant greater capital and operational costs for environmental protection activities (MacKerron 1992; WCD 2000; McNerney et al 2011).[97]

Finally, the oil embargo and energy crises of the 1970s focused policy-makers' attention on energy security concerns. The response to the energy crisis differed from country to country with, for example, the pursuit of nuclear power in France, Japan and Korea, and wind power in Denmark (Hadjilambrinos 2000; Kessides 2009; Valentine & Sovacool 2010). Energy efficiency also emerged as a key policy response, focus moved from least-cost electricity provision, which had guided ESI policy, to least cost energy service provision. This could also serve to undermine the dynamic of cost reductions through expansion under-written by a guaranteed cost-plus tariff (Jaccard 1995).

Figure 4.12. Electricity consumption growth in OECD countries 1960 - 2010



Source: IEA 2012

Thus the technologies and consequent economic logic, which drove the expansion of the ESI was confronted by technological limits to scale and significant cost pressures. There

97 While these technologies were probably marked by IRS in terms of efficiency and declining unit costs at larger scales, this was probably off-set to some extent by lower pollution control requirements for smaller generation plants.

was the perception that the sector was underperforming. The cost-plus regulatory model that had been in place since the 1930s was under threat. While it may have served the sector well when IRS could yield both the expansion of supply and falling consumer tariffs. Once IRS had been exhausted and demand growth slowed, institutional arrangements had promoted over-investment in capacity (so-called 'gold-plating'), and investment in risky nuclear technologies. Cost-plus regulation and state ownership essentially meant that the consumer would have to under-write these risks and pick up the tab.[98]

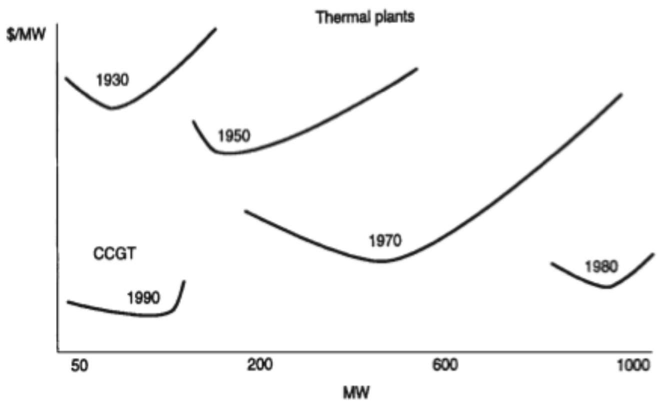
At the same time technological advancements were leading to a decrease in the efficient and economic scale of generation, meaning that other ways of organizing production in the sector were becoming viable. In particular, the development of Combined Cycle Gas Turbines (CCGTs) would prove influential in driving change in the sector, and further destabilize the incumbent institutional arrangements. Through the 1970s and 1980s gas fired electricity generation technologies, and in particular, CCGTs started to compete with traditional coal-fired generation technologies (Islas 1997; Winskel 2002; Watson 2004). By the 1990s, with improvements in the technology, bringing increased reliability and larger-scale generation units, the technology became able to compete with coal.

CCGT plants had a number of important advantages over other generation technologies these included much higher thermal efficiencies (approximately 50% greater than other fossil fuel plants), lower unit capital costs and limited civil works for projects which meant the risk of construction (and cost) overruns was much lower, lower pollution emissions than coal or other fossil fuels.[99] CCGTs were more compact and could be placed closer to load centres, and construction times were much shorter. CCGTs had a smaller efficient size in terms of thermal performance, the optimal plant size in terms of cost per unit-installed capacity was significantly lower than coal (Figure 4.13).[100] After the mid 1980s falling gas prices also made CCGT much more attractive, as did the availability of North Sea gas in Europe and the prospect of Russian supplies of gas

[98] It should be noted that by the 1970s marginal cost pricing was being used to some extent within publicly owned utilities in France and the UK.
[99] CCGTs also have the advantage of being a technology that is relatively clean compared to other fossil fuels, coal producing practically no SO_x and limited amounts of NO_x, emissions of particulates and volatile organic compounds are similarly limited. CO_2 emissions are also lower per Kwh than other fossil fuels, although at the time this was not an important consideration.
[100] It should be noted that the development of CCGT benefited from R&D in the jet propulsion turbines for aircraft, existing use in the oil and gas industry for driving pipeline pumps, and the discovery of gas reserves both in the USA and Europe (notably the North Sea) (Islas 1997; Winskel 2002; Watson 2004).

following the end of the Cold War. The net result of this was a significantly lower unit cost for electricity from CCGTs compared to that from coal (Watson 2004). In particular, CCGT technologies would prove to be sufficiently cheap and have a sufficiently attractive risk profile to allow significant private re-entry into the electricity generation market once regulatory conditions allowed.

Figure 4.13. Optimal plant size per MW cost curves 1930 - 1990



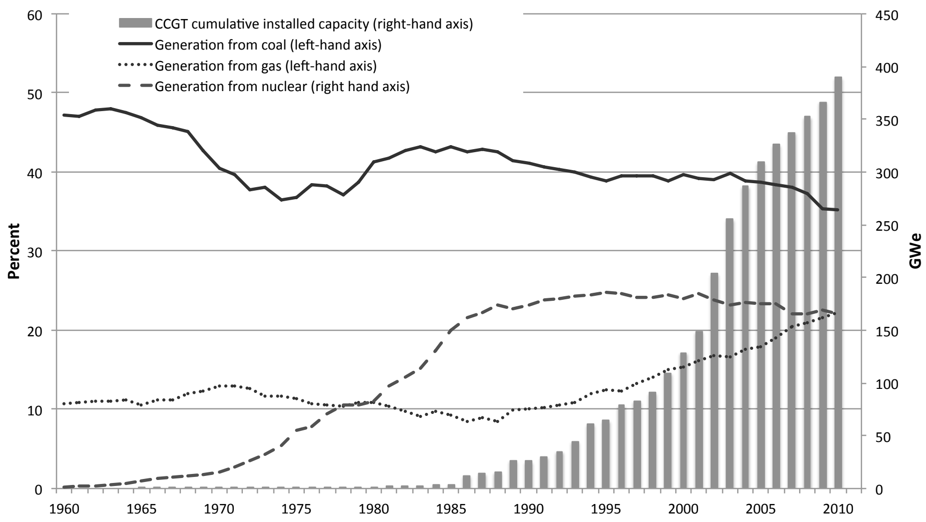
Source: Casten 1990 reproduced in Kunneke (1999)

In the USA, as a response to the energy crisis, and after significant resistance from states to new federal legislation, the 1978 Public Utility Regulatory Policies Act (PURPA) was passed (Hausman & Neufield 2011). The legislation was initially designed to improve energy efficiency through promoting combined heat and power (CHP) and renewables generation. To enable this PURPA created a new class of generation companies that were essentially independent of the utilities. The regulated utility companies were required to purchase all the electricity generated by these independent firms at a price calculated to be the 'avoided cost' of the utilities provision as determined by state regulators, rather than based upon the non-utility generators own costs. This represented a significant advantage for these generators. Many new generators entered the market frequently using renewables and CHP technologies (often using gas turbines) that subsequently saw considerable deployment in the 1980s (Jaccard 1995; Hirsh 1999). High oil prices did not last, and rapid price declines in natural gas prices the 1980s further added to the competitiveness of these technologies. Electricity produced by these smaller producers cost the same or less as that produced at large troubled utility owned plants (Hirsh 2007).

The largely unforeseen implications of PURPA and supporting legislation were wide ranging and set the scene for liberalization globally.[101] First, a *de facto* competitive generation market was created. While regulations differed from state to state, an important class of non-utility generators were created that effectively competed with the utilities. This undermined the notion that the ESI was a natural monopoly – in generation markets at least - competition was possible. Secondly, a competitive generation market implied equal access to transmission and distribution infrastructure, access that was guaranteed by legislation, but this in turn implied a vertical unbundling of generation, and T&D functions of the system. Thirdly, PURPA made cogeneration and CCGT installation at larger industrial plants feasible. Excess electrical power could be sold to the grid. This undermined the monopolistic power of utility electricity service provision in some market segments, and pressured utility suppliers who had been effectively cross-subsidizing service provision to household and rural customers. This in turn put upward pressure on utility tariffs (Chao et al 2007). Finally, the large-scale entry of so-called 'merchant' generation companies to the ESI in the US (and later globally) was closely associated with the increase in electricity production from natural gas, using CCGT generation technologies. As explained above, the favorable cost structure of these technologies leant themselves to private sector financing. The installed capacity of CCGTs grew rapidly, the share of coal and nuclear in the US (and global) generation mix fell (Figure 4.14) (Islas 1997; Winskel 2002; Watson 2004).

[101] Hirsh (2007) comments: "…. I would love to report that the lawmakers who crafted and passed that law acted in an informed and rational manner, seeking to employ market forces to eliminate inefficient and illogical bureaucratic practices and thus yielding a lower-cost, more environmentally friendly way of producing and using electricity. Of course, I can tell no such story. Instead, I relate a history of corporate lobbyists who influenced uninformed and time-constrained legislators. When they passed PURPA in 1978, lawmakers thought (if they thought about it at all) they would make a marginal impact on improving energy efficiency of utility companies while appearing to do something substantive after the 1973 energy crisis. But as often happens in the legislative process, creation of policies have unintentional consequences." (16)

Figure 4.14. CCGT cumulative installed capacity and proportion of gas fired generation high-income OECD countries[102] 1960-2010



Source: IEA 2012

Similar pressures were being felt throughout the industrialized world. The combination of technological stasis, energy price increases and over investment in expensive generation technologies placed the techno-economic paradigm and the institutional structures it supported under pressure for reform. In some quarters, this also fed into growing doubts about the broader role of the state in society in both industrialized and developing countries.[103]

It was the radical restructuring of the ESI in the UK in the early 1990s that in many ways set the global reform agenda. During the late 1970s and 1980s the sector showed many of the problems that had come to be deemed typical of publicly owned ESI utilities, according to Newbery & Pollitt (1997):

"The experience of this period [of public ownership from 1948 – 1990]…[…]…can be briefly summarised as a *classic example of a cost-of-service regulated public utility*, with excessive capital costs, overdependence on high-cost indigenous coal and nuclear power, a low rate of productivity growth, a low rate of return on assets, in turn reflecting the inefficient balancing of interests of the coal miners, the industry itself, domestic voting consumers, large industrial consumers, the Department of Energy, and the Treasury." [emphasis added] (Newbery & Pollitt 1997:275)

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102 OECD countries excluding Mexico and Turkey.

103 See chapter 3.

In the UK the pressure for institutional reform came from a perception of poor performance. To this we can add that there was a real belief that privatization and competition could reduce costs to the consumer by providing better incentives for more efficient management and investment. Technology choice would not be decided in response to broader public policy goals, but by the market. Privatization would also provide significant receipts to the sate budget and cut the amount of subsidies paid by government to the sector – generating greater fiscal space for politically popular tax reductions. Finally, there was a perception that the ESI had been effectively subsidizing the UK's large coal industry through favorable long-term contracts. A privately owned ESI would not be compelled to renew contracts on such favorable terms, and the power of the coal mining unions would be reduced (Bacon 1995; Turnheim & Geels 2012). The rationale and ideology of private ownership and liberalization of the sector dovetailed neatly with political concerns to enhance electoral prospects through tax reductions, and longer-term concerns with shifting the structure of power within the national polity, in particular, in shifting power away from the powerful mining unions.

The reforms of the ESI in the USA, and at around the same time the wholesale reform of the ESI in Chile during the late 1970s and 1980s were important in the formation of a new institutional paradigm for the ESI. This was followed by reforms in the 1990s by England and Wales, Norway, Australia, and elsewhere (Besant-Jones 2006). Putting the broader ideological and political goals to one side, the stated economic goal of restructuring the ESI in industrialized countries was to realize sufficient competition to ensure the efficient allocation of resources in the sector given binding constraints relating to system reliability, energy security, universal service provision and environmental requirements (Murray 2009).

Reform typically involved a number of discrete steps, starting with privatization of the sector and then the incrementally introduction of competition to different parts of the sector. Typically the reform steps proceeded as follows, i) corporatization of the utility and creation of an independent regulator (if one was not already in existence); ii) unbundling the different parts of the electricity supply chain (generation, transmission, distribution and retail) into functionally separate units; iii) splitting up generation into competing blocks and allowing entry by other providers; and, iv) creation of an independent system operator (Gratwick & Eberhard 2008; Murray 2009). These steps were typically followed by the development of market mechanisms in order to facilitate competition. This was deemed easiest in generation, but more difficult in wholesale and retail segments.[104] Restructuring thus sought to enable competition between privately owned entities in generation and retail, and to create market structures that would facilitate this competition.

Gratwick & Eberhard (2008) in their analysis of the 'standard model' for ESI restructuring note the emergence of an institutional ideal and a package of restructuring measures, based in a large part on the early experience of restructuring in industrialized countries and the UK in particular (Table 4.3). The actual implementation of this programme differed between countries, and was fully implemented only in a few cases in industrialized countries (Besant-Jones 2006; Williams & Ghanadan 2006; Gratwick & Eberhard 2008). Nevertheless, this package developed into a technological and institutional template for ESI reform supported by powerful institutions such as the European Commission and the World Bank (Thomas 2006):

"…these reforms gradually crystallized into a standard model for power sector reform, which would be related to countries across the globe…[…]…A number of the consultants involved in the reforms in Chile, Argentina (later) and the UK, subsequently were involved as advisors to development finance institutions and developing country governments, and were often directly involved in the design of power sector reform in developing countries." (Gratwick & Eberhard 2008: 3949)

Table 4.2. "Standard textbook model" for electricity reform

Policy Dimension	Key features
Unbundle	Separate generation, transmission, distribution and marketing of electricity
Privatize	Sell those parts of the system amenable to completion to multiple private firms
Create regulatory institutions	Setup independent regulators to oversee market conduct in the competitive industry and to regulate the monopoly-prone parts of the system
Create markets	Allow markets to function for parts of the system that are amenable to completion.

Source: Victor & Heller (2007: 6)

In much the same way that the dominant system design that emerged in the 1930s was supported by an influential engineering ideal, so the standard package of restructuring

[104] There are a broad-range of market arrangements that have been adopted in different countries, it is beyond the scope of the discussion to investigate these further, Murray (2009) gives a useful technical overview of different market arrangements.

reforms and its technological implications that emerged in the 1990s has been promoted and underwritten by an important body of economic and institutional theory - supported by groups of specialized practitioners – as well as its relationship to the broader neo-liberal program of economic reforms that dominated policy making at the time (Williams & Dubash 2004; Thomas 2006).

4.2.7 Dynamics of ESI liberalization in developing countries

Institutional changes happening in the industrialized world had far reaching implications for the development of the global industry. The standard model of institutional reform was promoted in response to the emergence of increasingly acute problems with the ESI in developing countries coupled with more general macro-economic problems. By the end of the 1980s it was widely recognized that the ESIs in developing countries faced a number of increasingly acute problems (Williams & Ghanadan 2006; Victor & Heller 2007; Gratwick & Eberhard 2008; Tan 2011):

> "Notwithstanding the alleged advantages of the pre-reform structures, from the early 1990s [developing] countries have been experiencing power shortages and frequent interruptions. Their power generating plants emit toxic pollutants, their power utilities are bankrupt, their power tariffs do not cover costs (particularly for residential users), electricity is widely stolen by customers (frequently with the active support of existing employees), many citizens - especially those in rural areas - lack access to electricity supply, and the power sector drains the government's fiscal resources." (Besant-Jones 2006:10)

Many ESIs were caught in a downward spiral of falling revenues and under-investment leading to poor technical performance, which again put pressure on revenues (Jhirad 1990). Gratwick & Eberhard (2008) catalogue a long list of performance failings typical of developing country ESIs at the time, including high transmission and distribution (T&D) losses, low average load factors, very low self-financing ratios, low and falling rates of return, low worker productivity (and over employment), and low levels of electricity access and consumption. Kessides (2005) stresses the problems faced by ESI monopolies in developing countries were a result of underinvestment caused by failure to set tariffs at levels which reflected costs, particularly during periods of high inflation. During the 1980s tariff increases failed to keep pace with cost increases leading to severe capital shortages at ESI utilities (Dunkerley 1995). The capital requirements for the expanding ESI were large. Jhirad (1990) estimated that during the 1990s more than one trillion 1990 US dollars would be needed for ESI investment. Loans for ESI investment during the 1980s accounted for around 25% of public sector foreign debt in developing countries, and as high as 50% of debt in some (Jhirad 1990). The exact problems of the sector varied from country to country, but there was a perception that reforms to improve the performance of the sector were needed.

From the perspective of IFIs, their involvement in developing country ESIs was also problematic. The experience of the World Bank in particular in lending for the power sector during the 1970s and 1980s was poor, projects often under performed, financial and environmental performance were particular areas of concern (Wamukonya 2003). These performance concerns were compounded from the 1980s onwards, by the awareness that IFI resources would not be sufficient to cover the large investment needs in developing countries for rapidly expanding ESIs.

As is often the case, the opportunity for reform emerged out of a destabilizing macro-economic crisis. Global macro-economic conditions had deteriorated as a result of the energy crises and ensuing economic stagnation of the 1970s. By the 1980s many countries were mired in unsustainable foreign debt, budget deficits and high inflation. Developing countries were encouraged to engage in programmes of structural adjustment, opening capital accounts to encourage foreign investment and fiscal austerity reducing government spending (Önis & Senses 2005; Adam & Dercon 2009; Booth 2011). A second round of reforms in the 1990s sponsored by the World Bank and the IMF, promoted neoliberal Washington Consensus economic policies. In need of capital and offering potential for commercialization and revenue generation the ESI was seen as a prime candidate for institutional reform based upon what was regarded as the successful experience of ESI reforms in Chile and the UK (Williams & Ghanadan 2006). By the early 1990s the World Bank made funding to the power sector contingent upon government commitment to ESI reform, including the introduction of competition and enabling private sector participation. Other IFIs followed, including the IMF, ADB and AfDB, which also promoted liberalisation (Williams & Ghanadan 2006; Gratwick & Eberhard 2008).

While IFIs and the World Bank in particular were instrumental in promoting and designing reforms (Wamukonya 2003), it is inaccurate to suggest that developing countries were simply in thrall to the IFIs as some writers seem to suggest (e.g. Thomas

2006). In fact, developing country governments were often keen to comply. Reform of the sector offered the opportunity to attract inward investment into a strategic and politically important sector and remove a significant burden from state budgets (Williams & Ghanadan 2006; Gratwick & Eberhard 2008). The poor performance of the ESI and the perception of high levels of corruption were also a source of widespread political dissatisfaction (Wamukonya 2003). Williams & Dubash (2004) also note that in a number of countries ESI reform was part of a political process as military leaders were replaced by a more democratic polity, the emerging business elites saw reform as a way of breaking-down their political power and the networks of patronage upon which it was based (such as in Argentina, Korea, Thailand and Taiwan) (see also Chapter 3, section 3.2.3). There was also the argument that investment by foreign firms would be a key conduit for technology transfer, bringing up-to-date technologies know-how, management practices and financial skills thereby improving the performance of the sector (Besant-Jones 2006; Hausman et al 2008).

Finally, it should be added that many industrialized countries had a vested interest in promoting reforms. They saw an opportunity for their newly independent and aquisative ESI companies in pursuing investment opportunities in emerging markets. Liberalisation in developing countries could also provide opportunities for a coterie of international consultants, lawyers and project financiers, to generate valuable business (Williams & Dubash 2004; Nepal & Jamasb 2011).

Reform of developing country ESIs took-off relatively rapidly in the 1990s, and by 1998 figures show that a large proportion of developing countries had undertaken a number of steps derived from the 'standard model' (Table 4.4). Reviews of ESI reforms conduced by Estache & Goicoechea (2005) and Besant-Jones (2006), also illustrate the continuing implementation of reforms (see Table A4.1 in data annex). The geographical distribution of reforms was uneven, with Latin America and the Caribbean seeing highest number of countries undertaking the most wide ranging reform efforts and with Sub-Saharan Africa seeing the lowest level of reform.[105] Many countries underwent at least some reforms, with the corporatization of utilities and the entry of independent power producers (IPPs), being particularly common. On the other hand, Besant-Jones (2006) notes that by 2006 only 20 countries had introduced wholesale competition (i.e. for distributors and

[105] Gratwick & Eberhard (2008) note that in some countries low income countries with small power sectors are generally constrained in their ability to adopt reforms.

other bulk buyers), and full retail competition was rare. And it is perhaps significant that there is no case where the full 'standard model' of reforms has been adopted (Williams & Ghanadan 2006; Victor & Heller 2007; Gratwick & Eberhard 2008).

Table 4.3. Developing countries taking key reform steps in the ESI 1998

Corporatize	Pass a new electricity law	Establish regulator	Independent power producers	Restructure	Private generation	Private distribution
51 (44%)	38 (33%)	33 (29%)	46 (40%)	40 (35%)	24 (21%)	21 (18%)

Source: ESMAP 1999 Note: sample of 115 developing countries

The technocratic ideal may not have been realized in developing countries, but the impacts of ESI reform have been significant. The most visceral indication of this can be seen in the expansion of foreign and private capital into the ESIs in developing countries, with investment first peaking at over US$ 40 billion in 1997 just prior to the Asian Financial Crisis and again at a little over US$ 70 billion in 2009, just before the Global Financial Crisis made its impacts felt (Figure 4.15)[106]. Cumulative investments between 1990 and 2011 have exceeded US$ 560 billion, with Latin America and the Caribbean, South Asia and East Asia and the Pacific accounting for 82% of investment. Although these large capital flows should be considered along–side the size of investment needs in the rapidly growing and capital-intensive sector, they clearly represent the significant re-entry of foreign capital into developing country ESIs.

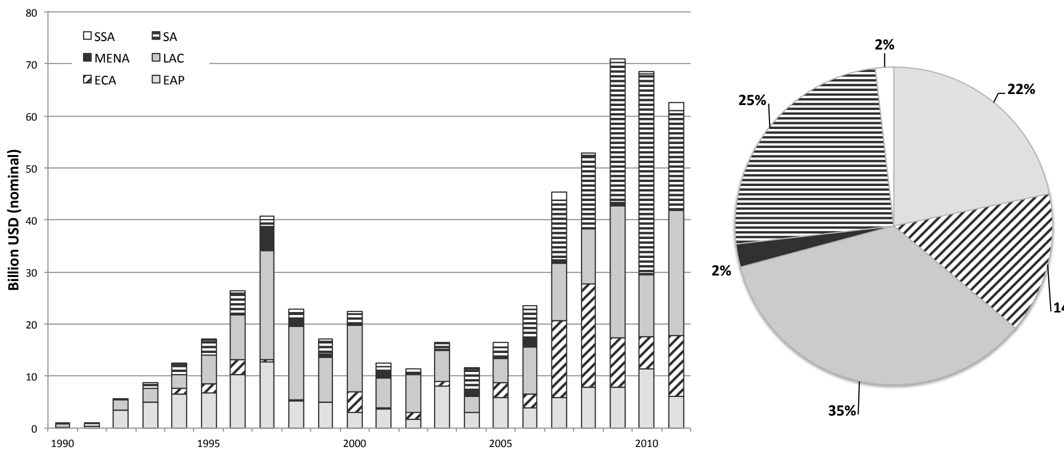
These reforms had coincided with the infrastructure investment boom of the 1990s, and the rapid increase in private investment exceeded initial expectations (Harris 2003; Williams & Dubash 2004; Williams & Ghanadan 2006):

"Development bank prodding alone likely would not have produced such a stampede effect, however, had it not intersected with other elements of the great economic boom…[…]…new commercial interests, aggressive persuasion by Northern governments and unprecedented capital flows. All these elements had specific manifestations in the electricity sphere."(Williams & Dubash: 425)

106 As Estache (2004) points out caution should be exercised with this data as it records commitments rather than disbursements, projects may be cancelled before disbursements are made but figures on these are not available. The likelihood is that commitments tend to over-estimate actual disbursements in boom-times, and are perhaps closer to disbursements during a bust. Nevertheless, commitments are a measure of genuine interest and given the significant investment that initial project identification entails it is likely that they are at least some indication of the magnitude of investment realized.

Similar to the first round of global electrification at the beginning of the twentieth century, freer international capital flows, coupled with an opportunity to invest - enabled by (albeit) partial ESI reforms – allowed the capital needs of expanding ESIs to forcefully reassert themselves. With this private transnational corporations (TNCs) active in the ESI have re-emerged as important players (Annex A4, Table A4.3).[107] The emergence of large TNCs specializing in electricity supply technologies and utilities as a result of liberalization of the ESIs in their home markets, particularly in Europe stands out (Hausman et al 2008; UNCTAD 2008; Kolk et al 2013).[108] The net result of this, Estache (2004) estimates, was that by about 2000, private sector investment had replaced the traditionally dominant ODA as the main source of infrastructure funding in developing countries.

Figure 4.15. Private sector involvement in electricity infrastructure in low and middle-income countries 1990 – 2011 (left) and cumulative (right)



Source: World Bank & PPIAF 2013 Note: SSA – Sub-Saharan Africa; MENA – Middle-East and North Africa; ECA – Europe and Central Asia; SA – South Asia; LAC – Latin America and the Caribbean; EAP – East Asia and Pacific.

The structural implications of the influx of private capital and foreign TNCs to the sector varied between countries and regions. Much of the private sector involvement in Latin America and Eastern Europe was driven by divestiture of assets as Argentina and later Brazil privatized their relatively well-developed ESIs. In South and East Asia greenfield investment to meet rapidly expanding demand was more common. Most of this investment has been in generation, through independent power producers, with relatively little investment in the politically more sensitive and financially less rewarding areas of

[107] While most of this investment has been through M&A activity in industrialized countries, these firms have also have significant investments in developing country ESIs.
[108] Although companies from the USA, Japan and Hong Kong have also been important.

transmission or distribution (Figure 4.16) (Williams & Ghanadan 2006; Victor & Heller 2007).

Reform in developing countries, while falling well short of the ideal of the 'standard model,' has resulted in large-scale re-entry of private capital into the sector, mainly in the form of independent power producers (IPPs) in the generation market. But reforms have not really achieved their initial intentions of introducing the rigors of competition-induced market-discipline to investment choice and utility operations (Thomas 2006; Williams & Ghanadan 2006; Victor & Heller 2007):

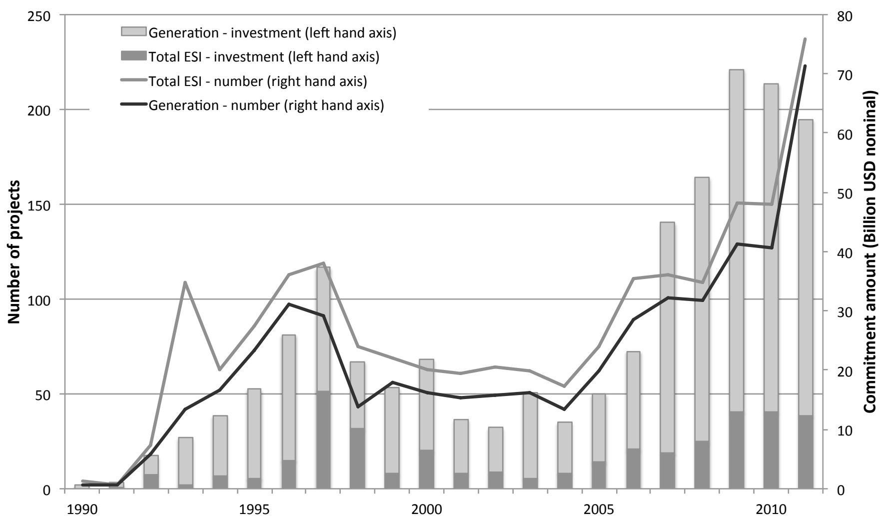
> "It is now evident that implementing sustainable market-oriented electricity reforms is more complex than initially anticipated. Even reforms in developed countries, have led to some unanticipated problems and unintended consequences. Developing countries have had to reform technically and financially less efficient systems with less developed private sectors, weaker economic and political institutions, and less regulatory experience and skilled human resources." (Jamasb 2006: 25)

By the mid 2000s reform in developing countries was perceived as having stalled. Investment had dropped dramatically from a peak before the Asian Financial Crisis (Figure 4.16) TNCs withdrew from a slew of overseas investments. Most famously, AES which withdrew from large investments in the UK after taking heavy losses, as well as investments in India (Orissa), Georgia (Tiblisi), Brazil, Khazakstan and the Bujugalie dam in Uganda (Hall 2005; Thomas 2006; Victor & Heller 2007; Hausman et al 2007; Woodhouse 2006). The French utility GDF Suez announced a reduction in investment in developing countries by one third in 2003. In general, it was felt that the ESI in developing countries had not lived up to its promise of high returns on investment, with a 2003 World Bank survey finding that interest in developing country power sectors had declined dramatically. Reasons given by investors for this reversal included inadequate tariff levels, poor payment enforcement, weak legal foundations for contracts and regulatory frameworks, and political interference (Williams & Ghanadan 2006).

The failure of the 'standard model' to take root in developing countries is generally regarded by the proponents of liberalization as a failure of the process to take adequate account of the broader institutional and related political context for reform. The fundamental problems facing the ESI in developing countries were deemed to rest on the same failings regarded as intrinsic to publicly owned utilities, i.e. they lacked adequate incentives to improve efficiency and performance, had no incentive to avoid investment risk, and were vulnerable to political interference (Bacon 1995; Bacon & Besant-Jones 2001; Besant-Jones 2006). It was felt therefore that a similar program of reform to that adopted in industrialized countries would be appropriate.

However, the issues facing ESIs in most developing countries differed markedly from those faced by industrialized countries. In the latter, problems were generally the result of over-capacity and rising energy prices, and reforms justified by reference to the efficiency of investment and costs reductions to consumers. By contrast, ESIs in developing countries were characterized by the opposite problem, under-investment and tariff levels too low to cover costs. The issues in industrialized countries were ones of improving efficiency and performance in the context of relatively strong legal and regulatory institutions. In developing countries, in general, the requisite institutional framework was generally not in place to allow the emergence of an effective arms-length regulatory approach - namely strong property rights and contract enforcement, guaranteed by an impartial judiciary, and an independent electricity regulator with adequate technical and legal authority to ensure beneficial outcomes (Dagdeviren 2009; Tan 2011; Dubash & Morgan 2012). Political forces were able to subvert what were weak institutional arrangements (Thomas 2006; Victor & Heller 2007).

Figure 4.16. Private sector involvement in electricity infrastructure by sub-sector 1990 - 2011



Source: World Bank & PPIAF 2013

The reform of institutional arrangements had implications for the distribution of benefits and was therefore a politicized process:

"*If reform were only a matter of economics, power systems would not have been experiencing the problems experienced in so many countries*. Political factors cover both the importance of politics and many vested interests, and they include the willingness or opposition of politicians to support a political consensus in favor of power market reform. This consensus is needed because reform entails a redistribution of property rights (to remove politics from the management of public service providers) and formulation of new ground rules (introduction of competition and market-oriented incentives) through changes in laws and regulations. Governments must generate public acceptance and stakeholder consensus for these programs"[emphasis added] (Besant-Jones 2006: 14)

In a process somewhat familiar from the NIE accounts of economic development (Chapter 3, section 3.2), the diagnosis therefore shifted, from failures related to the micro-economics of the sector, to those related to the formation of institutions, to those related to the political process. In this context, the political process was seen as an external constraint to achieving otherwise technically (and socially) desirable reforms. The task of government then was to mange reform effectively through building a consensus for reform.[109] But there emerges from this a tension that is not resolved. The government's role is to build a consensus for performance enhancing reforms. If, as in the case of Latin America, reform has been unpopular, this is deemed not the fault of the reform package, but the fault of government for not managing the reform properly (Kessides 2005; Hall et al 2005). It is precisely this narrow conception of governance that we criticized in Chapters 2 and 3. Rather, it is through a consideration of the historical evidence of the reform process that we are able to achieve a more satisfactory account of what is fundamentally a political economy process.

The reasons why the 'standard model' was not fully adopted, are complex and differ from country to country, but in general relate both to perceptions of the technical performance of reforms, and fundamental political economy processes. Doubts about the technical and economic performance of the model became increasingly apparent during the late 1990s and early 2000s. The Californian electricity crisis in 2000, whatever the actual reasons, was perceived as a failure of the liberalization reforms (Williams & Ghanadan 2006; Gratwick & Eberhard 2008). Secondly, the Asian Financial Crisis

[109] To do otherwise is a governance failure because it leads to 'sub-optimal' outcomes.

exposed some governments, most notably the Philippines to problems with long term 'take-or-pay' agreements made with IPPs.[110] The economic downturn in the late 1990s led to a fall in electricity demand and utility revenues. Under these long-term power purchase agreements (PPAs) the utility was required to pay for electricity that was not generated. In addition, payments usually needed to be made in dollars, the devaluation of domestic currencies as a result of the crisis made servicing these obligations more difficult. In the end, public utilities ended up carrying the investment (supply) risk and exchange rate risk for these projects at great expense (Wyatt 2002; Williams & Dubash 2004).

Privatization was also unpopular in many countries due to the perception that it lead to increased tariffs, people being cut-off when they were unable to afford supplies, and the loss of jobs - particularly amongst unionized workforces (Thomas 2006). Similar to the situation in the post war period in developing countries (section 4.2.3), privatization was seen as serving the interests of elites and foreign capital by generating profits that did not benefit the country nationally. Whereas the costs of reforms were obvious in the shape of immediate increases in consumer tariffs, any benefits only emerged incrementally over a realtively long period of time (Hall et al 2005).

Despite the surge of literature diagnosing the failures of the standard model in realizing market based reform in developing countries in the mid-2000s (much of it referred to here), since the late 2000s private sector investment in developing country ESIs has seen a resurgence (Figure 4.15 and 4.16). Developing country ESIs have not seen either a return of public ownership, or any reversal of the reform steps that have been undertaken (Gratwick & Eberhard 2008). On the other hand, reforms have slowed to a snails pace or stalled in many countries. The characterization of the sector by Victor & Heller (2007) from their research in five major developing countries gives a useful exposition of the current situation, one in which political economy considerations play an important role.

Victor & Heller (2007) argue that while reforms have stalled, the situation can be seen as having reached a new partial equilibrium in which the private sector and large publicly owned and controlled monopolistic electricity utilities exist side-by-side. They argue that

[110] This type of agreement was developed as a means of mitigating some of the investment risks discussed in section 4.2.2. .

a 'dual-market' has developed. The core of the system typically remains owned and operated by state-owned electricity utilities (or their privatized progeny), with private capital (from both domestic and foreign sources) meeting a good portion of grid expansion needs:

"…the power system that has emerged is neither state nor market dominated. Rather, financially viable units (generally privately owned) and insolvent systems (generally state-owned) can co-exist, along with a few profitable state assets, such as generation units. Islands of profitability have arisen within seas of insolvency. Around the profitable islands, hard budget constraints and standard efficient management for accountability prevail. The rest of the system is characterized by opaque budgets, and units are solvent only when they obtain politically controlled allocations of subsidies, soft loans and other special payment and financing arrangements." (Victor & Heller 2007: 283)

Four types of firms feature in this new set of institutional arrangements. Firstly, there is a limited presence of foreign owned IPPs. These generally using new technologies (CCGT, renewables etc.) as mentioned above, these technologies are easier to fund for have lower incremental capital requirements, imply lower construction risk and so are easier for the private sector to finance. They also use technologies that are frequently novel to the country context and so could not otherwise be easily deployed. IPP investors require long-term PPAs (usually from 15-25 years) and relatively high rates of return on investment to offset political and regulatory risks (Hall et al 2009). As a consequence they represent a long-term upward pressure on system costs compared to older technologies, which have fully depreciated their assets and often have access to subsidized inputs. Therefore these firms act both to introduce inertia into the system precluding further reform, and at the same time put financial pressure on incumbent utilities, which are forced to cover the difference between the relatively expensive IPP-generated electricity and controlled end-user tariffs (Woodhouse 2005; Victor & Heller 2007).

Secondly, captive generation at isolated plants, typically servicing large end-users such as manufacturing plants and mines. These are common in locations where grid service is poor and usually function as an ancillary back-up service. These plants use relatively small-scale technologies such as gas turbines, diesel and heavy fuel oil, to this we may also add CHP technologies (Wu & Wang 2006). In so far as these plants are used as a back-up for grid supplies they may not pose a threat to the system. But if the quality of service provided by the grid declines markedly, the prices charged to these consumers increases, or the costs of power from increasingly efficient isolated plants declines then there is the possibility that these large users will exit the grid. In this case, grid based suppliers will lose valuable customers whose use often cross-subsidizes that of poor and rural users (Victor & Heller 2007).

Thirdly, state-owned elements of the ESI utility. This is typically composed of the insolvent rump of a partially reformed power sector, including transmission, distribution and retail and some generation assets and is typically marked by heavy levels of subsidies. Generators will have inherited old technologies usually including some mix of hydropower and coal, however assets are fully depreciated, inputs are subsidized and electricity can be generated cheaply. The degree of solvency or otherwise of these firms is determined by the extent to which 'asset sorting' has taken place. This is a process by which the better performing solvent parts of the system are sorted out and hived off from the insolvent rump. In some countries this may have progressed substantially, in others not at all (Victor & Heller 2007).

Finally, firms which have aspects of both private and public sector entities, what Victor & Heller (2007) call 'dual-firms'. These may be owned privately or operated as state owned corporations. They benefit both from better organization and operating practices associated with private firms, but also enjoy close political connections with government that makes investment of large sunk costs in a weak institutional climate possible. Importantly, this combination of commercial orientation and political connections makes them better able to mobilize the level of financing needed to meet growing demands than the other types of firm. These firms are composed of both dedicated utilities but may also be companies with broader interests in electrical and engineering manufactures, or fossil fuel extraction. They are also typically the vehicles for large capital investment projects such as nuclear and large hydropower dams. This includes examples from OECD countries such as EDF (France), Iberdorola (Spain), and E.ON (Germany), TEPCO and Mitsubishi (Japan), but also from developing countries such as EGAT (Thailand), ESKOM (South Africa), Tata and Reliance (India), China Power Investment Corporation and China Huaneng Group, as well those from smaller economies such as Kazakhyms (Khazakstan) and Petrovietnam (Vietnam). These firms have the flexibility to manage the unstable environment presented by operations in emerging economies by tapping government support through their political networks. (Victor & Heller 2007; Williams & Ghanadan 2006).

Not all these types will be present in all systems, but this typology does illustrate the pressures partially reformed ESIs in developing countries face. Victor & Heller (2007) note that while there are forces exerting inertia on the system such as fully depreciated assets and long-term PPA agreements, other factors such as cost pressures, capital needs to meet expanding demand, and the need to control politically unpopular tariff increases may lead to instability. This model also serves to emphasize the importance of political economy considerations, which they warn should not be considered as:

"…simply "barriers" that can be cleared with enough political will. Economists and investors must consider the likelihood that fragmented and transitory systems are reasonably stable political economic orders." (Victor & Heller 2007: 305)

This is particularly the case in weak institutional contexts, and in the case of many developing countries one in which there may be a significant gap between the interests of those in power and the rest of society, a gap which is narrowed, perhaps only a little by mechanisms ensuring better state accountability.

4.2.8 Distilling the implications for technological change

The emergence of what we have called the dominant system design in the 1930s, and the dominant institutional form of state-owned (or controlled) monopolistic provision of electricity services by the 1970s was marked by a degree of convergence. The fundamental technological and economic characteristics of the ESI and associated performance benefits to the techno-economic paradigm, conferred positive performance and political benefits which could be better appropriated and controlled through public ownership. By contrast, the period of reform since the 1980s represents a divergence in institutional outcomes across countries. Nevertheless, within the wider range of heterogeneous outcomes patterns emerge that serve to re-emphasize the fundamental characteristics of the ESI and the importance of political economy processes.

Firstly, physical constraints in terms of technology and energy resource availability have been fundamental to enabling institutional change in the sector. Pressure on incumbent institutional arrangements came from the failings of the energy supply system in the

1970s. These included the oil crisis, large unanticipated nuclear costs, and the emergence of 'technological stasis' leading to the end of IRS that had underwritten the expansion of the sector for 90 years. On the other hand, the smaller efficient scales of technology, the availability of better ICT systems for management and control of the sophisticated systems needed to operate a system based on competitive markets and the availability of new energy sources such as natural gas acted to facilitate reform. Reforms in turn further promoted the use of these facilitating technologies.

Secondly, technological change alone was not sufficient to realize momentum to reform the ESI. The pursuit and elaboration of political power formed an important basis for the adoption of the standard model of reform which was previously untried and untested. The physical constraints enumerated above lead to tariff increases which were politically unpopular. This dissatisfaction was given a neo-liberal ideological rationale which suggested publicly owned utilities should be expected to perform poorly and empahsised the advantages of private ownership.[111]At the same time the pursuit of vested political interests not directly realted to either the performance of the sector or ways of understanding it also played an important role. This was an act of Schumpeterian creative destruction, as old industries and configurations of power were broken and new vested interests asserted themselves – this time in the form of large international ESI companies and a body of professionals dedicated to reform of the sector. Technological and institutional change was subordinated to the articulation of political and economic power.[112]

The experience in developing countries also speaks of a predominant role played by political economy. Macro-economic constraints, public dissatisfaction, rapidly expanding capital needs, and in some contexts, the desire to rearrange power relations. External pressure from the ideologues of the IFIs likely played a secondary role in most cases. Politics also explains the limits to reform as higher tariffs and foreign ownership were unpopular, and the weak institutional environments that facilitated patronage relations, represented a risk that drove up investment costs.

[111] Or in the USA, protected monopolies could be expected to perform poorly.
[112] Indeed while not reviewed here the outcomes of these reforms in terms of ESI performance has been equivocal (Erdogdu 2010; e.g. see for recent analysis Erdogdu 2011a; Erdogdu 2011b).

Finally, liberalization reforms were based upon an economic and institutional ideal that did not fit well with the fundamental characteristics of the sector. Since the 1990s these characteristics have largely reasserted themselves as private sector investors seek a guaranteed return on their investment, and monopolistic power abounds in most markets, which in turn need to be tightly regulated. In developing countries, where ESIs are dominated by capital needs and constrained by the exercise of political power and patronage, institutional arrangements remain in flux. Indeed, in the case of both developing and developed countries there are indications that changing ESI technologies and imperatives are likely to have profound implications for the future development of the sector.

4.3 Conclusion: Political settlements, holding power, rents and the ESI

We are now in a position to understand the implications of the historical record and draw some initial conclusions relating to the development of the ESI. Exactly how policy pressures are likely to be elaborated depends upon the political economy context. We should recall that, from a political economy perspective the role the ESI plays is *not* best understood as the delivery of a public service, and the best means of managing the ESI is *not* best regarded as a means of realising socially optimal solutions. Rather to understand the choices made about the management and operations of the ESI, the institutional arrangements, and the flows of resources associated with them, it should be regarded as a political economy process. That is to say it should be looked at with a view to uncovering the way in which the ESI functions to create and reinforce patterns of power. This is *not* to say considerations of technical performance or societal outcome are unimportant. Quite the opposite, the provision of this essential good may be central to maintaining a particular distribution of power, but it is to say that *if they are important they are likely to be mediated through the political economy processes.*

The key benefit to flow from the sector is the provision of an electricity service, which can be put to all sorts of productive and consumptive uses. The sector also has the potential to produce a number of general public goods including direct and indirect employment, strategic targeting of resources (e.g. to heavy industry), to promote equality and poverty reduction (though the cross-subsidisation of prices), and environmental protection (i.e. reduction in environmental harm) (Jaccard 1995).[113] Additionally, it is the source of less widely disbursed benefit streams accruing to power sector financiers, technology and fuel suppliers, project developers, utility owners and the government, to name but a few. All these groups stand to benefit from the sector. The pattern of benefits accruing to each of these groups depends upon the institutional arrangements of the sector. As argued in section 4.2, institutional arrangements in the ESI in turn depend upon the interaction between the nature of the technology and the economic implications of this, and the broader disposition of power in a particular context.

Changes in technologies or institutional (formal and informal) arrangements that may alter the distribution of benefits are likely to be opposed (promoted) by those who stand to lose (gain).[114] Changes in the disposition of power in the groups that are able to appropriate these benefits is likely to lead to changes in technological or institutional factors that determine the distribution of those benefit flows. For example, according to Hughes, in the USA the opposition and subsequent failure of the Giant Power project in 1925 was explained as a result of incumbent utilities protecting the economic benefits that accrued to them through existing arrangements, and resisting the formation of new technical, economic and institutional arrangements (Hughes 1976). And Coopersmith's (1993) example of the Russian Revolution, is a good example of the latter case.

This is not to say that actors are not often highly constrained, or that they had a perfect insight into the prevailing conditions or the implications of their actions, far from it. Essentially random changes in resource endowments or access can have destabilizing impacts such as the implication for the coal-mining sector in the UK of the discovery of North Sea oil and gas (Turnheim & Geels 2012). Technological advances are notoriously unpredictable, the importance of civilian nuclear power did not inform the US research program, nor later were its significant costs foreseen (Cowan 1990; Grubler 2010). Patterns of institutional reform in the 1980s and 1990s also had unexpected effects, such as the impact of PURPA on the adoption of CCGTs and gas consumption more generally, the implications of sector liberalisation for the nuclear technologies, the

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113 There are some very specific public goods associated with the sector which are not included here, but from hydropower could include flood protection and water supply for irrigation, and possibly from fast-breeder nuclear reactors, plutonium for armament manufacture and the provision of national security.

114 Changes are unlikely to start with institutional arrangements as we have argued they are generally the result of interactions between technology and the disposition of political power. Unless they are enforced from outside the system. Arguably this has been the case with liberalization reforms in the sector, and especially in the case of developing countries, the essential techno-economic characteristics of the sector and associated power relations have reasserted themselves.

Californian Energy Crisis or the need for the renegotiation of IPPs in Latin America and Asia (Williams & Dubash 2004; Williams & Ghanadan 2006; Hirsh 2007; Hausman & Neufeld 2011). The private sector has also seen its share of imperfect foresight. To wit, the billions lost by AES in India, Uganda and the UK stand testament. But this is not to say that human agency is inconsequential, nor history 'just one damn thing after another,' as Hirsh & Sovacool (2006) note in their review of technological change in the US ESI:

"…stakeholders play important roles in channeling momentum. Though they may not always realize the consequences of their actions - contributing to forces that alter momentum in unanticipated ways - people remain at the core of technological systems because of their concern for political control, influence, money, and power…" (Hirsh & Sovacool 2006).[115]

The problem is to identify the systematic elements, the regularities that characterise behaviour in the sector. We have illustrated a number of fundamental technological and economic characteristics of the ESI that recurrently influence investment decisions in the sector, i) large sunk costs and capital intensity; ii) the monopolistic nature of electricity service provision; iii) the wide range of public and private goods generated by the sector (employment, pollution abatement, upstream and down stream linkages). To this we can add, equally important but contingent, iv) natural resource endowments. These in turn give rise to appropriable benefit streams or economic rents (described in Chapter 3, section 3.3.2).

The distribution of these rents is determined by the both formal and informal institutional arrangements that characterise the ESI. That is property rights, levels of taxation and subsidy, government policy, and informal patronage networks. It should be noted that rents are not guaranteed but are have risks associated with them. The expected rent will be some function of the available appropriable rent and an assessment of risk. Risk perceptions will be extremely important in determining investment and policy choices relating to the sector, given sunk costs, capital intensity, the political importance of the sector, increasingly acute sectoral pressures (highlighted in section 4.3), and on-going institutional and technological change.

[115] The author fully endorses this view of history, a view shared by Heffer: "All major 'historical' events have been motivated either by the preservation of the degree of privilege that comes with sovereignty in all its forms (including spiritual), or the desire to expand it. The pursuit of power through history has largely been a manifestation of the aggressive and competitive nature of men (and almost always men): that is clear from Thucydides onwards." (Heffer 2011: 7)

The institutions which determine the allocation of rents are in turn a function of holding power.[116] As noted in Chapter 3, the stability of the political settlement is dependant on the distribution of rents being consistent with the disposition of holding power. Where it is not there will be pressures for reform, and where there is consistency between the two there will be, *ceritus paribus*, a tendency for inertia. Any equilibrium between holding power, institutional arrangements and benefit flows is likely to be temporary, as external factors are likely to influence the system. Moreover, as both North et al (2009) and Khan (2010, 2012) argue, some social orders are likely to be more stable than others.

Our contention here is that for a particular set of institutionally intermediated patterns of rent distribution, and the associated distribution of holding power to be stable, it must be concordant with the patterns and magnitude of rents generated by a techno-economic paradigm. In this case, it must in some sense be consistent with the technological and economic characteristics of the ESI. If a technology is perceived as a threat to a particular settlement it may well face barriers to its wider use. If it enhances existing distributional patterns, it may benefit from political momentum. Conversely, changes in the structure of societal power may influence technological choice.

Thus the maintenance and pursuit of these rents and associated patterns of power is a dynamic process. The ability of a group to mobilize power and influence these processes can be thought of as depending on three broad characteristics, identified by Mokyr (1992, 1997) and Moe (2009, 2010) (see Chapter 2, section 2.2.4 and Chapter 3, section 3.3), we are now in a position to articulate how this it likely to be experiences in the ESI. Firstly, the strength of the incentive to oppose (promote) technological change, for example in the strong opposition from municipalities to interconnection (and state regulation) in the US due to prospective loss of politically important quasi-rents, or the opposition of utilities to Giant Power and Super Power in the US, and the development of the National Grid in the UK (Hughes 1976, 1983).

[116] See section 3.3.2 in chapter 3. It should be noted that holding power in Khan's conception is predominantly articulated in terms of economic power, but it should also be through of as including ideological power and coercive power. It can also be thought of as roughly equivalent to political power. Articulations of power can be complex, and in many cases closely interact with scientific or technological vested interests. A technological vested interest often provides a fig-leaf for more fundamental articulation of power. For example, arguably the arguments of economists relating to the privatisation of the ESI in the UK were a fig-leaf for a more fundamental power struggle between the miners unions and the Conservative party during the 1980s.

Secondly, the extent to which costs and benefits are concentrated amongst winners and losers. The paradigm example of this may be resistance to hydropower projects by surrounding communities. We may add to this that the perception of a loss may be opposed more effectively by cohesive groups such as miners or nuclear industry workers. Business or technical experts whose competitive advantage is bound up with particular technologies may be particularly obstructive. The technological complexity and specialised skill sets required by the ESI means that the sector is replete with these groups, including hydropower, nuclear and systems engineers, which tend to favour technologies associated with their skill set (Hughes 1983b; Unruh 2000; Greacen & Palettu 2007). The groups of economic consultants, lawyers and project financiers involved in the liberalisation process since the 1990s would also seem to fall into this category (Thomas 2006; Gratwick & Eberhard 2008).

Third, the position of those in power as regards the technological change. The interests of this group are likely to be bound up with the performance of the sector in delivering goods to wider society, but also with narrower self-interests realised through patronage networks, particularly where formal institutional arrangements are weak. Although there may be a tendency to inertia in a stable political settlement, there also will be periods of rapid change in response to pressures internal and external to the sector. Examples include, the promotion of nuclear generation technologies in France, Korea, Japan and China, or PURPA in the US in response to long-term energy security concerns; the promotion of large hydropower projects in East and South East Asia; and, the development of wind power industries in Denmark, India and China (Hadjilambrinos 2000; Lewis 2007; Urban et al 2012; Walz & Delgado 2012; Silva & Klagge 2013).

To be sure, there are complex interactions and feedbacks between each of these elements. For example, politicians pursuing their own vested interest use the 'objective' and 'scientific' advice of technical experts pursing theirs, and close-knit groups who stand to lose everything such as mine workers, are better able to mobilise than dispersed groups who stand to benefit marginally. In this regard environmental and climate change considerations stand out as problematic, the incentive is small as immediate losses are relatively small and are dispersed amongst different groups. Conversely, addressing these issues would imply disrupting large rents, which are concentrated in powerful groups.

It is worth stressing again that this cannot necessarily be reduced to a narrow material self-interest. The role of ideology has occurred as important in many cases, socialism, nationalism and environmental concerns have all been important to a greater or lesser extent. Similarly, physical coercion (whether it be a physical conflict at picket lines, or the forcible resettlement of households to make way for a hydropower project), has also played an important role in some circumstances. But it remains the contention of this thesis that above all else material or economic power and the wherewithal to appropriate this has been the most important way in which power has been articulated in the sector and this is reflected by the focus on rents.

It is extremely difficult to generalise about institutional and political economy factors. They differ considerably within different contexts, and it is to the elaboration of a particular political economy case study, and its relationship to technology choice in the ESI that we turn in Chapters 6 and 7. As regards technologies, however, there are some determinate generalisations we can make about the particular rents associated with different technologies, which will be important in understanding how the political economy is likely to be related to technologies. These have been outlined in Table 4.7. Finally, it should be noted that the existence of rents in the conception we use here is dependant not just upon a changing structure of rights, but upon changes independent of those structures. For example, fossil fuel rents will only last as long as fossil fuel supplies, demand for some resources or technologies may wax or wane, or technological innovation may create some rents and destroy others.

Table 4.4. Main economic rents associated with the ESI, technologies and groups

Rent	Description	Types of technologies and role	T
Natural resource rents	Difference between the cost of extraction, processing and transport and consumptive value.	All technologies have natural resource rents associated with them. However, they are likely to be largest for hydropower and low heat rate coals, although also significant for most fossil fuel thermal technologies. For renewables may be off-set by high technology costs. These rents may be undermined by energy efficiency technologies or alternative fuels.	E a E t h e
Monopoly rents	Difference between the long-term marginal cost of supply of the utility and the long-term marginal cost of supply for the customer.	Particularly associated with technologies with large-scale economies and technologies (coal, hydropower, nuclear). Intermittent technologies that benefit from being part of a large grid (hydropower, wind and solar). Smaller scale technologies, energy efficiency technologies, or technologies that promote distributed generation may undermine these.	U c r c
Quasi-rents	Difference in long-run marginal cost and short-run marginal cost. Appropriable in short to medium term.	Associated with large sunk costs involved in the sector in general. Are likely to be larger for more capital-intensive infrastructure, and where recurrent costs (O&M, fuel etc) are low relative to capital costs. Exmples include, hydropower, possibly renewables, but extend to the sector in general. These rents can also be extended up-stream to accound for differences in long-run and short-run marginal costs in the development of fossil fuel resources.	C E
Rents for innovation and learning	Cost or quality advantage yielding higher return not achievable by the owners of the next best technology.	Accrue to holders of IP rights, or otherwise excludable technological knowledge. Less likely to be associated with old incumbent technologies, but technology that allows integration of renewables, or technologies such as renewables that improve efficiency and environmental performance of technologies.	I r E u
Rent based transfers	Transfers of other rents appropriated through the political system (formal and informal).	Not generally associated with particular technologies. As regards the ESI can be a means by which cross-subsidisation of favoured end-use sectors, or groups, or particular generation technologies (e.g. renewables and nuclear) are funded, or can be appropriated through taxation, corrupt payments or other mechanisms.	E p E F C c

Source: Authors own adaption based on Khan 2000; Khan & Blankenburg 2009

Chapter 5: Introducing the Vietnam case study

5.1 Introduction

In Chapters 2, 3 and 4 we have started to describe a possible approach to understanding the relationships between political economy and technological systems with a particular focus on electricity systems. In Chapter 4 we noted that the ESI has important technological and economic characteristics, which through economies of scale and scope have been important in determining a dominant system design. These factors are more or less dependant upon available technologies and as such exert similar influence on the ESI the world over.

The institutional arrangements surrounding the sector to a large degree have answered these same technological and economic needs. Change in institutional arrangements, however, has tended to be slower, and institutional outcomes have tended to be more heterogeneous.[117] We contend that the primary reason for this is the crucial role (formal and informal) institutional arrangements play in intermediating the resource flows generated by the technological system such that they are consistent with the distribution of holding power. We have illustrated the role of holding power and political economy in the ESI in Chapter 4 by showing how in some cases vested interests have slowed institutional convergence in the ESI, just as in other cases political crises have provided opportunities for change.

The relationship between technological change and the political economy is complex. We have argued (Chapter 3, section 3.2 and Chapter 4, section 4.4) that a useful way of approaching this is through understanding the flows of rents associated with different technologies (Table 4.7).[118] Identifying the sources of rent generation and the groups that are able to appropriate those rents helps illustrate both where inertia and resistance to change is likely to emerge and where possibilities for technological change may emerge.

However, the analysis so far has only allowed the identification of general types of rent likely to be associated with the ESI and groups to whom they typically accrue. Institutional and political economy arrangements differ greatly between countries and are

[117] As described in Chapter 2, section 2.6, this is a consequence also of the particular micro-foundational dynamics of institutional and political arrangements, i.e. weak negative feedbacks and strong positive feedbacks to political power.
[118] Mokyr's typology of political resistance to technological change is also useful in illustrating factors other than rents alone are important in determining the extent to which change is obstructed, emphasizing the perceptions, the ease of collective action and the role of the state.

highly contingent, dependent upon, *inter alia*, natural resource availability, climate, geography, demographics and history. Therefore, to arrive at an adequate understanding of how technological change and the political economy are related in any particular case will require the development of a country case study. In this this Chapter we introduce the case study methodology and give background for the chosen case study country, Vietnam.

This short chapter has two main functions, the following section gives a brief rationale for the choice of Vietnam as a case study and section 5.3 gives an overview of the literature on the political economy of Vietnam with a view to setting the scene for a more detailed discussion of the political economy of Vietnam's ESI in Chapter 6.[119]

5.2 Vietnam as a case study

The choice of Vietnam as a case study country is primarily pragmatic, based on the researcher's experience of the country and access to data. Nevertheless, there are a number of compelling reasons to consider Vietnam (section 5.4 and annex 6A for greater detail). Since the beginning of the 1990s, and following the start of the gradual institution of economic liberalization policies Vietnam has had one of the most rapid economic growth rates in the world, with an average real annual GDP growth in excess of 7% between 1990 and 2010. Along side this growth Vietnam has seen dramatically increasing electricity demand running at approximately double economic growth rates between 1990 and 2010. This rapid growth is expected to continue with electricity demand expected to increase from around 100 TWh in 2010 to 400 TWh by 2030 (MOIT 2011). Vietnam's status as a rapidly growing economy, and the concomitant rapid structural and institutional change the country is undergoing make it an interesting case study. The rapid growth of the ESI over the last two decades and expected rapid future growth, particularly in fossil fuel thermal generation capacity mean that it is of interest in exploring the barriers significant to GHG abatement in the ESI. Finally, as there is no political economy research on the ESI in Vietnam this means that a case study of Vietnam's ESI is a novel contribution to the literature.

5.3 Vietnam's evolving political economy context

Vietnam is generally perceived as a development success story (Commission on Development and Growth 2008; Cling et al 2009). Vietnam's 'liberalisation' process –

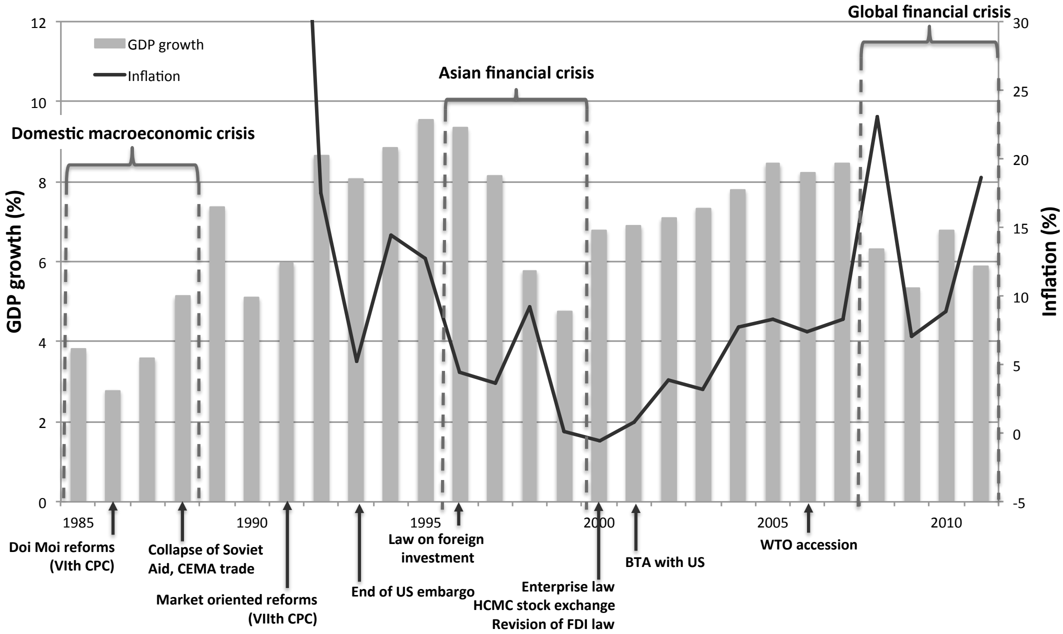
[119] Methodological and epistemic considerations relating to the case study are discussed briefly in Annex 5A.

moving from a centrally planned command economy to more market based allocations of resources - and consequent economic growth and poverty reduction have become the trite platitudes that have uncritically launched a thousand donor reports. Defying the urge of semantic satiation, Table 5.1 and Figure 5.1 illustrate the remarkable pace of economic development in Vietnam since the early 1990s. In the two decades between 1990 and 2010, Vietnam saw an average annual real GDP growth of 7.4%, coupled with relatively modest population growth, this lead to dramatic increases in per capita GDP and declines in the poverty rates (Rama 2008; GSO 2013; World Bank 2013). Rapid export driven industrial growth and large capital inflows have been key growth drivers as Vietnam incrementally opened its economy to trade and foreign investment. This was accompanied by dramatic social change marked by falling population growth, employment growth in the manufacturing sector and rapid urbanisation. Here it is not our purpose to investigate Vietnam's economic performance or prospects in detail, suffice to note that Vietnam has seen remarkable levels of economic growth and development over the last three decades.[120]

The political economy of Vietnam's economic performance in the reform period remains the subject of considerable academic contestation. The broad contours of the impetus for reform and of economic performance in the reform period are generally agreed upon. The meat of the debate focuses upon an understanding of the role and efficacy of the state and polices adopted in the *Doi Moi* era. This goes the heart of our concerns in understanding the political economy of Vietnam, and it is with this in mind that we move onto section 5.3.1.

[120] Annex A5.1 gives an overview of the economic context for interested readers.

Figure 5.1. Overview of key macro-economic and policy developments in Vietnam 1985 - 2011



Source: Author

Table 5.1. Key social and economic indicators for Vietnam 1990 and 2010

Indicator	1990	2010
Population (million)	66.0	86.9
Urbanisation rate (%)	19.5	30.5
GDP (2000 US$, billion)	15.0	62.8
GDP (current US$, billion)	6.5	106.4
Of which (%):		
Agriculture	*38.7*	*20.6*
Industry	*22.7*	*41.1*
Services	*38.6*	*38.3*
Employment (million)	29.4[d]	49.1[c]
Of which (%):		
Agriculture	*73.0*[d]	*49.5*[c]
Industry	*11.2*[d]	*32.3*[c]
Services	*15.7*[d]	*18.2*[c]
GDP/capita (current US$)	98	1,224
Poverty headcount ratio at USD 1.25/day (PPP) (% of population)	63.7[a]	16.9[b]
Net FDI inflows (current US$, million)	180	8,000
Gross capital formation (% of GDP)	12.6	38.9
Exports (current US$, billion)[c]	2.4	72.2

Note: a – figure for 1993; b – figure for 2008; c – figures from GSO 2013; d – figures from GSO 2003
Source: GSO 2003; World Bank 2013; GSO 2013.

5.3.1 Characterising the political economy of the reform period

We argued at length in Chapter 3 that the process of economic development is one that can only be properly understood through an analysis of the underlying political economy (Chapter 3, section 3.1). For development to be sustainable in the long run, patterns of wealth created by economic activities need to, in some sense, comport with the disposition of political power. A dynamic and dislocating economic transition of the sort Vietnam has been experiencing implies a large change in the scale and type of economic activity, the mechanisms of wealth generation and rents associated with this. It typically entails concomitant changes in distributional processes and outcomes to maintain the stability of the political settlement, in much the way Beresford (2008) has in mind in her writing on the legacy of *Doi Moi*:

"All states in modern societies share two common functions: they need to facilitate sustainable capital accumulation as well as maintain legitimacy of the regime. These two do not occur in isolation from each other, although that may happen in the short to medium term. Successful late industrialisers appear, with ups and downs, to have achieved both. Often beginning with authoritarian regimes, they have succeeded not only in promoting high rates of accumulation and growth, but in spreading the benefits in a way that blunts and isolates opposition…[…]…Politics and economics are thus inextricably intertwined, although the essentially political nature of alliances is not always clearly visible" (Beresford 2008: 223 - 224)[121]

Vietnam is no exception to these political-economy dynamics. Since reunification in 1976, as a single party socialist state the Vietnamese Communist Party (CP) has been able to maintain a monopoly on decision-making within the formal political institutions of state, ostensive ownership and control over key economic sectors, and the considerable societal power associated with this. But, it has only been able to do this through spreading the benefits of economic growth to maintain popular consent and popular legitimacy (Thayer 1992; Van Arkadie & Mallon 2003; Masina 2004; Kerkvliet 2005; Fforde 2007; Penrose et al 2007; Thayer 2009; Thayer 2010; Vuving 2010; Beeson & Pham 2012).[122]

Unpacking the components of this 'popular consent' Carlyle Thayer (2009, 2010) identifies three main sources of the CP's political legitimacy since reunification, namely i)

[121] Indeed, as noted in Chapter 3 a very similar case is made by the report of the Commission on Growth and Development (2008) and increasing numbers of scholars, although as we have endeavored to argue in that section, the understanding of political economy is still hobbled by the implicit teleology of the neo-classical canon.

[122] As Kerkvliet (2005) puts it: "The Communist Party government's base of support remains in the peasantry. Were it to lose that backing, its days would be numbered."(242)

nationalism; ii) ensuring political and social stability; and, iii) delivering economic and social development. Firstly, nationalism has been closely associated with developmental states as a key source of state legitimacy (Beresford 2008). In Vietnam this had a particular resonance following thirty years of nationalist struggles against the French (1946 – 54), the US (1958 – 75), China (1979) and the Khmer Rouge (1978 – 89), and the ongoing threat posed by China (Vuving 2010; Thayer 2010). Secondly, Thayer (2010) argues that given the long experience of armed conflict, the CP's role as a guarantor of political and social stability should also deemed a key element in maintaining the CP's legitimacy. Finally, the delivery of the widespread benefits of economic and social development – either through a realization of socialist modernization, or in the *Doi Moi* era, as market based economic growth and poverty reduction:[123]

> "The legitimacy of Vietnam's one-party state since 1986 has largely rested on performance legitimacy, that is, success in delivering economic growth, and the maintenance of political stability for society at large. In this respect the regime has been very successful as measured by high GDP growth rates accompanied by a marked decline in the national incidence of poverty. " (Thayer 2010: 440)

In this way, the source of party and state legitimacy has evolved over time. As war veterans die, and the memory of the years of conflict lift,[124] the sources of legitimacy have shifted. From the CP as victor and champion of successful nationalist struggles in the twentieth century, to the CP as guarantor of post-conflict social stability, to the present day and the increasing importance of ensuring the benefits of economic growth and development are shared widely enough amongst the general population. Thus ensuring good economic performance and continuing poverty reduction is regarded as essential to the long-term maintenance of CP authority and power. The need for popular consent is amply illustrated by the adoption of *Doi Moi* reforms, the economic crisis posed a severe crisis of legitimacy for the CP, deeply held socialist tenants were dropped in favour of maintaining CP power.[125] In the context of our concerns here, the provision of basic goods and services has been an important part of this performance. Since 1975, Vietnam has seen significant improvements in provision of basic health, education and infrastructure services (UNDP 2006; World Bank 2006a; World Bank 2011b).[126][127]

[123] Thayer (2010) divides this source of legitimacy into two, i) socialist modernization; and, ii) market based economic reform, growth and poverty reduction. However, here we regard both these sources as essentially in the same in that

[124] Over 60% of the population in Vietnam was born after 1975 (GSO 2013).

[125] See annex A5.3 for more background on Vietnam's recent economic history.

[126] For example, electrification has increased from 2.5% of households in 1976 to 96% of households in 2009 (World Bank 2011b).

Although it should be said that nationalism also remains an important source of state legitimacy insofar as the CP is perceived to be standing up to the sovereign threat posed by China's territorial ambitions in the South China Sea (Thayer 2008; Vuving 2010; Thayer 2011).

As far as it goes, there seems to be a general consensus in the literature around the key sources of CP and broader state legitimacy in Vietnam. Where the difference of opinion lies is in the understanding of the effectiveness and coherence of the state. On one hand, writers such as Van Arkadie & Mallon (2003), Luong (2007), Beeson & Pham (2012), Beresford (2008) and Thayer (1992, 2010) tend to regard Vietnam as a more-or-less effective developmental state, which has been able to evade capture by narrow factional interest groups and as such maintain policy autonomy *where it matters,* enabling the state to realise developmentally desirable outcomes. On the other hand, writers including Fforde & De Vyler (1996), Fforde (2007, 2009, 2012, 2013), Gainsborough (2009a, 2009b, 2010), Masina (2004), Painter (2008) and Perkins & Vu (2010) tend to stress the weakness of the state, its capture by elites and the somewhat vestigial role of government policy in Vietnam's economic transition (Fforde & De Vylder 1996; Beresford & Fforde 1997; Masina 2004; Fforde 2007; Gainsborough 2009a, 2009b, 2010). For this second group of commentators there is a big gap between maintaining 'performance legitimacy' in the way the CP has been able to, and being a successful developmental state in a similar mould to Taiwan or Korea. This distinction has important implications for understanding Vietnam's political economy context.

5.3.2 Understanding Vietnam as a developmental state

The former account - in which Vietnam is best understood as a developmental state – the Vietnamese state and its policies are regarded as having been instrumental in realising the rapid transformation of the Vietnamese economy over the last three decades, to cite Van Arkadie & Mallon (2003):

"Viet Nam has combined a willingness to shift vigorously towards using market policy instruments and maintaining a fairly orthodox macroeconomic stance, while maintaining an *active role for the state*, particularly in investing in infrastructure and human resource development, and in providing strong planning and

[127] While evidence on the public perception of the reform programme and support for the CP is limited, a recent paper by Migheli (2012) presents evidence of broad support for the CP and reform programme. It also points to declining popular support between 2001-2006, the weakening of CP legitimacy is noted by a number of other authors, especially related to issues of corruption and economic mismanagement (e.g. Fforde 2012, 2013; Thayer 2010).

policy guidance regarding medium-tem growth and equity goals…[…]…*in a broad sense, Viet Nam can be seen as yet another variation in the East Asian model of the developmental state.* The approach has been both flexible in the use of market instruments and pragmatic about the requirements for active state intervention to develop infrastructure and market institutions and influence the allocation of resources to realize national and social development goals" [emphasis added] (Van Arkadie & Mallon 2003: 253)

Van Arkadie & Mallon (2003) stress the continuity and stability of political institutions, allowing decisive macroeconomic policy when called for, a gradualist approach to reforms adopted through a consensus building process which lead to real 'ownership' of reforms 'facilitating profound institutional change.'[128] Despite recognition of the impact that decentralization has had on the power of the central state and the importance of informal institutional arrangements, the state is viewed by-and-large as effective in realizing developmental goals. Close connections between the organs of the state, industry and agriculture have been efficacious in the formation of economic policy, either through the active solicitation of feedback or, in some cases, lobbying for policy change (Van Arkadie & Mallon 2003; Kerkvliet 2005).[129] Part of this process has been the formal institutionalization of informal (and if not illegal then frequently in contravention of policy) practices followed at the local level (so-called "fence-breaking" activities), which has also turned out to be an effective method of policy formation. This pragmatic openness to feedback on policy is deemed to be an important element of state strength:

"The differences in [policy] interpretation partly reflect the gap that often exists between the definition of objectives and policies at the national level and the pragmatic accommodation of the decentralized decisions of individual actors in the economy, even when in apparent conflict with stated policies…[…]… *this pragmatic willingness to accept change resulting from decentralized initiatives is indicative of the strength of the state*."[emphasis added] (Van Arkadie & Mallon 2003: 253)

On this account, the Vietnamese context is regarded as some variant of 'alliance capitalism' (Wade 2004; Beresford 2008).[130] Beeson & Pham (2012) adopt a similarly statist line, suggesting that the Vietnamese government has been able to effectively control 'strategically significant parts of the economy'. They argue the state's direction of

[128] In this account there is an implied and sometimes explicit account for the big bang reforms of Eastern Europe and the Russian Federation, at the time Van Arkadie & Mallon (2003) were writing in the wake of the Asian Financial crisis a defense of the developmental state by drawing this contrast with the perceived problems of other former communist countries seemed a pressing task.

[129] In this context Evans' (1998) metaphor of 'embedded autonomy' is relevant see Chapter 3, section 3.2 for a fuller discussion of the term.

[130] Alliance capitalism described the situtution where the state works in close alliance with the private sector to realize mutually beneficial developmental and economic outcomes. The paradigm example of this is perhaps post-war Japan.

the overall course of economic development, and the retention of its capacity to do so despite pressures from the international integration of the economy, point to the continuing usefulness of the notion of the developmental state, of which Vietnam is an example:

"…we acknowledge that Vietnam has serious economic problems to confront and there are concerns about the durability, transparency and efficacy of some aspects of governance in that country, nevertheless, it has made remarkable progress in a short period of time from inauspicious beginnings, *and the state has been a central actor in this process*." [emphasis added] (Beeson & Pham 2012: 553)

In short, while these writers are well aware of the weaknesses of policy implementation, and issues with inefficiency, lack of capacity and corruption, they understand the role of government as being effective in realizing change where it *mattered*. This includes areas such as the reform of state owned enterprises (SOEs), macro-economic management, land rights and administration, international integration and trade, developing an environment that in general gave encouragement to both domestic private sector and foreign investors, and in ensuring the provision of essential infrastructure goods and services.

5.3.3 Competitive clientism and the weak state

Although there is a considerable amount written about horse-trading over policy issues within statist accounts, this is seen frequently in terms of disputes over ideology (e.g. regime modernisers v's regime conservatives), or issues relating to maintaining party power and legitimacy within formal state institutional arrangements (Thayer 1992, 2009, 2010; Gainsborough 2010). A key weakness of the statist account of Vietnam's transition is its failure to address the political economy of reform in a satisfactory manner. Statist accounts are marked by an over-emphasis of the distinction between state and society, a superficial acceptance of policy at face value (assuming more-or-less effective policy), and insufficient attention to informal institutional arrangements such as patronage networks (Gainsborough 2009; Fforde 2010). There is a reluctance to grub below the surface appearance of official policy and formal institutions to reveal the mechanisms by which *power* is actually articulated.

The alternative account suggests a more nuanced, less monolithic and altogether more heterogeneous understanding of the state and its interests. In this vein, Vuving's (2010) analysis of Vietnamese politics recognises a number of analytic groupings, regime 'modernisers' and 'conservatives', and the important geopolitical role played by the presence of China. He also recognises a forth group, the 'rent-seekers' whose primary motivation is characterised as pursing their rather narrow material self interest. The increasing influence of 'rent-seekers' in the political system is attributed to the expansion of markets in a weak institutional context. Indeed, Vuving (2010) argues that during the *Doi Moi* period the interest of 'rent-seekers' and regime conservatives have coincided. The desire of the conservatives to preserve administrative fiat and state control over key productive sectors has provided ample opportunities for rent generation by the 'rent-seekers'.[131] As a result the 'rent-seekers' have been able to capture most of the 'commanding heights' of the economy. Painter (2008b) reaches similar conclusions about the growth in the importance such rent-seeking behaviour over the reform period:

"Public officials, acting at first from within the state, have occupied new economic and political roles beyond the state as they participated in and benefited from the dispersal of the state's resources into the market economy. Informal and illegal uses of state power and resources to facilitate economic accumulation have taken advantage of official programs of state restructuring. State capacity in regulating society and the market has been weakened at exactly the same time as administrative reforms sought to strengthen it." (Painter 2008b: 14)

Penrose et al (2007) also point to the heterogeneity of Vietnam's political elite and attribute the stability of the political settlement in Vietnam during the *Doi Moi* period to the broad distribution of benefits between different elite factions.[132] Fforde (2009, 2012b) takes a similar tack, highlighting both the fragmented nature of the state, wide-spread rent-seeking behaviour, and as a result an intense competition for rents. He agrees that the CP has been able to maintain a 'dynamic balance of political interests' during the 1990s and 2000s (Fforde 2013). The upshot of this has been a political economy context characterised by a 'competitive clientism' (Fforde 2009):

"The political economy, one may conclude, showed again that it was highly antipathetic to rent-creation, not because individual politicians and their clients disliked it, but because behaviour comparable to

[131] Gillespie (2008) notes a similar pattern, commenting "Never far below the surface was the political concern that regulatory agencies need broad licensing powers to ensure that entrepreneurs do not accumulate levels of wealth that pose a threat to party power." (Gillespie 2008: 693)

[132] It is interesting to note that Abrhami et al (2008) argue that the formal political institutions of the Vietnamese state actually place more constraints on the leadership and represent a broader distribution of power amongst party insiders. They argue that this in turn explains why Vietnam spends a large portion of its revenues in transfers, which are needed to maintain support amongst a boarder range of interest groups. This is contrasted with China, which has more concentrated political power and does not face the same pressure for redistribution as Vietnam.

'competitive clientelism' meant that, in the absence of political agreement, political competition made it impossible to maintain the selective targeting of rents upon particular client groups. The political culture, thus, could not cope with the concentrations of power, and the implications for the political order, required for managing such strategies. And this has important implications for the viability of proposals for major state interventions to alter the basic parameters of Vietnam's growth process." (Fforde 2009:84)[133]

Thus the alternative view of Vietnamese state that emerges is as one that is weaker and more dysfunctional than the statist account would have us believe. The state is fragmented by competition between factional interests, such as between different sectors (i.e. ministries or productive sectors), and between different locations (i.e. provinces).[134] This is also indicative of a fragmentation of power, the result of which is the inability of the state to direct a coherent development strategy (Fforde 2012, 2011; Perkins & Vu 2010).

At the heart of the alternative account of Vietnam's political economy lies a critique of both the statist state-society dichotomy and the willingness to take policy and formal institutional arrangements at face value. Gainsborough (2009, 2010) articulates the central problem with the statist tendency to regard the 'unitary state' as standing separate from an 'undifferentiated society':

"In much writing on the state, including on Vietnam, a blurring between public and private is depicted as an aberration and not something which occurs in 'developed' Western states…[…]…it is also depicted as something that can be put right (through 'reform'). However, this is a distortion: public and private are blurred in all states by definition because…[…]…the state is a conceptual abstraction (i.e. there is not a real boundary between state and society or between public and private). That it appears otherwise is testament to the state's unique character as a historically contingent form of rule, and indeed this blurring, and the policing of the boundary by those who inhabit the state, is central to how power is exercised." (Gainsborough 2010: 181)

Whereas statist writers tend to regard the Vietnamese polity as some kind of rational Weberian state, maintaining its popular legitimacy through the provision of public goods (economic development, public services, national defence etc.), from the perspective of

[133] Other writers on Vietnamese industrial policy essentially subscribe to this view, for example Perkins and Vu (2010) comment: "The major problem, in our view however, is that the government's industrial policies appear to be raising barriers to competition rather than establishing an environment where competition among industrial firms flourishes. *It is not much of an overstatement to say that the relevant ministries see the main task of industrial policy as one of protecting and promoting the state owned sector*."[emphasis added] (5)

[134] The relative decentralisation of the Vietnamese state and productive forces in the economy was in part a result of wartime exigencies requiring localised self-sufficiency (the district as fortress), and received opprobrium from Soviet planners in the period following reunification.

Fforde, Gainsborough and others this is mistaken. In fact, as Gainborough (2009) persuasively suggests the notion of a benign developmental state can serve to obscure and legitimise the exercise of political power. In the case of polities like Vietnam, as Gainsborough puts it, "…politics is much more about patronage and much less about delivering 'public goods' " (Gainsborough 2009: 1326). Gainsborough (2002, 2005, 2007) and Painter (2005, 2008a) argue convincingly there is no easy distinction to be drawn between the public and private sectors.

The positive characterization of Vietnam's political-economy which emerges from this criticism of the statist position is of a polity understood largely in terms of the self-interested pursuit of power and influence by individual actors and groups. Gainsborough offers a telling description of the fundamental incentives facing political actors in Vietnam:

"As old routes or opportunities for advancement are closed down, new ones need to be found. People's stars dim. Patrons grow old and die. Certain business interests survive, perhaps by diversifying into new areas. Others go to the wall. Of course, some people are better operators than others, and through a combination of luck or the fortune of their birth have more going for them. But success is never guaranteed. In the face of interventions - what are often referred to as 'reforms' – which seek to upset what people are doing, the system constantly reinvents itself to ensure that its underlying money-making and prestige-seeking functions are not upset. However, for the reasons just outlined, the system never entirely stays the same." (Gainsborough 2010: 179-180)[135]

Typically, questions of policy, reform and long-term developmental goals simply do not feature in the day-to-day decision making upon which constitutes the political-economy, and upon which those dynamic processes supervene:

"For most actors, debates about reform or policy choices, or the consequences of World Trade Organisation membership and such like, are not their day-to-day concern. Instead, surviving, getting things done, using one's connections, and paying people off, all in the system are key, whether it be through

[135] An important point to note, of relevance to the more ontological concerns of this thesis, is that what Gainsborough describes here seems to be tantamount to an evolutionary understanding of the political economy, Fforde is much more explicit in his advocacy for an evolutionary understanding of Vietnam's political economy: "…since the empirics support an evolutionary and endogenous view of change in Vietnam, leading to a stress on process rather than on comparative statics, I will argue that neo-classical approaches have only limited value. In my view, processes of change are best viewed as evolutionary, with economic logics interacting with others, and the Vietnam case study provides evidence to support this. But how does the support arise? For me, the key entry point to understanding the literature is the treatment of policy, and the role given to it in explanations of systemic change." (Fforde 2010: 128)

doing business, exploiting a regulatory position, or milking the international donor community. This is the day-to-day stuff of politics." (Gainsborough 2010: 180)

Expanding on this understanding of the Vietnamese polity, there are three factors salient to our concerns, i) the role of uncertainty; ii) the fragmentation of the state; and, iii) the ambiguous role of policy. Firstly, on the role of uncertainty in the political economy, Gainsborough (2010) points out that the institutional and regulatory environment is one characterised by uncertainty. Laws, policies and regulations are frequently ambiguous, contradictory and unenforced, effectively supplanted by, or in conflict with informal institutional norms. Gillespie (1994) notes a similar and illustrative confusion relating to the profusion of legal documentation:

"While the prime minister may issue decrees and instructions, ministers may issue decrees and resolutions. In practice these instruments are often treated as if they possess a similar legislative authority. People's Committees add to the confusion by enacting subordinate legislation that duplicates, and at times contradicts, provisions passed at the national level. Additional confusion arises from the power of the National Assembly to abrogate instruments passed by the Standing Committee, the prime minister, or the ministries, while the prime minister may abrogate instruments passed by ministers and People's Committees." (Gillespie 1994: 4)

This uncertainty functions as a means of control. A direct result of this uncertainty is that people are always vulnerable and therefore dependent upon patronage networks for protection (Gainsborough 2010). Of course, the level of uncertainty may be greater in some areas that others. For example, the perception is that there have been significant efforts to reduce uncertainty for foreign investors where this does not conflict with the interests of existing elites. But, for politicians, administrators and businessmen the high level of uncertainty means that cultivating their links to powerful political players is much more important than knowing the law.

Secondly, the fragmentary nature of the state with power dispersed widely between different groups such as provinces, ministries and SOEs (see for example Jandl 2012) results in the inability of state agencies to coordinate their activities. The existence of overlapping, duplicate or contradictory legislation is indicative of this fragmentation. Of equal interest is the inability of ministries or SOEs to coordinate their planning or investment activities. Agencies frequently do not share information, even where close connections exist ostensibly public owned information is treated as a commodity to be bought and sold. Investment planning and investment fund allocation are similarly subject to "competitive clientism", meaning that investment projects are not developed on a purely rational basis and determined by where the (public) need is greatest, but on the basis of patronage and maintaining consensus. Pincus & Vu (2008) describe this tendency:

"Vietnamese institutions are characterized by ambiguous lines of authority and consensus decision-making. On the plus side, Vietnamese politics has been marked by stability. But consensus-based decision-making has also reinforced a tendency to distribute rents widely across the system. This problem is evident in the allocation of public investment. Vietnamese politicians approve 10 projects when one will do, and spread them across the landscape. For example, Vietnam is building a string of deep sea ports in central Vietnam despite the fact that port infrastructure in the southern provinces of Ho Chi Minh City, Dong Nai, Binh Duong and Ba Ria Vung Tau-which together comprise more than 50% of Vietnam's job growth and nonoil budget revenues-is stretched to the breaking point." (Pincus & Vu 2008: 31)

The structure of state institutions compounds the fragmentary and uncertain nature of the Vietnamese state. State institutions are characterized by duplicated and overlapping remits, reporting lines and authorities. For example, provincial line agencies (Departments) at the provincial level are answerable to both the Provincial People's Committee (PPC) (the administrative arm of government at the provincial level) and their associated line ministry. A Department of Construction at the provincial level will report to both the Ministry of Construction and the Provincial People's Committee. This is further complicated by overlapping responsibilities to the provincial CP and (nominally at least) the Provincial People's Councils. Moreover, the dual role of ministries mean they effectively 'own' and control key SOEs[136] while also making legislation, which affects SOE operations. The picture is complex, but serves to emphasize the degree of uncertainty in navigating what is at the best of times a byzantine state bureaucracy.[137]

Thirdly, and closely related to the first two points is the ambiguity of policy. Given the uncertainty surrounding implementation, policy consistency and the contravention of established informal institutional norms implied by policy, it is frequently difficult to know how to interpret formal policies. Fforde (2010) makes the case that the

136 Many ministires and provinces own or maintain a controlling interest in large SOEs related to their ministerial and provincial remits. For example, MoC in construction and cement production.

137 Sharma and Minh Do note that the energy sector is also plagued by poor coordination by different ministries and other agencies (2011).

developmental activities of the Vietnamese state cannot be considered as consisting of 'insulated policy making and implementation' (Fforde 2010: 128). Fforde dubs what he deems the over-emphasis on formal institutions and policy making found in some accounts (particularly those of the donors) a 'policy fetishism'. A number of other writers agree, arguing that policy is frequently not effectively implemented (e.g. see Thayer 2013a, 2013b on the implementation of anti-corruption policy). Nevertheless, it would be wrong to think of policy as *purely* epiphenomenal, while in many cases it may well be it also potentially serves a number of purposes. Sometimes policy *does* signal a commitment to a particular intervention, elsewhere policy serves to legitimise the role of the CP and state, and in still other circumstances policy is entirely serious. Sometimes policy is implemented sometimes it isn't, and the reasons are an admixture of capacity and inclination. The lack of policy certainty, coordination and the (closely related) pursuit of the vested interests of a fragmented polity also act to condition policy outcomes.

Despite the weakness of the Vietnamese state in some respects, it is important to bear in mind that, one way or another, the Vietnamese state has actually been relatively successful in the provision of basic public goods. Whatever the motivation for the allocation of resources to better infrastructure or poverty reduction programs, and irrespective of the efficiency of this investment, the evidence of improvement in the provision of broad public goods is pretty incontrovertible. Even if we accept that at the macro-economic level the story of the reform period is better understood as good luck rather than good management (Fforde 2009), and even if politics is more about patronage than a rational provision of public goods (Gainsborough 2010), this does not preclude the effective design and implementation of rational policy interventions.

Moreover, if the provision of public goods is an intrinsic part of Vietnam's particular political settlement, then where the provision of these goods requires the application of technical skills – then rational policy decisions, which are more-or-less realized in concrete outcomes *must* be part of the process. If there is broad agreement about the performance based legitimacy of the state, and if the public goods delivered to earn this legitimacy are dependent upon the effective formation and implementation of rational policies – then we cannot dismiss policy or the role of technical knowledge in its formation. And this point has been central to the arguments presented in Chapters 2, 3 and 4, it *must* be an intrinsic part of the way in which incumbents have been able to create and recreate a particular disposition of power. When seeking to understand the causal processes behind particular outcomes, the question then becomes, not so much a case of dismissing rational policy formation and effective implementation, but one of better understanding how the activities of elites are constrained and circumscribed by material conditions, and how technical knowledge and policy choice relate to this.

5.4 Conclusions: Implications for the ESI

This last point is particularly germaine to our understanding the political economy of the ESI. The technical complexity and material wherewithal required for the provision of electricity services is substantial (Chapter 4). The central importance of the ESI in the generation of a broad range of goods in a modern economy - public and private, licit and illicit results in a particular political sensitivity to certain aspects of the ESIs technical performance (in terms of ensuring the quantity and quality, and price of electricity) in virtue of the public goods it provides. Whatever else the ESI can provide (tax revenues, investment opportunities, natural resource rents, kick-backs etc.), at bottom, an important component of CP legitimacy rests upon the technical performance of the ESI. Ensuring adequate technical performance in the ESI implies the complex mobilisation, allocation and management of resources. This requires informed and effective decision making and a coordinated coherent organization. The provision of electrical energy may be the paradigm example of this. In short, it requires state capacity for the sector to function in a satisfactory manner.

On the other hand, certain aspects of the ESI lend themselves to the exercise of discretionary power in the pursuit and preservation of rents and quasi-rents, which abound in the sector (Chapter 4, Table 4.4).[138] It is in these spaces, where the contestation of rents and quasi-rents is feasible (i.e. without threatening the 'whole show'),[139] that the play of political power is likely to be important. Given the argument presented above, we do not expect to find rational Weberian bureaucratic structures engaged in rent management for the provision of developmental goods operating in these spaces, rather, we expect to find vested interests engaged in a version of competitive clientism.

[138] i.e. in the slack afforded by weak feedback mechanisms.
[139] We borrow this from Gainsborough (2010) that is without upsetting the political settlement or equilibrium.

The task of the analysis of Vietnam's ESI is therefore to start understanding where the shifting boundary between the material, technical and financial constraints and the exercise of power itself occurs. To do this, we need to understand the material conditions of the ESI, the techno-economic paradigm, which determines the perceptions of material possibilities within the sector, the institutional arrangements, which intermediate the generation and distribution of benefits in the sector, and how this seems to relate to the articulation of holding power in the ESI. It is this to which we move in Chapter 6.

Chapter 6: The political economy of the power sector in Vietnam

6.1 Introduction

The arguments presented in Chapters 2 and 3 suggested that when considering the process of technological change, either from the perspective of technological innovation and diffusion, or from the perspective of economic catch-up, the political economy is likely to be an important factor. In both cases, we have argued that technological change is often not distributionally neutral. This is especially likely to be the case when we are considering radical technological change such as a transition to 'low carbon' energy systems, or the process of industrialisation and economic development. This is because these types of technological change imply a significant change in the types and magnitude of rents that are generated by the application of technologies in the process of production, and thus changes the way rents are distributed.

Rents are the material wherewithal through which societal power (following Khan (2010) what we have characterised as 'holding power'), is generated. The preservation and dynamic recreation of holding power depends upon the maintenance of rents. To the extent that technological change creates new streams of rents or disrupts established rental streams they also have the potential to disrupt the distribution of holding power. Thus we have argued technological change can have important political economy implications. It can change the distribution of rents and as a consequence holding power. Conversely, the political economy context is likely to influence the potential for technological change. If technological change threatens established rent streams and the disposition of holding power then it is likely to be resisted. Thus, very generally speaking, the political economy is seen as both a consequence of technological systems and also a condition for technological change.

While rents are generated through the process of production, their distribution is intermediated by (formal and informal) institutional arrangements. As we have argued in Chapters 2 and 3, institutional arrangements typically co-develop with technological systems. At the same time as they enable technologies they also determine the distribution of rents. For example, rights to fossil fuel extraction allow right holders to appropriate associated natural resource rents, and at the same time enable the exploitation of those resources. Similarly, IPRs allow their holders to appropriate rents for innovation and patron-client relationships may entitle the patron to kickbacks.

Chapters 2 and 3 outlined the analytical contours of our account, but the broad concepts they sought to elucidate said very little about how those concepts were instantiated in particular technological systems or political economy contexts. A consequence of the evolutionary micro-foundations (adopted in Chapter 2) is that we would expect historical contingency to affect the dynamics of particular technological systems and institutions and lead to divergent outcomes. In seeking to apply this approach to an empirical case it therefore becomes important to elaborate how particular technological and political economy processes developed.

Chapter 4 sought to concentrate on the ESI, representing as it does a set of similar general-purpose technologies that are found the world over. The objective was to help sort out on one hand, typical systematic elements of the system attributable to its fundamental technological and economic characteristics, and on the other hand, the aspects of the system which might be thought of as more properly attributable to institutional and political-economy factors.

More substantively, in respect to the ESI, Chapter 4 found that technical and economic efficiencies of scope and scale, and the need for centralised management and control of electricity systems mean that electricity supply systems have typically been monopolies. The concentration of market power in the hands of monopolistic firms, as might be expected, was from the get-go politically fraught. Moreover, both the strategic importance of the sector in terms of ensuring productivity and economic competitiveness, and the ubiquity of electricity, which quickly came to be regarded as an essential public service, served to reinforce the sector's political significance. The sheer scale of resources sunk in electricity generation and distribution has necessitated political intervention in one form or another in facilitating investment in the sector. Finally, the ESI has been an important source of rents (from various sources), as a result it is an important locus for the creation and recreation of societal power. In short, the ESI seems to be a sector where the political economy plays an important role.

The task that remains in this research is elaborating how these typical processes have been realised in a particular political economy context and how this is likely to affect technology choice. This is the objective of this Chapter. Picking up from the outline of Vietnam's political economy in Chapter 5, in this chapter we develop a narrative account of the development of Vietnam's ESI, elaborating in greater detail how political economy factors have influenced the development of the sector. In the following section, we give an overview of the material development of the ESI in Vietnam. Section 6.3 investigates the co-evolution of key institutional arrangements in the sector and examines how they reflect the distribution of power in the sector, and section 6.4 concludes. In the Chapter 7, we draw on the political economy dynamics identified in this chapter to understand how they have conditioned technology choice.

6.2 The development of the ESI in Vietnam

Vietnam's ESI has seen dramatic change since reunification and in particular over the *Doi Moi* period. As a 'leading sector' in the economy, and essential to modern industrial development electricity production grew at an average annual rate of 12.6% between 1986 and 2010, almost double the rate of economic growth. At the same time, Vietnam has managed a remarkable expansion of electricity access, the proportion of households with access to electricity expanded from approximately 10% to 98% over the same period (World Bank 2011). This growth was enabled by a large capital investment program which saw expansion of generating capacity from 1,165 MW to 20,542 MW between 1986 and 2010, and of the transmission grid - with the length of medium voltage (220 kV) transmission lines increased from less than 1,000 Km in 1985 to over 8,000 Km by 2008, and the development of over 3,500 Km of high voltage (500 kV) transmission lines. This section looks in a little more detail about how this development unfolded, and importantly seeks to elaborate the emergence of the dominant techno-economic paradigm in Vietnam's ESI.[140]

6.2.1 Post-war reconstruction and central planning 1976 - 1986[141]

When Vietnam was reunified in 1976, power infrastructure was in a poor condition with many generation assets out of operation or unable to operate at capacity, and transmission and distribution (T&D) infrastructure in particular damaged during the conflict. Electricity consumption was extremely low by international standards at

[140] See annex A5.2 for more detail on Vietnam's energy sector.
[141] See annex A6.1 for a short narrative on the development of the ESI pre-1976.

approximately 47 kWh/capita. Only around 2.5% of the rural population had grid access. The years immediately after the end of the war were marked by the rehabilitation of the ESI. By 1978 much of the available capacity was back in use and electricity production had increased to 3.8 TWh, a 60% increase from 1976 (World Bank 2011b; World Bank 2013).

The period up to 1985 was marked by three separate infrastructure development trends in the sector. The first and the most significant was the large expansion of generation capacity that got underway with the construction of a number of large coal fired thermal and hydropower plants. In the north, coal-fired plants at Ninh Binh (100 MW) and an extension at Uong Bi (bringing the installed capacity to 105 MW) were commissioned in 1976. Work also started on the large 1,900 MW Hao Binh hydropower project in 1979, in 1980 on the 440 MW coal fired thermal plant in Pha Lai, Hai Duong province and in 1986 on the 400 MW An Tri hydropower plant in Dong Nai province (Cosslette & Shaw 1987; World Bank 2011a).[142] All these large plants (mostly situated in the northern part of Vietnam) were built with Soviet technical and financial assistance.[143]

Secondly, at the same time, in the more remote and mountainous areas of the country there was significant expansion of small and very small hydropower generation units linked to local or mini-grids. Small hydropower projects were typically developed by cooperatives, local communities and military units, often with financial support from the provincial authorities. It is also estimated that in the region of 150,000 pico-hydropower units were installed during this period (Meier 2013).

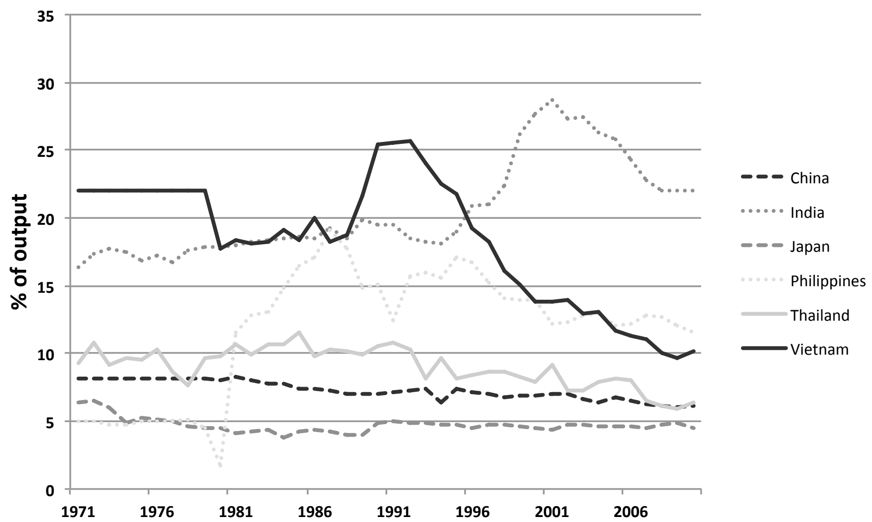
Thirdly, there was also considerable extension of the medium voltage network, with 220 kV lines being expanded from 257 Km in 1975 to 904 Km in 1985 (EVN 2009a). The expansion of the grid network at this time did imply some increase in the proportion of on-grid households, but the priority – guided by the precepts of central planning – was productive sectors, with rural electrification efforts focused on the provision of power to irrigation pumps in important rice growing areas (World Bank 2011).

[142] Hao Binh remains the largest hydropower plant in SE Asia.
[143] As Wyatt notes Soviet financial and technical assistance remained important even after the collapse of the USSR for environmentally damaging hydropower projects that IFIs shunned such as Se San 3 and Son La (Wyatt 2002).

Despite developments of the physical infrastructure, as with much else in the command economy in the years between reunification and the adoption of *Doi Moi* policies, the ESI was not functioning particularly well. The sector suffered from shortages of fuel and spare parts, there had been limited capacity expansion, there were continuing significant transmission and distribution losses (estimated to be around 20% Figure 6.1), power cuts were common and production grew only slowly. On the eve of the extensive economic reforms heralded by *Doi Moi* in 1986, Vietnam's annual power consumption was approximately 4.4 TWh, with only 1,165 MW of installed capacity (England & Kammen 1993; World Bank 2011). Per capita power consumption was at a level of just 73 kWh - one of the lowest levels of energy and electrical power consumption in the world at the time, ranked 104th out of 114 countries (World Bank 2011b). Little in-road had been made in the development of a national grid, southern and northern Vietnam had separate power systems, and the central region was still served by a number of small-disconnected local grids. The stagnation of the sector impeeded industrial productivity forcing many industrial facilities to operate at less than 50 % capacity (Cosslette & Shaw 1987; England & Kammen 1993; EVN HCMC 2012). Due to the poor supply situation many industries and essential services relied on isolated (i.e. off-grid) generation facilities (England & Kammen 1993). Similarly, while progress had been made in improving access to electricity, only around 10% of rural households had grid access by 1986 (Figure 6.3).

Notwithstanding this poor performance, it is a point often made by writers on Vietnam that the roots of the rapid economic growth seen in the period following *Doi Moi* lay in the post-war period. When commenting on economic reforms the importance of this period lies in the emphasis placed upon the inability of the center to exert adequate control on the disparate parts of the economy, and the creeping commercialization of many enterprises that was able to flourish in these conditions (e.g. see Ffrode 2007). By contrast, the rapid expansion of the ESI and the development of a centralized national grid in the three decades following *Doi Moi* was an important prerequisite for industrial growth. This was underwritten by the implementation of large state lead heavy engineering projects, which were in many ways central to the Stalinist, state-led development paradigm. The massive expansion of capacity and electricity production that the large Soviet funded projects entailed set the scene for the dramatic transformation of the ESI in Vietnam, enabling the development and expansion of a national grid, and provided critical inputs to Vietnam's rapid industrial growth in subsequent years.

Figure 6.1. Transmission and distribution losses selected Asian countries 1971 - 2010



Source: IEA 2013

6.2.2 Building socialism, building a techno-economic paradigm

The development of the ESI in Vietnam in the post war period was only influenced by the availability of Soviet technology and capital. The overall system design, institutional arrangements, culture and ideology of the power sector, under the tutelage of Soviet engineers and planners was heavily influenced by a broader ideological approaches linked to socialist notions of development. Coopersmith (1993) noted the dominant techno-economic paradigm in the ESI of a centralised, large scale national electricity grid run by vertically integrated, state owned utilities had a particular resonance with the Soviet economic development policies. Electrification and the development of the ESI stood at the heart of Soviet-style development (Williams & Dubash 2004). The role of the ESI in a command economy was as a leading sector in modernisation and development, and essential for the forced industrialisation that was at the core of the central planning ideal (Chapter 4, section 4.2.2-3). The emphasis on large power plants, particularly hydropower and a faith in engineering solutions were important elements of the techno-economic ideal.

Thus large scale Soviet assistance in the post war years was not only a question of transferring material technologies to Vietnam, but of also the transfer of technological know-how, of ways of addressing problems and of understanding the ESI (section 4.2.1). This body of knowledge was transmitted by cadres of Soviet planners and engineers involved in building Vietnam's ESI, through the technical training offered to the large number of Vietnamese professionals who passed through higher education institutes in the USSR and other Eastern European countries, and through the development of many of the higher education and technical institutes in Vietnam (Mazyrin & Moscow 2010). This represented not only the transfer of financial capital, physical resources and embodied technologies but the transfer of a whole techno-economic paradigm, its institutions and the know-how that went with it. This established an approach to the development and operation of the ESI in Vietnam amongst the cadres of power engineers and planners that continues to this day in many ways to dominate thinking about the ESI.

Quinn (1998) in a critical review of Vietnam's power sector notes this tendency in Vietnam, in common with other transitional economies:[144]

"In most transition economies, power systems were designed by engineers, not economists. The fascination with proving the success of the [centrally planned] economic system through the work of its engineers was a key ingredient of centrally planned systems. When capital has no value, projects tend to favour massive technically complicated investments over smaller proven technologies. This was certainly the case in Vietnam where large resources were (are being) spent on the development of large hydroelectric facilities, which now make up the majority of Vietnams' power resources. The most important issue on the supply side for transition economies is assigning value to capital and having that value guide investment decisions rather than other factors." (Quinn 1998: 2)

Quinn over-states his case. Large hydropower was attractive at the time for a number of other reasons. Firstly, hydropower was a mature and well-understood technology at the time. Secondly, the capital, technology and engineering wherewithal were made available on very favourable terms to Vietnam from the USSR (see below). And thirdly, it is far from clear that hydropower represented a more expensive alternative to thermal generation, i.e. hydropower may have been cheaper.[145]

Nevertheless, Coopersmith (1993) observed that the Soviet style development of the ESI was out of synch with conventional economic logic in terms of promoting least cost, incremental capacity expansion based upon urban load centres. Vietnam also opted for the mega-project in Hoa Binh and the national transmission grid to match, rather than an

[144] i.e. former communist countries.

[145] It is certainly now the case that the best hydropower projects in the region tend to be cheaper than alternative technologies (see for example MRC 2009).

incremental expansion based on existing capacity. The short term impact of Hoa Binh was that in the early 1990s coal plants in the north of the country were running at around 25% of capacity and the coal industry at about 50% of capacity (World Bank 1993). A more long-term impact of an over emphasis on hydropower has been the vulnerability of the ESI to hydrological risks which would plague in later years. The observation that there was an inherent bias towards engineering solutions in a centrally planned economy and has been amply reflected in the techno-economic paradigm prevailing in Vietnam's ESI is undoubtedly true. Moreover, this emphasis on hydropower and the development of an influential group of hydropower engineers with a clear vested interest in developing this technology, would continue to have influence at the ESI utility and affiliated energy planning intuitions that would shape the industry of years for years to come.

A second strand to the development of the ESI and its techno-economic paradigm was the importance of the ESI ideologically. Thayer (2010) has noted (section 5.4.1) in the immediate post war period the legitimacy of the CP was closely tied to both nationalism and nation building, but also performance in terms of building socialism and delivering the material goods associated with this. In this context, the development of the ESI was emblematic of the reach, legitimacy and benevolence of the CP. Hydropower plants in particular, claimed to offer the multiple benefits of electrification, irrigation, flood control, Thai's (2000) gushing account marking 10 years of electricity production at the Hoa Binh dam serves to illustrate:

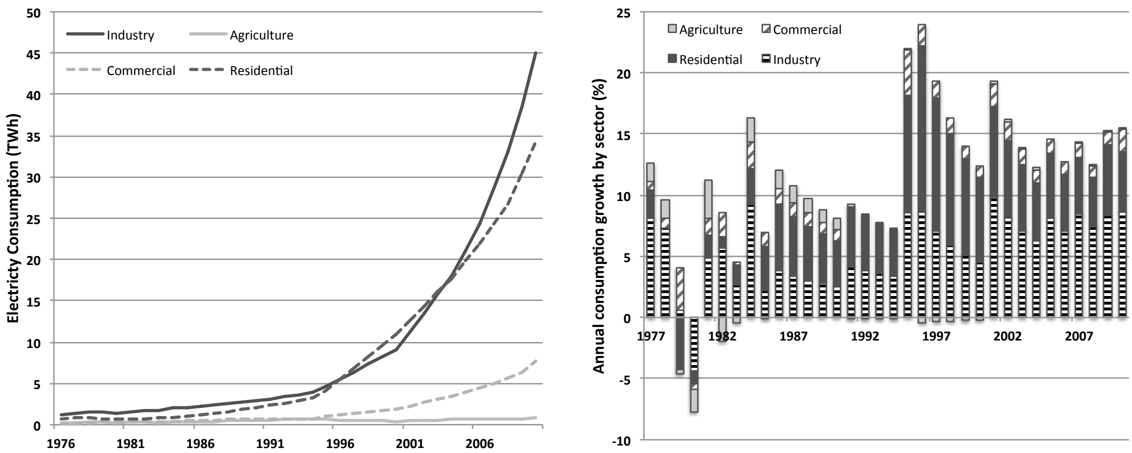
"Start-up of the first [generation] set was celebrated by the entire Vietnamese nation. The many thousands of Vietnamese and Soviet hydraulic builders, who had labored unselfishly in constructing the hydroproject for nine years, celebrated an inordinate victory on this date. Since that time, the Hoa Binh hydroproject has actively proceeded to make a major contribution to the solution of four critical national-economic problems…[…]…the most acute deficit of electric power, which had put the country's national economy to the test at that time, was mitigated. The risk of catastrophic flooding in the Red River Delta, where 15 million people reside and the capital of the Socialist Republic of Vietnam - Hanoi - is located, has been significantly reduced as a result of flood-flow regulation by the reservoir. The shortage of water for irrigation over an area of more than one million ha has been compensated during the low-water period of the year. Navigation on the Da-Red River system has been appreciably improved." (Thai 2000: 130)

The importance of the ESI and the tropes of electrification, the power engineer, and perhaps above all else the hydropower dam,[146] appear time and again in propaganda materials (Figure A6.6 and A6.7). In fact, that a hydropower plant still features on the reverse of the 5,000 VND note currently in circulation speaks of the persistent importance the image of hydropower and the mega project still has at least on the imagination of some in the CP and its development planners.[147]

6.2.3 Rapid growth of the ESI in the reform period 1986 - 2010

The situation after more than two decades of rapid economic growth stands in marked contrast to that in 1986. In 2010 annual national power consumption stood at 84.8 TWh, an increase of over 1,800% since 1986, a growth rate of approximately 13.1% per year. This growth in demand has been closely associated with Vietnam's economic growth and industrialisation, with industrial and residential sectors representing the key drivers of electricity demand (Figure 6.2).

Figure 6.2. Evolution of electricity consumption by sector (left)[148] 1976 – 2010 and annual electricity consumption growth by sector (right) 1977 – 2010 in Vietnam



Source: World Bank 1996, 1999, 2001, 2002, ICEM 2013

Industrial demand for electricity has increased from 2.2 TWh in 1986 to 45.1 TWh in 2010 accounting for around 51% of demand growth, with energy intensive industries

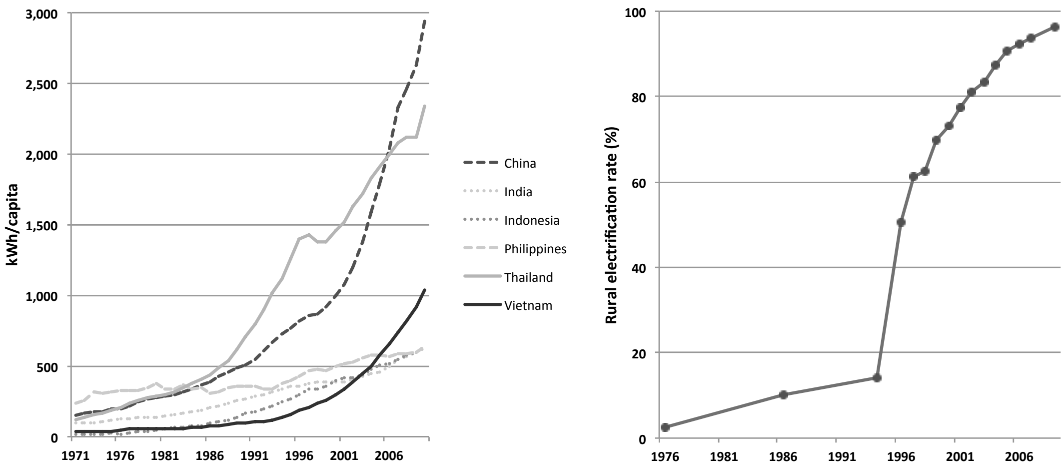
[146] It should be noted that hydropower dams were (and still are) touted as multiple use projects serving water needs in agriculture and flood control services as well as the provision of electrical power (see section xx for greater discussion).
[147] While in the reform period the ubiquitous propaganda posters have come to be something of an anachronism, they are redolent of Soviet central planning and socialist propaganda. They do serve to illustrate the importance of the ESI as an essential element of the forced industrialisation process.
[148] Complete time series not available intervening years interpolated (i.e. 1986-89, 1991-93, 1996 – 99 and 2001 – 2003).

including steel and paper production, food processing, chemicals, textiles and the manufacture consumer durable goods being particularly important drivers of growth (World Bank 2008, 2009). Similarly, the residential sector has seen consumption grow from 1.2 TWh in 1986 to 35.2 TWh in 2010, accounting for approximately 40% of consumption growth over the same period (Figure 6.2). This has in turn been driven by increased electrification rates and levels of household consumption leading to more widespread use of domestic appliances such as TVs, refrigerators and air conditioners (Figure 6.3). Nevertheless, per capita electricity consumption in Vietnam is still relatively low by global standards for middle-income countries, standing at 1,035 kWh per capita in 2010 (EVN 2011; World Bank 2011) (Figure 6.3).

Capacity growth has been equally rapid. From 1,165 MW of installed capacity in 1986 to 20,542 MW by 2010[149] excluding an additional 1,000 MW of capacity from imports from the Chinese Southern Grid (CSG) (ERAV 2010).[150] Peak demand also rose from 2,345 MW in 1994 to 15,416 MW in 2010. As noted above in the early years of *Doi Moi* electricity production was given a considerable fillip from the commissioning (with Soviet assistance) of the large plants at Pha Lai, Tri Anh and Hoa Binh, in 1986, 1988 and the years 1988 to 1994 respectively (Thai 2000; Vietnam Business Forum 2010). For example, in 1994 the first year after full commissioning of the 12.3 TWh generated nationally, Hoa Binh plant alone generated 5.3 TWh or 46% of total electricity production (Thai 2000).

[149] Of which 19,735 MW is regarded as firm capacity (NLDC 2010)
[150] Actually the contracted maximum peak load for these five interconnections is 1,152 MW (ICEM 2013).

Figure 6.3. Electricity consumption per capita selected Asian countries 1971 – 2010 (left[151]) and Rural household electrification rate in Vietnam 1976 – 2009 (right)



Source: World Bank 2009, 2011, 2013

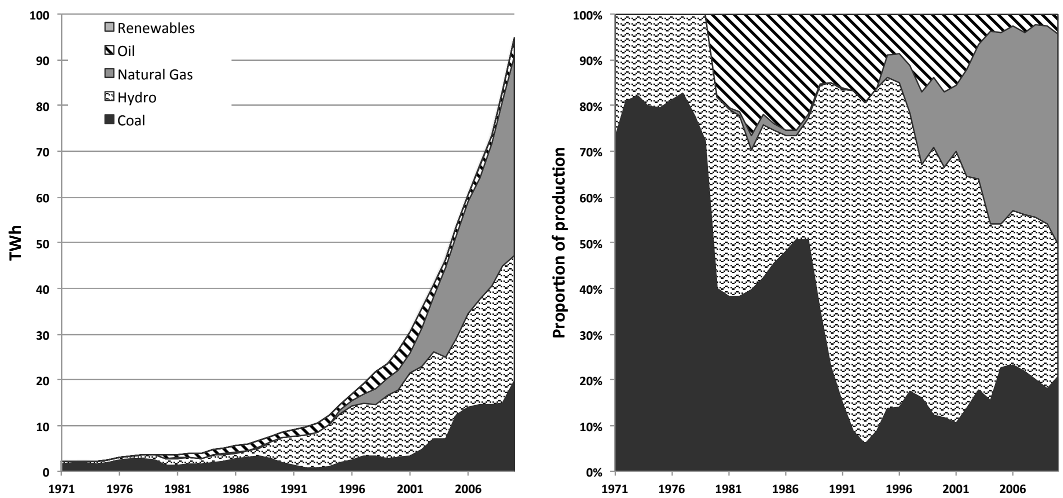
Capacity expansion has continued a pace with a number of large hydropower projects being commission at Ya Ly (720 MW) from 2000 - 2001, Son La (2,400 MW) in 2011 – 2012. From the mid 1990s onwards a significant amount of newthermal power capacity was commissioned. In the south of the country this has mainly been composed combined cycle gas turbine (CCGT) capacity following the completion of a pipe-line enabling the off-shore exploitation of associated natural gas from the Bach Ho field from 1995 onwards, and from 2003 onwards other off-shore sources in the Nam Con Son basin gas fields. A large complex of gas thermal generation has been developed in southern Vietnam at Phu My (3,820 MW) and there are expansion plans for existing plants at Nhon Trac (1,121 MW), O Mon (330 MW) and Ca Mau (1,440 MW). In the north of Vietnam, close to Vietnam's extensive coal reserves coal fired thermal plants have been upgraded and extended, notably at Uong Bi (1,010 MW), Pha Lai (1,000 MW) and Cam Pha (1,200 MW) (World Bank 1999, 2006b, 2010a).

Here it is important to note a few important aspects of the generation mix. Firstly, as we have noted Vietnam remained a hydropower dominated system. At its peak, in 1994 hydropower accounted for over 75% of electricity generation in the country as the best hydropower resources have gradually been utilised and other fuel sources have become available, this reduced to around 29% of electricity production in 2010 (Figure 6.4). This

[151] It is interesting to note, that despite Vietnam's very high growth in electricity consumption, it is following a similar path to China and Thailand – although Vietnam is around 10 years behind China and 20 years behind Thailand.

dominance has been a mixed blessing. The system has benefitted from cheap, relatively clean electricity from hydropower but this has meant the system is vulnerable to power shortages in the dry season which continue to plague the sector (England & Kammen 1993; Wyatt 2002; Nguyen 2005; Phong 2013; Daiss 2012). Secondly, both gas and coal fired generation technologies have become much more important, the availability of these resources - coal in the north and gas in the south – has lead the national ESI to have distinctly regional characteristics (Figure 6.5; World Bank 1999, 2006). Finally, due to the continuing need for load shedding (particularly at times when hydropower is not available) off-grid isolated generation from diesel or heavy fuel oil is in all likelihood considerably more important in some sectors than the figures suggest.

Figure 6.4. Evolution of the electricity generation mix in absolute terms (left) and as a proportion of production (right) 1971 – 2010 in Vietnam[152]



Source: IEA 2013

The extensive capacity additions and especially the large hydropower plants played an important role in the development and expansion of the national grid in Vietnam. Following capacity additions in the late 1980s, there had been considerable acceleration in the expansion of medium voltage (220 kV) and low voltage (110 kV) systems, which also enabled the expansion of rural electrification (Figure 6.8; World Bank 2011). These developments were dependent upon capacity expansion in the three separate power systems in the north, centre and south of the country. It was not until 1992 that the development of a unified national electricity grid got underway spurred by the

[152] This excludes imports from China which were 5.6 TWh in 2010, or approximately 5.6% of electricity supply.

commissioning of the first turbines at Hoa Binh hydropower plant. The 1,500 Km long 500 kV transmission line from Hao Binh hydropower plant in the north of the country to Ho Chi Minh City (HCMC) in the southeast was completed in 1994 and formed the 'backbone' of the Vietnamese national grid linking the three isolated power systems. This was subsequently upgraded with a second circuit (improving reliability and effective power) completed in 2005.[153] These developments are continuing with the expansion of the high voltage transmission grid from large generators to load centres, linking large hydropower projects in the central highlands (largest amongst them the hydropower plant at Ya Ly) to load centres in the north and south (World Bank 2006c).[154]

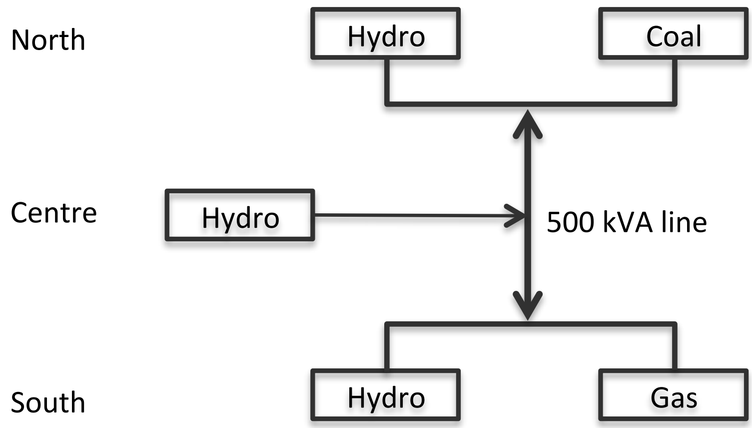
The development of a single integrated power system enabled the ESI to generate significant benefits from both increasing returns to scope and scale (see also Chapter 4, section 4.2.1), a donor document spelt out the familiar rationale:

"The commissioning in 1994 of the 500kV line, connecting the northern, central, and southern systems, has for the first time given Viet Nam a single integrated power system (IPS). The IPS will provide emergency support and sharing of reserve capacity and take advantage of demand and hydrological diversity. This project has already begun to repay the large financial investment by eliminating the operation of high-cost (diesel/thermal) generating plant and reducing the frequent load shedding in the south. Additional benefits will be realised through the coordinated operation and management of the transmission system as a single business unit." (ESMAP 1995: 25)

The development of an integrated national system offered improved reliability of supply and the transmission of surplus power from the north to the south. It also enabled the expansion of the grid to rural areas of the south and centre of the country as substations placed frequently along the length of the transmission line facilitated the connection of nearby population centres (World Bank 2011).

[153] According to EVN NPTC the north-south transmission line can serve an effective load of 3,000 MW.
[154] At initial commissioning the north-south line had an effective capacity of around 500 MW, today that figure is around 3,000 MW.

Figure 6.5. Regional characteristics of Vietnam's power system

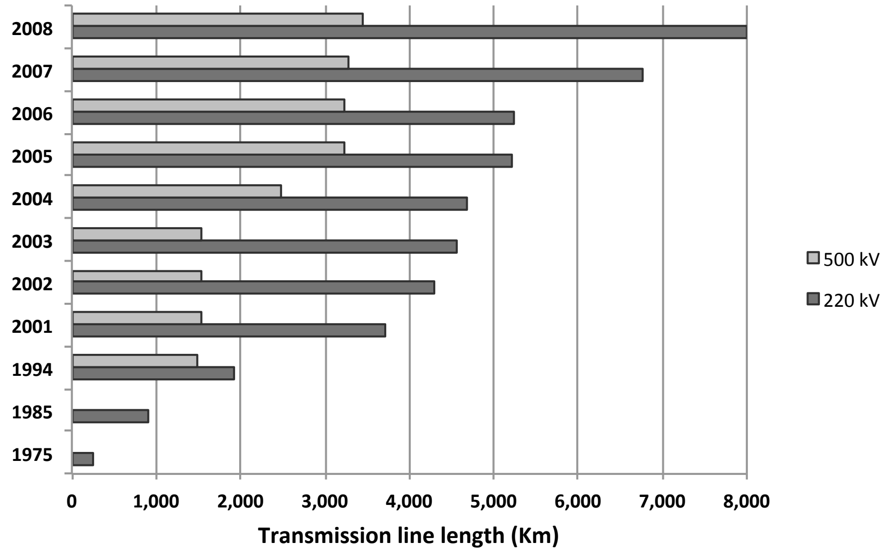


Source: World Bank 1999

The initial impetus to develop the north-south transmission line was the anticipation of a power surplus and overcapacity in the north of the country following the incremental commissioning of Hao Binh's eight turbines. By contrast, the industrial heartland of the south suffered chronic power shortages, with many factories were running at a fraction of their capacity (England & Kammen 1993; World Bank 1995, 1996). Other options such as power sales to China via a 500 kV cross-border interconnection were mooted, but energy security and other political considerations ruled this option out at the time (World Bank 2006b, 2011b). Baruya (2010) points out in a recent paper that the regional generation characteristics of Vietnam's grid and the reliance on a single transmission line has left the system vulnerable to outages at times of year when hydropower is not available, should the north-south connection be disrupted. For example, in a recent incident accidental disruption of the transmission line caused by collision with a crane led to power outages in 22 provinces in the central and southeastern region of the country (Tuoi Tre 2013).

The development of Vietnam's power system has been rapid, but in many ways typical. Firstly, like in so many other countries with abundant hydropower resources, hydropower has been closely related to the development of long-distance, high-voltage transmission lines, and as a consequence the national grid. If anything, hydropower has played a more important role than elsewhere due to the large hydropower resource available in Vietnam and the institutional emphasis on hydropower development due in no small part of Soviet influence. As the best hydropower resources have been fully utilised, and as the country has sought to diversify its generation mix, Vietnam has shifted towards domestic coal and gas resources. The development of a national grid has served to improve reliability and load factors by diversifying electricity supply, allowing greater diversification of load, and by effectively enabling returns to scale and scope in generation and diversification of load to be realised.

Figure 6.6. Transmission line expansion in Vietnam 1975 - 2008



Source: EVN 2009

Secondly, the close relationship between the development of the techno-economic paradigm in the ESI - with its particularly technocratic, hydropower focused bent – and the important ideological message on the development of socialism, should be noted. The role of ideology has diminished over the years, and the relative importance of the ESI's ability to deliver material benefits has increased, but the associated and underlying technical and engineering rationale which informed much of the development of Vietnam's ESI from the 1960s onwards continues to exert considerable influence.

Finally, the retreat of distributed generation in response to the expansion of rural grids is also an important feature of electrification in Vietnam. The 1980s saw considerable expansion of isolated generation and mini-grids. Small and pico-hydropower generation were not uncommon in areas of the country that were both relatively remote and had adequate hydrological resources, such as the northern mountainous regions of Vietnam. These have all but disappeared. A lack of funds for maintenance and construction and a lack of spare parts are important factors in this decline, but above all else the rapid expansion of the electricity grid has displaced these technologies (World Bank 2009, 2013; Meier 2013).

6.3 Institutional development and reform

The co-evolution of institutional arrangements in Vietnam's ESI plots a course familiar from the history of the ESI presented in Chapter 4. Private foreign ownership mixed with municipal ownership during the colonial period was displaced by state ownership following independence. At the same time power systems were slowly developing into vertically integrated state owned utilities. This development was disrupted by violent conflict and a lack of resources. The immediate post-war period saw state lead development of the sector and the emergence of a national grid and national electricity utility. The mid-1990s onwards was marked by the faltering re-entry of private and foreign ownership of generators in the ESI as the large capital needs of the rapidly expanding sector started to assert themselves. Here we argue that the developing situation in the Vietnamese power sector can be understood as representing a case analogous to that described by Victor & Heller (2007), Gratwick & Eberhard (2008), and Williams & Ghanadan (2006) (Chapter 4, section 4.2.7). That is, the Vietnamese ESI institutionally is in the half-way house between liberalisation and continued state ownership.

In many ways Vietnam and enterprises operating in the Vietnamese ESI are typical of the conditions in developing market countries, as they respond to similar technical and economic pressures emerging from the techno-economic paradigm which dominates the ESI. Here we argue that the differences between the situation in Vietnam and those in other countries do so not so much as a consequence of differences in resource endowments – although these are important – but do so as a result of Vietnam's political economy regime. In particular, the analysis of the ESI goes a long way to support the notion that the political economy is best described as one of competitive clientism driven primarily by domestic political considerations, as opposed to either an understanding of Vietnam as a developmental state, or as in thrall to neo-liberal conditionality.

6.3.1 Institutional arrangements prior to *Doi Moi*

The picture of institutional development that emerges from the available evidence is in some ways typical. Starting with private sector dominated ownership of generation capacity and distribution networks in the colonial period, with a mix of municipal power utilities and isolated generation units for industrial users.[155] While it is likely that the ESI was predominantly owned by the foreign private sector, it is also clear that at least by 1945 there was some public sector involvement in the sector. With the independence of the north under a communist regime in 1954 came state ownership of the ESI. What the situation was in the south is less clear, although given that public ownership was the default ownership pattern at the time, it is likely that in the Republic of Vietnam the southern ESI also fell into public hands. Our focus here is on the north, as the victors in the war, institutional and ownership patterns in the ESI were subsequently imposed nationwide. Of course, in the ESI this would not necessarily have implied much change as at the time the world over ESIs were state run and controlled. In the period between 1976 and 1986 there was little institutional change within the ESI. The sector remained organised as three separate vertically integrated companies (North, South and Centre) operating under the electricity department of the Ministry of Energy (EVN 2009a).

From 1954 in the DRV, there were a number of largely cosmetic changes to the organisation of the ESI. Responsibility for the sector was moved between ministries as part of wider administrative changes, from the Ministry of Industry and Trade in 1955 to the Ministry of Water Resources and Electric Power in 1961, to the Ministry of Heavy Industry in 1962, the Ministry of Electricity and Coal in 1969 and the Ministry of Energy in 1981 where it remained until 1995. Throughout all these administrative changes the ownership of the ESI remained essentially the same. It is worth stressing the emphasis that was placed on the ESI as a leading sector in the economy and central to the neo-Stalinist development policies of the government. As part of the central planning system the ESI was given preferential access to available resources, and electricity was allocated in turn to favored sectors – typically heavy industry. Structural changes that did occur were necessitated by the incorporation of the central and southern power systems under a single national administration following reunification in 1976, the expansion of the sector, which necessitated the formation of new organizational units, and some largely cosmetic and changes in the attempted formation of 'Enterprise Unions' in 1978 and again in 1989 (Van Arkadie & Mallon 2003; Cheshier & Penrose 2007; EVN 2009b).

[155] The available information on this is sparse, the extensive data on foreign ownership given by Hausman et al (2008), and partially reproduced in Chapter 4 (Table 2), does not include French Indochina or its constituent parts. The information that is available on French colonies and Francophone countries in their data (Algeria, Morocco and Haiti) suggest that in the pre-war period foreign ownership in the French sphere of influence was common. It is likely that similar ownership conditions were in place in colonial Indochina.

6.3.2 The material drivers of ESI reform[156]

Doi Moi lead to a further formal weakening of the already attenuated and generally dysfunction grasp of central planning. But key strategic economic sectors remained relatively untouched. The bulk of the ESI and other energy sectors remained under tight state control.[157] However, by the mid-1990s the sector was in dire need of substantial capital investment. Electricity demand from the burgeoning economy was growing extremely rapidly. Evidence from similar experiences of rapid growth in East Asia suggested that electricity consumption could be expected to continue its rapid growth, this is amply reflected in sector planning and donor documents published at the time (World Bank 1996, 1997). In addition, existing power infrastructure was in a poor state of repair. Some of the key existing power plants had suffered from chronic under-investment with the coal plants in the north in a particularly poor state:

> "The Pha Lai plant, the largest and most modem of the three [coal fired] stations, has major problems of equipment, maintenance, absence of adequate control systems, spares, as well as problems with boilers, which would require a considerable investment. The two other plants in the north, Uong Bi and Ninh Binh, are unlikely to be easily rehabilitated and present major environmental and safety problems; it may well be more economical to abandon them or to rehabilitate them only as necessary for providing reactive compensation in the 230 kV system." (World Bank 1993: vi)

Transmission and distribution networks were underdeveloped and unreliable. They used poor quality equipment, had no modern load dispatching facilities, many components were of Russian design for which it was difficult to obtain spare parts. Transformers, connectors and conductors were of insufficient capacity leading to high levels of losses, and there were multiple voltage standards across the country (with 6, 10, 15, 20 and 35 kV systems operating in different areas) (World Bank 1993).[158]

All this implied significant investment needs estimated to be in the order of one billion US$ per year between 1995 and 2000, or almost five per cent of GDP in 1995 (ESMAP 1995; World Bank 1996; World Bank 2006a). From 1954 onwards the ESI had been fully

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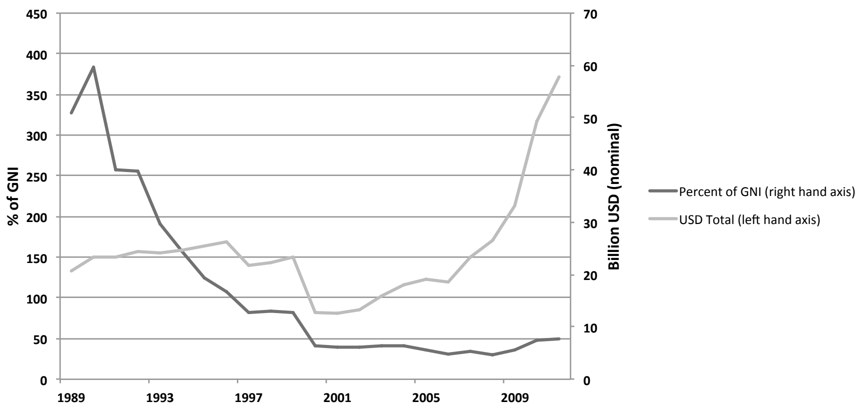
156 Here we distinguish between the material drivers for reform (borrowing the expression from Wyatt 2002) and the political economy elaboration of these material drivers, which are discussed in section 6.3.3.

157 Not withstanding the development of distributed generation in rural areas.

158 Different voltage levels reflect different supply technologies, but also differences in the French, Russian and American ESIs from which these technologies were supplied. A further problem resulted from issues with the localization of ESI technologies, which were not designed for the environmental conditions in Vietnam and lead to frequent breakdowns (World Bank 1993).

funded through the state budget, asset values and depreciation were not reflected in accounts and revenues barely covered operating costs. In 1990 the ESI's operating losses were around US$ 8 million, quite small relative to the sector turnover, but well short of the level needed to be financially sustainable (World Bank 1993).[159] Soviet aid had supplied the bulk of financing for capacity expansion but with the collapse of the Soviet Union, which had provided around 40% of the state budget (Probert & Young 1995), Vietnam would be forced to look elsewhere for investment funds.

Figure 6.7. Vietnam's external debt 1989 - 2011[160]



Source: World Bank 2013

Options were limited. Although Vietnam had been running a fiscal deficit of on average less than three per cent in the 1990s and 2000s, regarded as sustainable by international standards, it had a significant external debt burden (World Bank 1999, 2008; Adams 2012; Figure 6.9).[161] Given the investment needs of the sector and the need to maintain debt sustainability, other sources of finance needed to be identified. In addition, a number of powerful ministries in Vietnam, notably the Ministry of Finance (MoF) and the Ministry of Planning and Investment (MPI) along with most international donors argued that the ESI represented a relatively good opportunity for commercialisation, and public funds could be more productively used elsewhere in sectors that may be less amenable to operation on commercial principles (World Bank 2006a, Wyatt 2002, ESMAP 1995). The ESI would therefore need to rely on sources of investment other

[159] Typically, electricity utility companies are deemed to require a self-financing ratio of around 30% (World Bank 1993; Krishnaswamy & Stuggins 2007)
[160] This excludes around a debt of around nine and a half billion transferrable rubles that was being renegotiated with Russia in the early 1990s (Wyatt 2002).
[161] Given issues with accounting for sub-national debt, government bond issues and contingent sovereign obligations the fiscal deficit may actually be larger than official figures suggest (Adams 2012).

than the state budget and Soviet aid. Potential sources of funding included retained earnings, domestic capital markets and banks, concessional lending from IFIs and international investment. In the short term, the perceived opacity and inadequacy of sector management meant that any capital raised from external sources would require a sovereign guarantee (be it explicit or implicit). Such contingent liabilities could, in turn, also have implications for perception of long-term national debt sustainability (ESMAP 1995).

Fundamentally, and from the perspective of prospective investors, the bankability of Vietnam's ESI would depend on the strength of the balance sheet of the utility. This in turn increased the urgency of performance enhancing institutional reform to the sector. For the ESI to be financially self-sustaining, revenues would need to not only cover operational costs but adequately account for the depreciation of assets and allow the ESI to achieve a sustainable level of investment. That is to say, the long run marginal cost (LRMC) of supply needed to be reflected in the level of electricity tariffs. Average tariff levels following price reforms in 1992, however, were only at about 70% of the estimated LRMC (World Bank 1993). Tariff levels have proved to be both a key element of sector reform but also a source of conflict between the ESI, other state energy enterprises, line ministries, IFIs and the general public. We discuss this in greater detail in section 6.3.9 below, but here it is suffice to note the central importance attached both to achieving cost reflective tariff and to the contested nature of tariff increases.

Enhancing the performance of the sector implied significant technical and operational changes. Staffing levels were high, staff lacked training in modern managerial and operating procedures, transmission and distribution (T&D) losses were in excess of 20% (Figure 6.1), and these were likely underestimates as T&D losses were not measured downstream of power company metering points where an estimated additional 10-15% of electricity was lost (World Bank 1993). Levels of internal electricity use were around three per cent (higher than comparable countries), capacity expansion was inefficient, and the investment planning and approval processes were cumbersome and bureaucratic (World Bank 1996). What is more, companies constituting the ESI contained business units involved in a number of non-core activities (such as hotels and construction), there was a perception that these distracted from the operations of the ESI and should be sold off (World Bank 1993). In sum, there was a strong perception amongst donors, sector experts and in the Vietnamese government itself of the need to adopt reforms to the sector that would enhance performance (and expectations about performance) and better enable the ESI to raise the finance it needed to invest in capacity expansion (Quinn 1998).[162][163]

Institutional considerations aside, at around the same time, the country was facing an electricity supply crisis. The dominance of hydropower in the generation mix (Figure 6.4) together with drought conditions in 1996 – 1998 exposed the vulnerability of the system to hydrological risk. Water levels at the massive Hoa Binh reservoir were at dead-levels with the turbine water intakes fully exposed and the plant was producing only about 11% of rated capacity. This lead to unpopular and economically damaging load shedding and power cuts, especially in the north of the country that had greater dependence on hydropower (Wyatt 2002). This added the additional rationale of diversification of the generation mix to the already pressing capacity needs.

An additional consideration was the need to develop and effectively utilise Vietnam's significant off-shore gas reserves, which were situated off the coast of South Eastern Vietnam in the Nam Con Son and Bac Ho fields.[164] Without the large demand for gas represented by power generation and long-term supply agreements with generators it would not be possible for the government to raise the funds needed to develop this valuable resource (World Bank 2010a). CCGT technology and the upstream development of a gas pipeline network represented a particularly attractive solution, all the more so as gas fired generation would be situated in the south east of the country, where the demand for electricity was greatest. This seemed to present an opportunity in which foreign investment in IPPs could be both feasible and particularly advantageous. Feasible, as considerable up-stream activity by foreign firms in off-shore exploration and drilling that was already in place could act to mitigate perceptions of investment risk. And advantageous because foreign investment represented not only a source of capital,

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162 It should be noted that the sector experts employed by the donors seem to have been, almost uniformly, from countries which had undergone significant power sector liberalization with experts from New Zeland and

163 Source 19, Annex A6.4.

164 Nam Con Son is a gas field, whereas the gas produced from the Bach Ho was associated with oil reserves. Up until a pipeline to bring the gas from Bach Ho on-shore came into operation in 1995, the gas was flared as an unwanted by-product.

but as gas turbine technology was relatively unfamiliar in Vietnam, FDI could bring with it state of the art kit and valuable technological know-how.[165]

The IFIs and bilateral donors presented additional incentives for reform of the ESI. Substantial concessional lending and grants were tied to a commitment to reform the power sector along the lines of the 'standard model' (Chapter 4, sections 4.2.6). The recommendations in the first World Bank review of the sector were relatively tame, with the suggestion that there was a need to rationalise the ESI shedding non-core staff, facilities and units, that cost-reflective tariffs should be adopted, and that the responsibilities of the ESI and the MoE should be more clearly delineated, with the latter stepping back from planning and operational issues and focusing on policy. While it was noted that the private sector could potentially play a role in the ESI, the only concrete recommendation for private sector involvement at this point was for a joint venture to enable the development of CCGT generation facilities to exploit associated gas reserves from the Bach Ho field (World Bank 1993).

By contrast, the World Bank's following project appraisal documents, coming with substantial commitment to investment (US$ 165 million committed in 1995 and US$ 180 million committed in 1996), were more strident and the loan agreements required considerable commitment to sector reform on the part og the Government. These included undertakings to review tariff levels, accounting practices and the organisation of the ESI, and to achieve sustainable levels of financial performance (World Bank 1995). Thus, pressure was building from the World Bank, and IFIs in general to undertake reforms in the power sector. While the suggestions for reforms remained modest, the intentions were at this stage clear. The World Bank project appraisal document notes:

"The policies and programs pursued by the Government in the power sector are in compliance with IDA's policies and guidelines for commitment to efficiency improvement…[…]…sector reform and restructuring, moving towards commercialization and corporatization, and encouraging private participation." (World Bank 1995: 19)

165 A knock-on implication of this shift in generation technology, was the greater proportion of capital cost which would find its way abroad. In contrast to hydropower, for which heavy engineering goods (turbines etc.) typically account for around one third of capital costs with the rest being spent domestically on civil works, for other technologies including CCGT most of the capital costs would consist of capital goods purchased overseas.

To be sure, these reforms were relatively minor relative to liberalisation programs adopted in other countries. But they represented a staring point, and from the perspective of the Bank, one consistent with its broader commitment to power sector reform, a commitment which would be pushed with greater vigour over the coming years.

6.3.3 The first wave of reform: formation of EVN and the energy parastatals

Despite increasing IFI pressure, institutional changes in the sector seemed to have been instigated as a result of domestic concerns. Change started in earnest with the first round of restructuring in 1994 and 1995, which took place in the context of wider SOE reforms. The three energy parastatals Electricity of Vietnam (EVN), Petrovietnam (PVN) and Vinacoal (TKV)[166] along with 15 other State Corporations (as defined in the State Enterprise Law (1995)) were formed by the implementation of Decision 91 in 1994 (Annex A6.3, Table A6.1). The stated policy objectives of these reforms were to consolidate the SOEs, rationalise state supervision, and effectively reduce ministerial influence in everyday operations. An additional - and often implicit - reform objective was to create large-scale business groups or enterprises along the lines of Korean *chaebol* that would be able in the longer-term to build productive capabilities, generate dynamic comparative advantages and compete internationally (Quinn 1998; Van Arkadie & Mallon 2003; Perkins & Vu 2010).[167][168]

EVN itself was established as a state corporation in January 1995 by Decree 14 – CP. At the same time, with the separation of the energy parastatals, the Ministry of Energy (MoE) was slimmed down, rationalised and eventually absorbed (along with the ministries for light and heavy industry) within the Ministry of Industry (MoI) in October 1995 (World Bank 1996).[169] Operational responsibilities and the exercise of the 'ownership function' fell to the newly formed energy parastatals (EVN, PVN and TKV), while MoI maintained overall oversight and responsibility for the formation of policy and planning in the sector.[170]

[166] Later Vinacomin
[167] See also Chapter 3.
[168] Source 8, 9, 17 Annex A6.4.
[169] MoI was subsequently merged with the Ministry of Trade in 2008 to form the Ministry of Industry and Trade (MOIT).
[170] Quinn (1998) maintains that the Ministry of Planning and Investment (MPI) and MOI were responsible for ESI planning. This was not the case, while plans have to be endorsed by MoI, MPI and the Prime Minister the planning exercise itself is conduced by the Institute of Energy, which at the time was a department of EVN.

EVN was reorganised as 34 different business units, all of which reported to EVN's Director General. Of these 16 were dependant accounting units – cost centres without revenue these costs were consolidated in EVN accounts - including 12 large power plants, four transmission units and the national load and dispatch centre (NLDC). There were 17 independent accounting units, which had their own consolidated expenditures and revenues, of these five were regional distribution companies the remaining 12 enterprises were involved in the provision of services to the sector including finance, design, construction and planning (ESMAP 1995; World Bank 1996; Figure 6.8, 6.9).

The corporatisation of EVN represented the first step in the restructuring of Vietnam's ESI. The structural division of the different functions (generation, dispatch, transmission and distribution) and non-core activities was seen by many (and especially from the perspective of the IFIs, international financiers and project developers) as a further step in rationalising the structure of the industry in preparation for further reform along the lines of the 'standard model' (Chapter 4, section 4.2.6). The MoI (1997) power sector policy statement developed in close consultation with donors lists six policy objectives as follows:

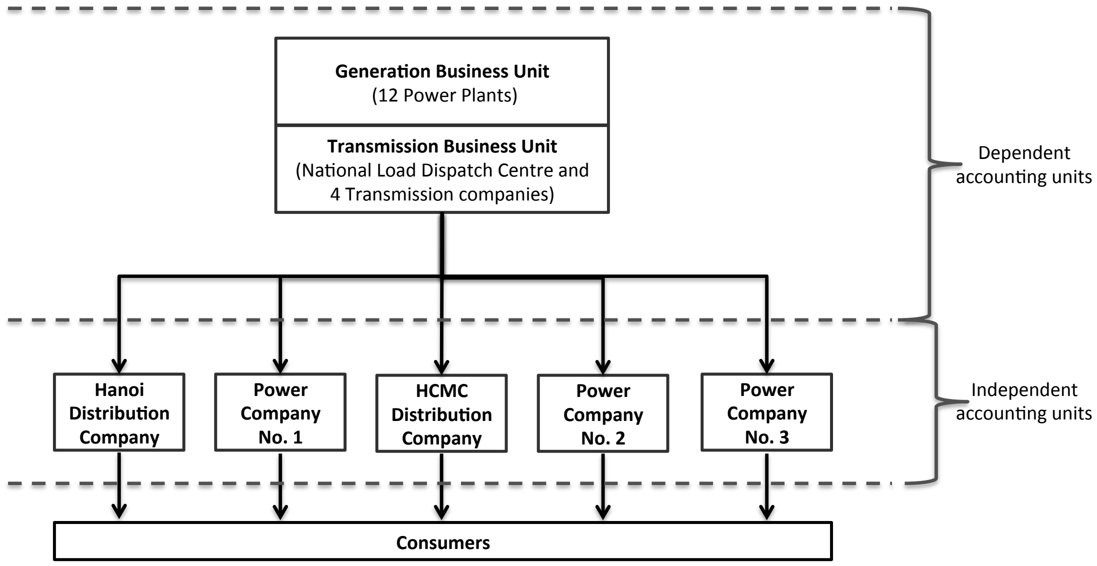
> "i) Provide electricity access to the national economy and the entire population of Vietnam.
>
> ii) Increase the operating/technical efficiency of the electricity sector to optimise the use of scarce investor resources.
>
> iii) Ensure reliable electricity supply of good quality.
>
> iv) Resolve the mismatch between market-based production costs and State administered prices.
>
> v) Clearly delineate and separate State management functions and business management functions.
>
> vi) Enable Vietnam to raise the necessary financing for power sector expansion to meet economic growth targets." (MoI 1997)[171]

The document also reflects a focus on further commercialisation and institutional reform of the sector. This included i) the further unbundling of the functional components of the ESI into independent business units operating on commercial principles; ii) the development of an Electricity Law, which would lay the legal foundations for a regulatory agency, and provide a consistent basis for service and tariff regulation, the licencing of activities in the sector, and importantly a grid code defining interconnection and operating standards for generators and transmission companies; iii) revisions to tariff

[171] An earlier version of this includes and additional objective of "Redefine and clarify ownership responsibilities to allow for asset preservation, asset development, and commercial management" (ESMAP 1995: 3)

structures and levels; and, iv) diversification of participation in the sector including the encouragement of projects through limited recourse (project) financing (MoI 1997).

Figure 6.8. The structure of EVN in 1995



Source: Based on ESMAP 1995 and Wyatt 2002

Thus there was an (ostensive) undertaking by EVN and MoI to reform the sector along commercial lines and ensure cost recovery though cost-reflective tariff levels. Importantly, the development of a grid code and the explicit undertaking to encourage private sector participation in the sector through project financing paved the way for the entry of non-EVN IPP generators, and in particular those of foreign origin. This built on the revised Law on Foreign Investment (1992) and Decree 87 – CP (1993) which introduced a framework for Build-own-transfer (BOT) type projects for infrastructure development. This was also closely linked to the development of the proposed Phu My 3 and Phu My 2.2 CCGT projects, which were in the pipeline at the time.[172]

The reforms however fell well short of the international 'best practice' as defined by the standard model. Firstly, the treatment of generation and transmission business units of EVN as dependant accounting units allowed transfer pricing and cross-subsidisation to continue, as a consequence these units did not need to operate on a cost recovery basis (Wyatt 2002). Secondly, with the formation of EVN the government undertook to make no further direct equity investment in the enterprise (apart for socially oriented projects) and to ensure it operated with "…no notable explicit subsidy from the government"

[172] Source 3, 17, 21 Annex A6.4.

(World Bank 2006b; Krishnaswamy & Stuggins 2007: 130).[173] But effective subsidies remained significant, in terms of input price controls on fuels (notably coal), preferential access to financial resources, in the allocation of hydropower resources, and through favourable taxation treatment (Tran & Jones 2011). To be sure, this was offset by price controls on end-user tariffs, but it also added to the opacity of sector operations, softening budget constraints and generating uncertainty. Thirdly, the ministry maintained the right to appoint board members (with prime ministerial approval) and voting rights at the AGMs.

What is more the reforms had done little to clear up the institutional and legislative uncertainty that characterised Vietnam's institutional environment more generally:[174]

> "These [energy] corporations have been slow to adjust to an increasingly market oriented environment. Reforms have given them more commercial focus, but old-style controls remain in place…[…]…this [new] corporate governance structure has failed to minimise interference from supervising ministries. Government policy oversight has not been separated from commercial management because there is no clear definition of state management functions and no clarity on procedures. Clear operating relationships have not developed because ownership and other functions are diffused among government agencies and ministries." (World Bank 1999: 9)

This candid observation is of particular interest to our argument. It echoes comments by Gainsborough (2010), Gillespie (1995) and others relating to the level of uncertainty that surrounds institutional arrangements in the Vietnamese polity. Whereas institutional uncertainty presents fertile ground for patronage networks, it is not conducive to attracting foreign investors, adding to investment risks. Which brings us to our final point, there was little appetite for IPPs or the introduction of competitive power markets. Competition - it would seem - was to be limited to the bidding process for the selection of the concessionaire for IFI supported BOT projects. IPPs were only really tolerated where they were regarded as absolutely necessary (i.e. in the provison of CCGT technologies).[175]

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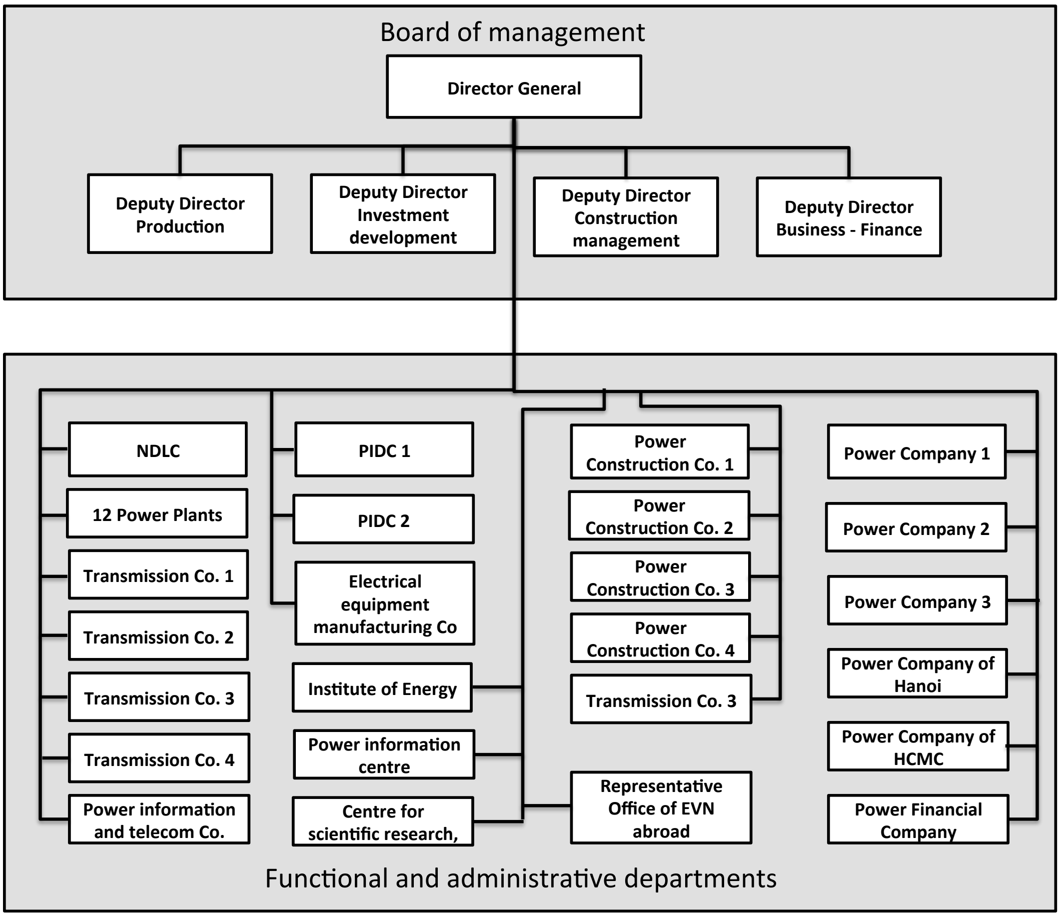
173 A somewhat over optimistic gloss to exaggerate the influence of World Bank sponsored reforms.
174 Source 17 Annex A6.4.
175 Source 22, Annex A6.4.

Figure 6.9. Organisational chart EVN in 1995



Source: Based upon ESMAP 1995

More generally, the open hostility in some areas of government to the notion of private sector involvement in the ESI per se would have given would-be investors pause for thought (Quinn 1998; Le 2000). There remained a strong commitment to maintaining state control over the ESI as a strategically important sector.[176] It is doubtful that this should be understood in terms of ideology, or indeed a 'rational' developmentalism of the Weberian variety. The upward pressure on tariffs private sector investment would entail was certainly one factor in this hostility. Competitive tendering and the 'cost discovery' more competitive generation markets were said to entail may also have left the impression that the scope for rent seeking may be squeezed.[177] Moreover, it should be noted that some stakeholders were more well-disposed to the prospect of reform than others. In fact, the ESI was an area in where a number of important political economy dynamics were being played out, between considerations of the delivery of public goods, ideological commitment and vested interest.

176 Source 3 Annex A6.4.
177 Source 29, 22 Annex A6.4.

To be sure, the development of the energy parastatals, and EVN in particular represented a significant change in the sector that was to have material impacts on the shape of its development. The material constraints facing the sector forced the government to make tentative steps towards the reorganisation, which would ensure the delivery of the public goods associated with electricity supply. At one level, the actions of the government in moving to improve performance and ensure the financial sustainability of the sector, answer the fundamental political logic of maintaining performance legitimacy.[178] But what is also clear is that state agencies were suspicious of private sector and foreign investment in the sector. From the donor perspective, this was only the first step on a long road to the reform of the sector. If there was some cause for concern due to the modest nature of reforms this was tempered by an understanding of the scale of the task ahead in reforming not only the ESI, but upstream and downstream industries, as well as the broader institutional environment for investment. The reluctance of EVN to undertake serious reform and its growing influence in the Vietnamese polity was at this stage largely unforeseen.

6.3.4 The faltering entry of FDI

In the period from the early 1990s to the second round of ESI restructuring in the mid-2000s, Vietnam's ESI saw the first significant private sector investments in electricity generation. These projects were enabled by the amended Foreign Investment Law (1992) which specifically encouraged foreign investment in infrastructure, and the BOT law (1993) already in the pipeline by the time the first round of power sector reforms took place. By 1996 a number of relatively small-scale foreign funded projects focussing on electricity supply to industrial zones and export processing zones had reached financial closure (Table 6.2). The plants at Hiep Phuoc in HCMC, Nomura Hai Phong Industrial Zone and Amarta Bien Hoa had permission from EVN to generate power independently. They were able to sell excess production to EVN on the basis of short-term power purchase agreements (PPAs). Similarly, the investment case for plants at the Bourbon sugar Mill in Tay Ninh province and later at the Formosa plant at the a textile factory and the Vedan food processing plant in Dong Nai were built upon a captive need for reliable power supplies, with excess power sold on to EVN. These independent

[178] Wyatt (2002) argues that the reluctance of the government to rely more heavily on foreign denominated debt rested on the reluctance of the state to give up its hard won sovereignty and become dependant upon foreign debt. However, this seems unlikely. As project finance is, if anything, more intrusive that foreign debt.

power producers (IPPs) met a need for reliable electricity supply in what remained a context of chronic power shortages and frequent blackouts, especially in the south. However, in terms of meeting the wider investment or capacity needs of the ESI these investments were not particularly significant.[179]

At around the same time a number of altogether larger BOT projects designed to address EVNs capacity needs were being developed (Table 6.4). This was part of the global trend fed by the excess petro-dollars, financial deregulation and the liberalisation of ESIs in the developed world (Chapter 4, section 4.2.6 - 7). In Vietnam as elsewhere, bilateral donors had the interests of their own domestic ESI utilities, engineering companies, financiers, project developers and lawyers in mind (Wyatt 2002). A JBIC press release on Vietnam at the time commented:

"Japanese power utilities have been vigorously expanding their overseas operations by finding business opportunities primarily for independent power producers (IPPs) in developing countries. At present, however, the private financial sector can hardly take risks on loans extended to Vietnam. Therefore, JBIC has collaborated with ADB and other official agencies in providing overseas investment loans on a project finance basis, with JBIC taking political risk. This enables private-sector financial institutions to structure a considerably large co-financing deal in support of Japanese power utilities engaging in overseas business operations." (JBIC 2003)

JBIC and Proparco (the private sector lending arm of AFD), for example leant funds of US$150 million and US$40 million respectively for Phu My 2.2, which was wholly owned by a consortium of French and Japanese companies. Japanese and French firms also supplied most of the engineering services and some capital equipment (Figure 6.12). Similarly, JBIC extended a loan facility of US$99 million for Phu My 3, which reached financial closure in 2003, one third of which was held by Nissho-Iwai Corporation and Kyushu Electric Power.[180] Additional JBIC support for the Phu My complex included a concessional loan of US$ 122 million made in 2000 to EVN for the development of a high voltage (500 kV) transmission line from the complex to HCMC (JBIC 2008).

More generally, the whole ESI restructuring programme of which these projects were part, held the potential to generate considerable business for lawyers and consultants who specialised in ESI liberalisation and project finance. In this regard Australian, British

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179 Source 2,3,22 Annex A6.4.

180 The remaining two thirds were split evenly between BP and Sembcorp.

and US firms were (and remain) prominent.[181] From the perspective of the IFIs, project finance was seen as a way to generate investment, and import best managerial practice and modern technologies to the sector, it also represented a step towards putting the power sector on a more sustainable financial footing, forcing EVN to adopt a more cost reflective tariff.[182]

Despite donor and TNC aspirations, the progress of BOT projects in the sector was proving to be painfully slow. BOT projects rely on complex contractual and financial agreements designed to protect investors and counterparties from risks associated with sinking large amounts of investment capital in projects with long cost recovery periods (Woodhouse 2006). This involves the distribution of risks between different counterparties to the project and the host government, ideally arriving at an efficient allocation of risk by allocating risks to those best equipped to deal with them (see Chapter 4, section 4.2.2 and Woodhouse 2006; Victor & Heller 2007; Delmon 2009).[183] Typically, the project developer will bear the majority of risk related to the financing, construction and technical performance of the project. This leaves a number of important risks relating to the ability of the counterparties to fulfill their obligations, including fuel supply agreements, power off-take agreements (which will cover both the quantity and unit cost), guaranteeing the availability of foreign exchange (i.e. that revenues earned in domestic currency will be convertible on demand to hard currency and transferrable overseas) and guarantees relating to natural *force majeure* affecting counterparties, and political *force majeure* including changes to the law, and expropriation risk (World Bank 2002; UNCTAD 2008; Delmon 2009). Risk were regarded as high in Vietnam because formal institutions were deemed weak, and corporate governance standards at the key counterparties to prospective BOT deals (i.e. EVN and the fuel suppliers PVN and TKV) left a lot to be desired. The perception of high-risks were also compounded by the lack of a credible BOT projects in Vietnam at the time.

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181 That high ranking staff from the UK's newly privatised National Grid Company and National Power, were the only representatives of private utility companies in attendance at the final workshop which laid out the strategy for ESI restructuring held in 1995 is indicative of the influence of the 'standard model' at the early stage of reforms (ESMAP 1995).

182 Source 4, Annex A6.4.

183 There is a considerable literature on the 'efficient' allocation of project risks, which is beyond the scope of this research. However, it is interesting to note Delmon's candid take on the textbook notion of efficient risk, "Risk management based on efficiency is, of course, an ideal, a goal. In practice, risks tend to be allocated on the basis of commercial and negotiating strength. The stronger party will allocate risk that it does not want to bear to the weaker party. This scenario does not necessarily imply the most effective and efficient risk management." (Delmon 2009: 155).

Table 6.2. Foreign private investment in captive generation in Vietnam 1990 - 2005

Name	Type of IPP	MW	Financial closure (contract period)	Fuel	Type	Investment (million US$)	Private ownership (%)
Hiep Phuoc Power Co. (Taiwan)	Concession	675	1996 (50 years)	Heavy fuel oil	ROT	205	70
Nomura Hai Phong Industrial Zone Development Corp. (Japan)	Greenfield	50	1996	Coal	BOO	N/K	100
Bourbon Sugar Mill (France)	Greenfield	24	1996	Waste (Bagasse)	BOO	N/K	100
Amata Power Bien Hoa Ltd. (Thai/Swiss)	Greenfield	20	1997 (30 years)	Diesel	BOT	110	100
Formosa Plastics Group (China)	Greenfield	87	2001	Coal	BOO	126	100
Vedan Vietnam (Taiwan)	Greenfield	72	2004	Natural Gas	BOO	N/K	100

Source: World Bank 2013

Negotiations were opened upon a number of larger power projects in the mid-1990s, but given the complexities of BOT agreements by 2001 none had reached financial closure and many negotiations had effectively stalled (Table 6.3).[184] External factors played an important if not decisive role in the sluggish development of these projects. The onset of the Asian Financial Crisis meant projects propolents found it more difficult to raise capital.[185] The onset of the Financial Crisis also affected economic growth rates and the growth of electricity demand in Vietnam. Nevertheless, and contrary to government claims at the time, the ESI remained severely capacity constrained (Wyatt 2002).

This suggests that factors internal to Vietnam probably played a decisive role in the failure of BOT projects to progress. In particular, five key factors seem to have been important in stalling project negotiations, i) inadequate institutional arrangements; ii) a lack of capacity amongst Vietnamese negotiators; iii) the reluctance of EVN to agree off-take tariff levels that could meet investors' expectations; iv) the perception and allocation of risk; and, as noted above, v) a continuing reluctance of the state to cede a role in this strategic sector to the foreign private sector (Dry & Vecchi 2000; Wyatt 2002; Quang & Diep Hoai 2003).

[184] Source 23, 25 Annex A6.4.

[185] Although it should be noted that globally significant amounts of FDI were still being committed to the sector in developing countries subsequent to the crisis (Chapter 4, Figures 4.15 and 4.16).

Table 6.3. Foreign BOT power projects being developed in Vietnam December 2001

Name	Equity investor	MW	Fuel	Note
Wartsila	Wartsila NSD Corporation (Finland)	120	Diesel	Negotiations failed. EVN wanted to renegotiate PPA tariff level of USc 5.79 was deemed too high. Unable to achieve financial closure.
Quang Ninh	Oxbow Corporation (USA)	300	Coal	Negotiations failed. Coal supply agreement with TKV and PPA with EVN could not be agreed.
Phu My 2.2	EDF, Sumitomo, TEPCO (France/Japan)	715	Natural gas	Financial closure in 2002, COD 2005. Partial risk guarantee from WB, Political Risk Insurance support from ADB. A BOT, with 20 year take or pay PPA.
Phu My 3	BP, Sembcorp, Kyushu Electric, Nisho-Iwai (UK/Singapore/Japan)	717	Natural gas	Financial closure in 2003, COD in 2005. ADB and MIGA provided parallel political risk guarantees. 23 year BOT with 20 year take or pay PPA.
Soc Trang	Enron International (USA)	475	Natural gas	Investment licence granted in 1998. Delays in completing gas supply. Dispute over location of plant Enron collapsed in December 2001.
Ormat Quang Ngai	Ortmat (USA)	50	Geother mal	Negotiations on-going.[186] PPA could not be reached with EVN, price of USc 4.9 was deemed too high.

Source: Based on Wyatt (2002: 88); Nguyen et al (2010)

Firstly, although the BOT legislation specified the right to convert profits into foreign currency, made provision for the mortgage of assets and resolution of disputes, and specified the stages of negotiation and approval of a BOT project, on all three of these fundamental issues the legislation proved inadequate to meet investor expectations, necessitating time consuming reforms. The legislation also remained incomplete; implementing legislation and guidelines were not in place, leaving the bodies charged with the negotiation of the projects in a position of uncertainty. Overlapping remits and unclear lines of authority added to the complexity and length of negotiations. As state agencies tasked with negotiating agreements were forced to consult a range of other bodies before agreement could be reached. Agencies that were in turn consulted were also unclear of their authority (Dry & Vecchi 2000; Wyatt 2002). As result of these difficulties negotiations for Phu My 2.2 and 3 took seven years to complete, and negotiations for the Ortmat sponsored geothermal plant on-going since the mid-1990s only reached some resolution in 2012 (Think Geoenergy 2012).[187]

[186] Negotiations are still ongoing, with a PVN geothermal plant proposed in 2012 using Ortmat technology.
[187] Source 22 Annex A6.4.

A second, closely related factor was the lack of capacity of Vietnamese negotiators to fully calculate the implications of what were technically complex agreements. In particular, the broader implications of risk allocations and any contingent liabilities the government was likely to incur as a result (Wyatt 2002). Overall, the negotiation process was marked by a developing and uncertain institutional environment, in this regard Dry & Vecchi's (2000) remarks, echo the warnings of Fforde (2010) against policy fetishism:

"Therefore, although steps in the negotiation process are clearly set forth [in legislation], the problems which have arisen relate to the *realities of the decision-making process and business practices in Vietnam*. There are also practical problems arising from the government's perception that the Vietnamese people may be unable to pay a tariff or toll which that will permit the BOT Enterprise says is necessary to receive obtain an adequate return on its investment."[emphasis added] (Dry & Vecchi 2000: 3)

This leads us to the third and perhaps most important point, aside from these institutional weaknesses, the largest obstacle facing these deals was the reluctance of EVN to guarantee an off-take tariff that would meet the returns demanded by project investors. EVN's retail tariff levels still only accounted for about 70% of the LRMC of supply. Investors typically eyeing an overall return in the order of 15% on this type of project, this implied off-take tariffs that were often higher than EVN's average retail tariff (e.g. see Gómez-Ibáñez 2007).[188] While efforts had been afoot to raise retail tariffs for a number of years these met with opposition from electricity intensive sectors and the general public (section 6.3.9). The inability to negotiate an adequate off-take tariff was the main cause of deal failure. In the failure of the Wartsila, Quang Ninh, Soc Trang and Ortmat projects, the inability of the parties to reach an agreement that would offer adequate (risk weighted) returns to investors lead to their failure (Dry & Vecchi 2000; Wyatt 2002). Indeed, numerous documents reflecting the interests of private sector investors and donors continue to note the fundamental issue of achieving a PPA which offers them an adequate return on investment (Krishnaswamy & Stuggins 2007; Asian Power 2009; American Chamber of Commerce Vietnam 2009; Conaty 2010; ADB & AFD 2012).

188 For example, the estimated internal rates of return on PVNs project list range from 9% - 12% and this is for a provider with access to concessional lending and which does not face a lot of the risks associated with foreign developers. Gomez-Ibanez cites estimates of 15% for low-income countries, 11% for low-middle income countries and 10% for middle income countries (Gómez-Ibáñez 2007)

The level of return investors required also reflected their risk perception, this depended upon the perception of the institutional, political and economic setting. In Vietnam the uncertain and shifting regulatory environment, the poor quality of institutions, the low creditworthiness of project counterparties (and EVN in particular) and the lack of experience with successful projects lead to a heightened perception of project risk (Quang & Diep Hoai 2003). As a consequence investors required sovereign guarantees covering the performance and obligations of the Vietnamese counterparties, undertaken by MPI on behalf of the government (Babbar 2003). On one hand, there remained both a great deal of uncertainty relating to the legislative status of these government guarantees, with 'letters of comfort' deemed unenforceable by much of the international project development fraternity, and from the prespective of the government concerns about the level of risk they were being required to undertake (Dry & Vecchi 2000; Wyatt 2002; Quang & Diep Hoai 2003; UNCTAD 2008; ADB & AFD 2012)[189].

Finally, it is worth recalling that all this was taking place within a context where there was ambivalence in many government agencies about the entry of the foreign private sector. Press reports at the time were fulsome in their praise of a series of completed investment projects undertaken by EVN. This contrasted with considerable criticism of the delays and costs involved in foreign investment in the sector.[190] Indeed, Wyatt (2002) notes that at the World Bank there was a growing concern that the Vietnamese government remained unconvinced of the advantages of BOT projects.

In this context, the project pipeline was slow to develop. Prior to 2010 the projects that managed to proceed farthest were able to do so due the fact that they offered more attractive risk profiles to developers. In the case of Wartsilia, as the capital goods would largely be obtained from the parent company, even if the project failed to become financially viable, the parent company stood to benefit from the sale of equipment. The limited recourse financing would mean that creditors claims would be limited to the special project vehicle (SPV) designed to carry out the project, and not the parent company. Although in the end the project did not proceed, the ability of the proponents to limit their risk exposure in this way was an important element in allowing the project to get as far as it did (Wyatt 2002).

[189] Source 12, Annex A6.4.
[190] Source 1, 22 Annex A6.4.

The cases of the CCGTs at Phu My 2.2 and 3 were somewhat different. As noted above, for a number of reasons the government saw these plants as strategically important in the provision of much needed capacity for industrial heartland of the southeast, in enabling the development of off-shore gas fields and in the provision of new technologies with which EVN had limited experience. Both projects also enjoyed the backing of the development banks, with the World Bank, ADB and JBIC involved in all three. This involvement itself gave a greater level of comfort to the private sector developers and creditors, and acted to reduce risk perceptions.[191]

The Phu My 2.2 project in particular was seen by the World Bank as demonstration project that would help define and better develop the Vietnamese institutional and regulatory framework, and capabilities in the Vietnamese government to assess and negotiate such projects (World Bank 1996). The project was to be tendered on a competitive basis and also serve to demonstrate to the government the financial advantages of this approach. In order to attract investors to the project the World Bank (IDA) offered a partial risk guarantee (PRG) of up to US$ 75 million covering breach of contract by Vietnamese counterparties, currency convertibility and transferability, political *force majeure* and frustration of arbitration (World Bank 2002; Babbar 2003). ADB also stood as guarantor of record for the Political Risk Insurance for US$ 25 million (ADB 2008). ADB, JBIC and Proparco supplied loans to the project giving further comfort to private sector investors. Thus in the case of Phu My 2.2, significant intervention by IFIs gave comfort to investors and ameliorated the risk burden for government, effectively enabling the project to go ahead.

The Phu My 3 project was different again. It also enjoyed considerable support in the form of loans from ADB and JBIC. ADB and MIGA[192] also offered parallel Political Risk Guarantee facilities (ADB 2007). As with Phu My 2.2 the extensive involvement of thee IFIs served to moderate investors risk perceptions, and effectively leverage private sector investment. An additional factor with Phu My 3 was the involvement of BP. The company was also involved in a joint venture with PVN to develop the gas supplies that would be used to supply the Phu My 3 project, thus mitigating counterparty risk related to the gas supply agreement. Thus in the case of the only two foreign IPPs to EVN that were actually able to reach commercial operations before 2005, both structural pressures

[191] Source 30, Annex A6.4.
[192] Multilateral Investment Guarantee Agency part of the World Bank.

on the ESI, and the extensive involvement of international donors were instrumental in enabling agreements to be reached (Quang & Diep Hoai 2003).

Up until around 2010 although many foreign IPPs were discussed none reached development save the Xiaozhong River Hydropower Station and Ba Ria Vung Tau wind farm. Both these projects, however, represented much lower levels of risk for the investor than would typically be the case. Xiaozhong River Hydropower Station (22 MW) is located in Lao Cai province close to the Chinese border. It has a total investment of around US$ 28 million and reached financial closure in 2007. The developer is the state owned China Southern Grid Corporation (CSG), which supplies electricity to China's five southern provinces as well as imports to Vietnam's grid in the northwest of the country. In this case, the clout of the company and the dependence of northwestern Vietnam on CSG for its electricity supplies probably served to reduce the perception of investment risk.[193] The second project, Ba Ria Vung Tau wind farm (7.5 MW) is a 100% Swiss owned US$ 20 million BOT project, which reached financial closure in 2009. It uses a combination of wind turbines and diesel generators to supply the isolated Con Dao islands 180 Km off the Vietnamese coast. Due to the remote off-grid location the project was able to reach an off-take tariff of USc 20/kWh, reflecting the alternative cost of supply in the remote location (Saigon Times 2008). Thus the only other two FDI projects in the ESI to go ahead from the completion of the Phu My projects to the end of the decade were these small atypical projects, which were effectively off-grid and serving remote locations.

It had been hoped that the development of the two Phu My projects would herald much more significant foreign private sector investment in the ESI. This failed to emerge. Issues with the quality of legislation and institutions, low tariff levels and the willingness of government to take on contingent liabilities all served to frustrate the process. Despite substantial rewrites of the relevant legislation in the amended Law on Investment in 2005, Decree 108 on BOT, BTO and BT investment in 2009 and in 2010 Decision 71 (Regulation on pilot investment using Public-Private Partnership model) and a constant tinkering with supporting legislation, the legislative and institutional framework still appeared weak, a fact attested to by numerous donor reports (ADB 2007; ADB 2008; ADB & AFD 2012):

193 Source 26, Annex A6.4.

"For an economy the size of Viet Nam and with its increasing openness to private sector participation, private investment in infrastructure and PPPs have been very limited. Government approvals and support have been uncertain. Competitive bidding processes have not been the norm…[…]…There is currently a lack of a credible PPP project pipeline. The private sector sees the government as "stop and go" when it comes to PPP policies and actions, and it views PPP bidding and negotiation processes as unpredictable and lengthy. Nor is the private sector entirely confident the government can carry out credible (pre)feasibility studies for PPP." (ADB & AFD 2012: 21)

And private sector commentators (Harris et al 2009; Asian Power 2009; BMI 2010; Conaty 2010; Vietnam Investment Review 2013):

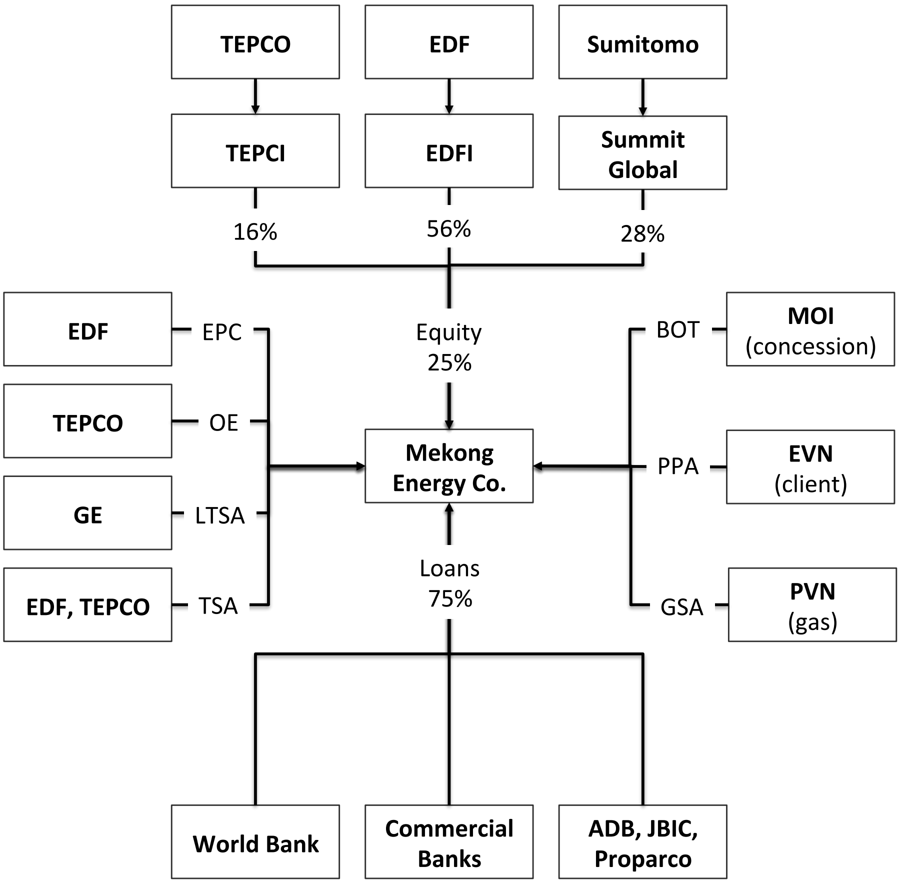
"…the Vietnam Government's approval process appears to some international industry leaders to be designed to 'tease' private power developers/investors without any guarantee of agreeing on an acceptable 'financeable' tariff or PPA, until such time as a PPA is actually executed. Project developers are therefore confronted with having to start PPA negotiations after 2-3 years of high-risk development work resulting in additional millions of dollars in out-of-pocket expenses. All of this expensive 'negotiation' limbo is played out against an atmosphere of uncertainty and unnecessary risk until the other shoe is finally dropped with an execution of the PPA." (Asian Power 2009:10)

The failure to catalyse the development of FDI in power projects might not be surprising considering the dissatisfaction expressed by government sources relating to some aspects of the Phu My projects (ADB & AFD 2012). In particular, the issue of EVNs failure to pay take-or-pay invoices for gas at Phu My 2.2 was only resolved once MoI was forced to intervene, and illustrated the extent of the contingent liabilities the government had incurred (ADB 2008). Government dissatisfaction with both Phu My 2.2 and Phu My 3 was compounded by repeated breakdowns in 2006 due to issues with the localisation of CCGT technologies, leading to system-wide power shortages (Viet Nam News 2006a; Viet Nam News 2006b; ADB 2008). Following Phu My 3, the government was reluctant to undertake such extensive guarantees for IPPs, and no significant majority foreign owned projects were licenced by MoI between 2003 and 2010 (Harris et al 2009)[194]. Finally, in the late 1990s and early 2000s according to industry sources, from EVN's point of view it was also time consuming and expensive to undertake complex IPP negotiations. It was felt that EVN could meet investment needs through funding offered

[194] In 2008 the roles of the Ministry of Industry (MoI) and those of the Ministry of Trade (MoT) were combined in the newly formed Ministry of Industry and Trade (MoIT).

by export credit agencies (ECAs) with MoF guarantees, or domestic financing deals.[195] It was only in 2008 when EVN was forced to withdraw from the development of 13 thermal power projects that the government had expected it to undertake due to lack of funding that the BOT route seemed viable again (VietNamNet Bridge 2012).[196]

Figure 6.10. Structure of Phu My 2.2 project



Note: EPC – engineering, procurement and construction agreement; OE – Operational engineering agreement; LTSA – long-term service agreement; TSA – Technical services agreement; BOT - Build own transfer project agreement; PPA – power purchase agreement; GSA – gas supply agreement.

Source: Based on Mekong Energy 2013

Issues with FDI in the power sector point to more fundamental institutional and political economy dynamics during this period. Firstly, the uncertainty caused by complex, overlapping and ever changing formal institutional structures. Secondly, and linked to this, the lack of coherent government, as different agencies with different agendas competed with and obstructed one another, even if it is in the interests of MPI and MoI

[195] Source 26, Annex A6.4.
[196] Source 26, Annex A6.4.

for a project to go ahead, it may not be in the interests of the State Bank of Vietnam (SBV) to provide for currency convertibility, or the Ministry of Justice (MoJ) of the Ministry of Natural Resources and the Environment (MoNRE) to allow the mortgage of foreign held land use rights.[197] Third, both these observations also reflect the limits to an analysis focussed on formal institutional arrangements. Although formal institutional arrangements in the ESI were constantly shifting the informal institutional arrangements and the political economy processes that belied them changed much more slowly. Change in the ESI seems to be more responsive to changes in the underlying patterns of power rather than changes in formal institutional arrangements. In some cases these may be in harmony but this cannot be taken for granted – as the case of BOT regulation illustrates.

6.3.5 Continuing pressure to reform

Vietnam emerged from the Asian Financial Crisis relatively unscathed, at its low point in 1999 GDP growth dropped below five per cent, but rebounded strongly in 2000, this was followed by something of an economic boom. The three years immediately prior to the Global Financial Crisis (2006-2008) saw growth in excess of eight per cent. This was accompanied by an asset price bubble, in 2007 the HCMC stock exchange index had risen 140% compared to the previous year, real estate prices had in some sectors risen to more than 200% of their pre-2007 levels (VietNamNet Bridge 2008; Pincus & Vu 2008; East Asia Forum 2009; Jehan & Luong 2010). Exports reached almost US$ 70 billion (78% of GDP) and net FDI inflows reached US$ 9.6 billion (10.5% of GDP) in 2008 (World Bank 2013). External factors including the global commodity price boom and Vietnam's accession to the WTO in January 2007 played an important part in this rapid growth. Howeer, this boom presaged greater economic volatility and bust in the years that followed.

For the ESI, this period was marked by continuing pressure to keep pace with rapid electricity demand growth, which between 2000 and 2010 was running at around 13.6% (IEA 2013). Despite significant capacity additions (over 6,500 MW between 1995 and 2005), improvements in the quality and reliability of service (World Bank 2001, 2008, 2009) and the remarkable expansion of rural electrification (Figure 6.4), the sector faced

[197] Source 22, 26, 2, 3 Annex A6.4.

mounting challenges.[198] Technical performance at EVN remained an issue, with significant transmission and distribution losses and considerable inefficient plant still in operation. But above all else, EVN was failing to meet higher expectations about the reliability of electricity supply, from both the business community and the public at large (e.g. see Nguyen 2005).

Difficulties with ensuring supply stemmed from both the rapid expansion in demand and the hydro-dominated generation mix. The fifth power development plan, developed at the end of the 1990s in the midst of the Asian Financial Crisis, and the rapid rebound in demand growth was not foreseen. As a result capacity expansion plans fell short of actual demand (World Bank 2006b; IE 2007). EVN was also meeting increasing problems in fulfilling capacity and network expansion plans, due to a combination of technical difficulties and limited financial resources. By 2006 approximately 1,700 MW of capacity was behind schedule (IE 2007). What is more, in dry years limitations on the supply of electricity from hydropower plants continued to necessitate extensive load shedding, for example in 2005, 2007, 2008 and 2010 (World Bank 2006b, 2008; Forbes 2010; The Diplomat 2010). EVN's large hydropower portfolio meant that load shedding and the lost sales this implied affected its financial performance, instead of selling cheap hydropower generated electricity for a profit, it would need to buy expensive electric from non-EVN suppliers and sell this on at a loss (Viet Nam News 2006).[199]

The net result of all this was that insufficient reserve ratios and a lack of grid capacity lead to frequent outages and voltage drops (World Bank 2009).[200] Power outages were frequently cited as a major constraint in doing business in investment climate surveys, with a survey in 2006 finding that 19% of manufacturing enterprises rated the quality and reliability of grid-based power supplies as a significant constraint to their business (World Bank 2009). Public expectations of cheap and reliable power supplies had increased with increasing affluence, rising residential demand in rural and urban areas lead to higher levels of discontent with power provision as perennial dry season power shortages

[198] For example, between 1995 and 2000, staffing ratios at EVN had improved from 72 customers/employee, to 94 customers/employee, and 385 MWh/employee to 630 MWh/employee (World Bank 2001). 2005 T&D losses had declined from 22% to 14%, rural electrification had increased from a little over 10% to 73%.

[199] That is CCGT plants at Phu My and imports from CSG.

[200] The World Bank (2009) notes that in the absence of systematic monitoring mechanisms it is difficult to be more exact about reliability issues. We are similarly forced to rely on anecdotal evidence.

persisted (Viet Nam News 2005a, 2005b, 2005c, 2006a, 2006b, 2007a, 2007b, 2007c, 2008a, 2008b, 2009, 2010; Saigon Daily 2010).[201]

Almost as frequently reported in the press was a simmering consternation about increased electricity tariffs. Both the public and energy intensive industries reacted strongly to proposed increases in electricity tariffs (Lao Dong 2005; Viet Nam News 2005d, 2006d). The Government fretted about inflationary impact of tariff increases, but was also conscious of their unpopularity – for which they were directly responsible (Nguyen 2008).[202] On the other hand, EVN, the IFIs and prospective private sector investors were dismayed by their failure to persuade government to move towards a more cost reflective tariff (discussed in greater detail in section 6.3.9).[203]

In these respects, from the perspective of the government, the corporatisation of EVN in 1995 had proved propitious. Despite continuing close links between EVN and government (both formal an informal), ostensibly at least EVN was an independent enterprise and at arms length from the state. The government and CP were thus somewhat insulated from public dissatisfaction with perceived performance failings at EVN and unpopular price rises.[204] Press reports reflect the executive (typically the PM and deputy PMs) positioning itself as an arbiter between EVN and electricity consumers. The truth may have been rather different, with close links between EVN (and other large SOEs) and the higher levels of government and the CP.[205] And in terms of provisioning essential public goods, the government maintained an obvious interest in improving the performance of the ESI and its long-term financial sustainability. Nevertheless, public expressions of discontent from Prime Minister and Deputy Prime Ministers with EVN's performance were reported with increasing frequency in the (state controlled) media. EVN became subject to more frequent criticism in the press, with various commentators blaming its monopoly on electricity provision for what was perceived as its poor performance (Inter Press Service 2005).

Rapid demand growth meant investment needs had increased precipitously. Estimates suggested capital investment needs in the ESI of between US$ 4 - 4.5 billion a year

201 Source 1,7,15 Annex A6.4.
202 Recommendations for price increases were sent through EVN and MoI to the State Pricing Commission. Their recommendation would be authorized by the PM.
203 Source 3,4 Annex A6.4.
204 Source 24, Annex A6.4
205 Source 24, Annex A6.4

between 2006 and 2010, and this relative to EVN revenues of US$ 2.7 billion in 2006 (World Bank 2008; MoI 2007; Nguyen 2008). Hitherto, capacity expansions - with the exception of the two Phu My plants - had been largely financed through domestic bond issues, borrowing from domestic banks and ODA. This large expansion of debt is reflected by EVN's changing financial position. Between 1996 and 2004 its debt to equity ratio had increased from 11:89 to 55:45, and its debt service coverage ratio had declined from 13 to 3.7 over the same period (Krishnaswamy & Stuggins 2007).[206] These levels of debt were not unsustainable, but with large investment needs, and without substantial improvements in performance and higher tariffs the trend was *not* (ADB 2003; World Bank 2006b; Krishnaswamy & Stuggins 2007). With the government unable to find financial resources to fund capacity expansion, and unwilling to underwrite credit risks EVN would have to look elsewhere for investment capital (World Bank 2006b, 2009).[207]

Finally, strategically it was clear that in the medium term prices would need to be raised. The cheapest sources of hydropower and coal had been exploited. The levislized costs of incremental capacity expansions were bound to be higher.[208] And by 2014 - 2015 Vietnam was expected to become a net energy importer (Table A6.2). This would mean that the power sector would need to increasingly turn to international markets and pay market rates for the fuel used at many of its new thermal plants. The control of prices for this critical input had, in effect, allowed the natural resource rents associated with Vietnam's fossil fuel reserves to be distributed to key sectors, the general population and perhaps into the back pockets of powerful patrons, but these rents would not be avialble for imported fuels priced in international markets. Of course the imperative to raise tariff levels was there anyway (i.e. to ensure that fuel and power suppiers could achieve a level of long-term financial sustainability), but the prospective reliance on more expensive sources of power represented a much more tangible and immediate reason to lift prices.

From the perspective of the IFIs, despite improved technical performance in the ESI, institutional reforms still left a lot to be desired. Firstly, a condition of ADB and World Bank lending to the sector was a government undertaking to raise tariff levels. However, average end-user tariff levels reached less than 5 USc/kWh in 2001, well below the target

[206] The debt service coverage ratio is the ratio of net operating income to debt repayments.
[207] Source 4 Annex A6.4.
[208] i.e. the average cost of generation of a particular type. Calculated based on investment costs depreciated over a fixed period, plus operational costs divided by electricity output, figure typically given in USc/kWh or US$/MWh.

tariff of 7 USc/kWh agreed with the banks. This lead to power sector loan programmes at both bnkas receieving unsatisfactory perofmance evaluations. Secondly, the promised Electricity Law that would set out an ambitious program for sector reform was slow to emerge to the evident chagrin of both banks. The law had been through an extremely long and time-consuming period of development. In 1997 the law was expected in 1998 with formal adoption later that year or early 1999, in 2001 a World Bank project completion report commented hopefully that, "…Government's commitment to sector reform remains high and the Electricity Law and secondary regulation are expected to be approved in 2001." (World Bank 2001: 12). The law had reached its 14th draft in 2001 according to ADB (ADB 2001; World Bank 2001). The law was eventually passed by the National Assembly in 2004 and came into force in 2005.

By the mid-2000s, a decade after the first round of reforms, the pressures for reform in the sector, to improve performance, expand capacity and achieve financial sustainability remained the same. If anything, larger debt burdens at EVN and ever increasing incremental capacity demands meant the pressures were more acute. Considerations of long-term energy security had also emerged as an increasingly important factor in sector strategy.

The political pressure for better performance in the ESI was mounting to boot, as expectations about the quality and reliability of supply, and electricity demand amongst both businesses and the general population grew. Again it is worth stressing the limited traction that IFI badgering seemed to have had. There were always reasons for delays in lifting the power price (the Asian Financial Crisis and the expected economic impacts of the 9/11 attacks), and foot-dragging on the adoption of the Electricity Law (the legislative burden facing the National Assembly) (World Bank 2001). Although donors were undoubtedly listened to, and the notions neo-liberal reform they purveyed were increasingly influential in some circles, their ability to effect the sort of institutional change that they recommended was limited. In the end it would be the combination of economic imperatives and political interests which drove the second round of reforms.[209]

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[209] Source 4,20 Annex A6.4.

6.3.6 The second wave of reforms

Between 2004 and 2006 a second round of reform in the ESI got underway, with the adoption of the Electricity Law in 2004. This was the first law governing activities in the ESI in Vietnam. It covered planning, the development of an electricity market, tariff levels, and licencing and regulation of the sector. Importantly, the law provided the legislative basis for the creation of a system regulator (the Electricity Regulation Agency of Vietnam (ERAV)) and the development of competitive electricity markets. A 'road map' for the development of competitive markets was published in 2005 by MoI, this envisaged the gradual unbundling of the ESI along the lines of the standard model (Chapter 4, section 4.2.6-7). Initially competition would be restricted to generation, then wholesale competition would be introduced for bulk supply (including large consumers), the final stage reached after 2024 would be that of full retail competition (Freshfields Bruckhaus Deringer 2005)(Figure 6.11).

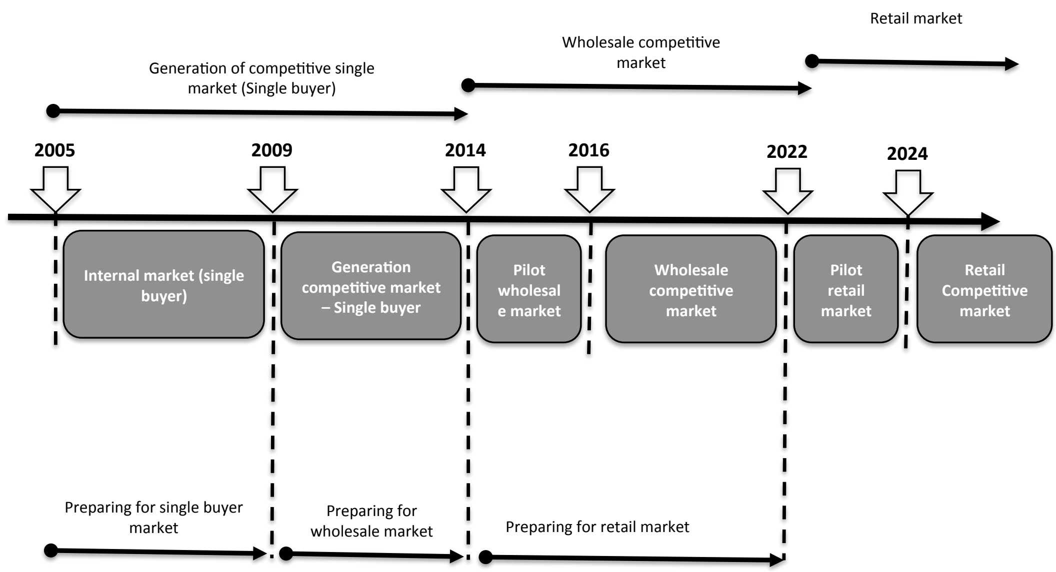
The law, in principle, signalled the government's long-term intention to embrace the standard model of ESI liberalisation. The stated objectives of the reforms were to improve the efficiency of the sector's performance, and raise prices to a level where they could reflect costs, attract investment, and discourage inefficient use of electricity. Another key element implied by the reforms was a gradual removal of the cross-subsidisation of residential by industrial tariffs.[210] The standard model would be the means of achieving these goals, with market competition would incentivising performance improvements. Cost reflective tariffs determined by the market, while inevitably leading to higher tariff levels than the subsidised rates that were in place, would incentivise more efficient use of electricity and attract much needed investment to the sector (and upstream energy sectors).

The state monopoly would be restricted to transmission and load dispatch. State ownership of power plants would be limited to those that were deemed strategically important, i.e. very large hydropower plants and planned nuclear plants. Hydropower plants were deemed strategic as they also had important flood control and irrigation functions that needed to be balanced against power generation needs. Thus the plant at Ya Ly and the Da river cascade (Hoa Binh, Son La and presumably Lai Chau which is yet

[210] Source 10, 13 Annex A6.4.

to be constructed) would remain under state ownership and control.[211] Similarly, proposed nuclear plants would be exempt from privatisation, reflecting the strategic nature of the technology – and perhaps the likelihood that a new and costly technology would struggle to complete in the market (National Assembly 2005; World Bank 2006b; Nguyen 2012).[212]

Figure 6.11. Roadmap for developing the Vietnam electricity market



Source: MoI 2005

The road map for the electricity market adopted a cautious timetable, with the Minister of Industry, Hoang Trung Hai, predicting that it could take up to 30 years to reach full retail competition given the technical and institutional complexity of the task (Viet Nam News 2006e). As such the immediate practical implications of the legislative changes were, at the time, limited. A regulator was formed, but this remained under the authority of MoI, which also remained in charge of EVN. Price levels were still effectively set by the Price Management Commission at the MoF, on representations from EVN and ERAV, and approved by the PM. EVN remained owned and controlled by MoI, and with 76% of the generation capacity (excepting the Phu My plants 88% of capacity), a monopoly on transmission, distribution and retail, EVN remained a vertically integrated electricity utility.

211 Operators at Hoa Binh, for example, are unable to optimise water use for power generation as the reservoir needs to be drawn down prior to the wet season to provide enough storage to allow the dam to act as a buffer against floods. Thus offering some protection to the capital city Hanoi from flooding during wet season.
212 These exceptions to the principles of equitization were further defined in a Prime Ministerial Decision in 2007.

Arguably the most significant change that took place in the wake of the Electricity Law was the further restructuring of EVN as a holding company, the development of generation and distribution units under EVN as independent legal entities, and their subsequent equitization.[213] Under Decision 147 of the Prime Minister adopted in June 2006, Vietnam Electricity Group was formed (PM 2006). Similar to the corporatisastion reform in 1995, this was part of a wider move to restructure the large SOEs in strategic sectors, but this time as 'State Economic Groups' (SEGs). As with the first restructuring that took place at EVN, ostensibly at least, this also reflected the continuing desire to emulate the success of the Korean *Chaebol* and Japanese *Keiretsu* (Kim et al 2010). This was essentially a continuation of the CP's stated policy since the early 1990s, which entailed the formation of the state corporations. The immediate prospect of membership of the WTO was an important factor spurring the creation of these groups. It was hoped that privileged access to inputs and increased autonomy would enable them to compete effectively with international firms (World Bank 2011b).[214][215]

In 2006 and 2007 eight economic groups were formed including EVN (and the other energy parastatals Vinacomin (TKV) and Petrovietnam (PVN)). These reforms were supposed to tighten corporate governance and place economic groups under the direct authority of the PM.[216] This represented a further extension and consolidation of the corporatisation that took place in 1995 (Kim et al 2010). In the case of EVN, former business units were either subsumed in the mother company (including National Load Dispatch Center, National Power Trading Company and a number of power plants, including multipurpose hydropower plants), or transformed into legally independent subsidiary companies (in which EVN held equity of more then 50%), affiliated companies (in which EVN held less than 50% of the equity) and other administrative entities (including a number of training establishments and the Institute of Energy).[217]

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213 The importance of rhetoric again, avoiding the term "privatization", in Vietnam it is termed "equitization".

214 It should also be noted that along with the objectives of increasing international competitiveness, EVN still had a mandate to provide important public goods including access to households in remote areas, technological upgrading, and the government maintained the option of using EVN's large economic footprint as a macro-economic leaver.

215 Source 18 Annex A6.4.

216 This was with the notable exception of the exception of Bao Viet insurance company which was under the authority of the MoF.

217 At the time of its creation Vietnam Electricity Group (as distinct from the holding company EVN) comprised of 50 member companies, 21 in which it held 100% of the equity, nine of which it held greater than 50% of the equity and a further 20 in which it held less than 50% of the equity (Kim et al 2010).

From the perspective of the standard model, this reform was an additional step towards the unbundling of the sector. The creation of legally independent enterprises prepared the way for equitization (in fact three generation companies had already had IPOs in 2005 (see following section)), and the conversion of business units to independent entities formally separated the different functions of the vertically integrated utility (generation, distribution, and load dispatch and transmission). Thus, from the point of view of sector reform it represented another important phase in the introduction of competitive markets to the ESI.

Parallel to the gradual development of standard model reforms, there was already an altogether different process going on at EVN.[218] One of the key donor recommendations in the first wave of sectoral reforms was that EVN concentrated on its core interests, and divest itself of units involved in activities not central to its function as an electricity utility. These units included construction companies (often but not always involved in the construction of power infrastructure), power consulting companies, mechanical engineering companies (again involved in supplying engineering equipment to the power sector), training companies and a number of hotels. This divestment had not taken place. On the contrary, EVN, along with a many of the other large SOEs, was increasingly diversifying into other sectors (at the same time a number of large SOEs involved in construction, engineering and energy supply were moving into the power sector (see following section)) (Pincus & Vu 2008). EVN's first annual report as an economic group, published in 2006 makes clear its intention not only to maintain its none core activities but to diversify out of the electricity industry, listing amongst its objectives:

> "…Enhance investment business in public telecommunication and internet services with objectives of providing telecommunication services with the lowest prices and best quality…[…]…strive for the target of having 2 million customers by 2007 and 10 million by 2010. Focus on studying and developing banking, financing, insurance and security services; gradually makes these activities become core operations[s] aiming to mobilize investment capital and increase revenue and income for EVN…" (EVN 2006)

EVN took a 30% stake in Anh Binh Bank in 2005. It also made ambitious expansion plans in the telecommunications sector, with investments of US$ 200 million in EVN

[218] The government was also keen to ensure that it retained sufficient control over these companies that they could be used as tools to achieve macro economic policies should needs be (World Bank 2011c).

Telecom in 2005 alone (Viet Nam News 2005e, 2005f, 2006f, 2007d)[219]. In the following years EVN also moved into securities, insurance, and real estate investment (Viet Nam News 2006g, 2006h; VietNamNet Bridge 2008; Nguyen 2010). Nor was EVN alone in this, as the other SEGs (including the energy parastatals TKV and PVN) also moved to diversify their business activities.

There were mixed views on the wisdom of this diversification. Whereas some commentators saw the move of the SEGs into other fields simply as a means to generate profits in what were booming sectors (Viet Nam News 2007d), others were altogether more cautious. They pointed out that in contrast to the Korean or Japanese models, by and large, these companies did not compete in export markets, but relied upon industrial policy and preferential access to inputs and markets to engage in import substituting industrialisation, thus seeking to dominate the domestic market over which they had privileged access (Kim et al 2010; Perkins & Vu 2010; World Bank 2011a):[220]

"The idea was that larger firms would realize economies of scale and scope, which would enable them to compete internationally. The gap in the logic was that most of the conglomerates…[…]…earned their money from mineral rents or preferential access to the domestic market. Rather than wade into the treacherous waters of international competition, most preferred to build on their market power in Vietnam to move into lucrative domestic ventures in the property market, financial services, telecommunications and tourism…. The conglomerates did not turn into world beaters, *but they did learn how to trade on their political influence at home*."[emphasis added] (Pincus & Vu 2008: 31-32)

Government was eventually forced to start reining-in the trend towards diversification at the SEGs. By the late 2000s there seems to have been the realisation that SEGs were not performing particularly well. By 2007 they were accounting for around 70% of foreign debt and 60% of loans from the SOCBs, but only 40% of GDP (Pincus & Vu 2008; World Bank 2011a). Pincus and Vu (2008) report that in April 2008 the PM ordered state general corporations and conglomerates to ensure that a minimum of 70% of their capital investment was in core businesses. At around the same time, expressions of doubt emerged from a number of authors as regards the possibility of effective state control of

219 Two chairs on the board came with this investment, that of Vice Chairman went to the EVN Chairman Dao Van Hung and a seat on the board for EVN's Deputy Director General, Duong Quang Thanh (An Binh Bank 2007).

220 Perkins and Vu (2010) for example are highly critical "EVN's expansion into telecommunications, financial services, and real estate development cannot help but divert its limited human and financial resources from its core responsibility…[…]…A regulated monopoly such as EVN should work best not if it is large and complicated with many side businesses, but if it focuses on its main task and does it effectively and profitably at a reasonable cost." (Perkins & Vu 2010: 36)

these enterprises (Pincus & Vu 2008; Fforde 2009). But divestment of non-core investments did not really get underway until the situation become critical (section 6.3.7). EVN differed from many large SOEs in that evidence of its performance was clear every time customers received a bill or suffered a power cut. In the years that followed this second rounf of restructuring, EVN's performance and management would come under increasing scrutiny.

On one hand, Vietnam had adopted a neo-liberal model of power sector reform, with the notional target of full retail completion sitting on the distant horizon. On the other hand, even as the institutional changes that would enable these reforms were being put slowly into place, EVN - in common with the other SEG behemoths - was leveraging its political and economic influence in pursuit of a set of interests that were not necessarily in accord with either the objective of the efficient operation of the ESI, or indeed with the broader public good.

A further illustration of this point was EVN's proposal for the creation of a single buyer market in 2007. This was the first step in the process of developing a competitive generation market. The function of the single-buyer was to buy electricity in a competitive wholesale generation market and sell it on at regulated prices to distribution companies and large consumers (Nguyen 2012). To act as the single-buyer EVN proposed the creation of a power buying joint stock company (JSC) the 'Electricity Purchasing and Trading Company' (EPTC). EVN would have a controlling stake in the new company of 51%, with the remaining shares held by a number of other large SOEs (PVN, TKV, Song Da, Liliama, the national steel and cement corporations and VNPT). The company's chartered capital was to be US$62 million, and according to Dao Van Hung Chairman of EVN at the time, it was expected to make a profit of between US$ 3.1 - 6.2 million per year (Viet Nam News 2007e).

This proposal was met with dismay by the World Bank. Martin Rama, the acting director of the World Bank in Vietnam at the time, took the unusual step of writing an open letter to MoI expressing his concerns about the proposed single buyer model (Viet Nam News 2007f). Two main concerns were raised about EVN's proposal. First, that the ownership of the single-buyer by EVN would represent a conflict of interest becaue EVN also owned a large proportion of generation capacity. There would therefore be a strong incentive for EVN to give preferential treatment to its own power generators. This in turn would discourage prospective investors and force them to require long-term PPAs, effectively side-stepping the market mechanism and damaging the prospect of the development of a fully competitive generation market. Secondly, there was concern expressed relating to the creation of a stand-alone single buyer operating for profit. This was because the operation of the single-buyer may imply duplication of dispatch functions in the existing NLDC unnecessarily increasing costs. Morover, it was suggested that the incentive to maximise profits at the single-buyer may also lead to higher than envisaged profits and higher consumer costs (Viet Nam News 2007f). The preferred solution was to create an entity combining the monopolistic functions of load dispatch, transmission and single-buyer, that was independent of the generators (Nguyen 2010).

EVN attempted to publicly rebut the World Bank's arguments, suggesting i) that the creation of an independent single buyer, transmission and load dispatch entity was prohibitively expensive; ii) that user tariffs were controlled by the Price Control Committee anyway so the proposed model could not lead to inflated prices; iii) that a conflict of interest would not emerge because stakeholders in the EPTC would agree to 'step aside' and not partake in power price negotiation; and, iv) perhaps most disingenuously, that collusion in bidding for new power supplies would not take place as "it was illegal and that member companies would be State-owned and therefore would follow Government regulations strictly and provide fair prices to Vietnamese consumers as promised" (Viet Nam News 2007e).

The unpopularity of the move forced the PM to order ERAV to investigate EVNs proposal, which was in the end rejected. As of 2008 a single buyer did start pilot operations but it was wholly owned by EVN, a dependant accounting entity and did not operate for profit – addressing some of the concerns raised by the bank (ERAV 2008; Nguyen 2010). Nevertheless, this meant that EVN retained effective control over power purchase and dispatch, which would lead to an abuse of its market power in just the ways envisaged by the bank (following section). More broadly, this was also indicative of EVNs reluctance to undertake reforms that may affect its position.[221]

[221] Source 25,26,30 Annex A6.4.

What emerges from a discussion of the second round of sector reforms are two main trends. Firstly, the need ensure that essential public goods were delivered remained paramount,[222] this is analogous to Fforde's (2009) observation (in relation to the public good of macro-economic stability) that Vietnam's political economy for all its dysfunction was marked by an ability to do what it takes to ensure the delivery of critical goods. In the case of the power sector, this was represented by need to improve the performance of the sector and ensure adequate capacity expansion. This must also speak of the influence in some quarters of technical experts and consultants schooled in the neo-liberal economic theory, which advocated the standard model of reform as the best way to deliver these public goods.[223] In key government institutions neo-liberal thinking has become influential, including for example the Office of Government, some sections in MPI, the Central Institute of Economic Management (CIEM) and ERAV, this echoes Gillespie's experience of legal reform in Vietnam:

"There are small but influential cliques within the lawmaking elite in sympathy with neoliberalism. They cluster around the collaborative structures that bind foreign donors/lawyers, Vietnamese consultants, and state officials working on law reform projects. These communities inculcate neoliberal regulatory ideas by bringing foreign advisors into a close working relationship with local legal consultants and state officials." (Gillespie 2008: 692)

Sector reform could also imply potential political benefits. While it is unlikely that the Vietnamese public take the reforms at face value, it is also likely that the formal independence of EVN from the administrative arm of the state has continued to prove politically expedient for the CP. The locus of blame for unpopular power cuts, tariff rises and environmental damage is shifted from the state and the CP somewhat. Further reforms which would allow prices to be determined by market mechanisms, rather than by administrative fiat would act to depoliticise the power price decisions by putting it in the hands of the market. But for this to be effective the monopoly that EVN enjoyed would need to be dismantled. And there would need to be confidence in the market mechanism.[224] Both of these conditions seemed a long way off.

[222] Source 5 Annex A6.4
[223] Source 4,6,22 Annex A6.4
[224] It should be noted that even in the UK market, within which the regulatory paradigm was developed, there remains little public faith in the operations of the power market. Even here power price and the suspicion of excessive profits at power companies remains a politically fraught issue.

Secondly, EVN was increasingly independent and assertive of its own interests. Bearing in mind the caveats that this may be partly illusory, and that in some ways the reorganisation of SEGs such that they were under the direct authority of the PM binds them more directly to the ruling elite.[225] EVN emerged from the second wave of reforms pursuing its own agenda more forcefully. While it dragged its feet on sector reform, it moved extremely quickly to acquire new business interests in telecoms and the booming finance and real estate sectors. Equally where reform was proposed by EVN this inevitably was in its own interests such as in the case of the single buyer, and in the pursuit of increased end-user tariffs.

6.3.7 The search for capital

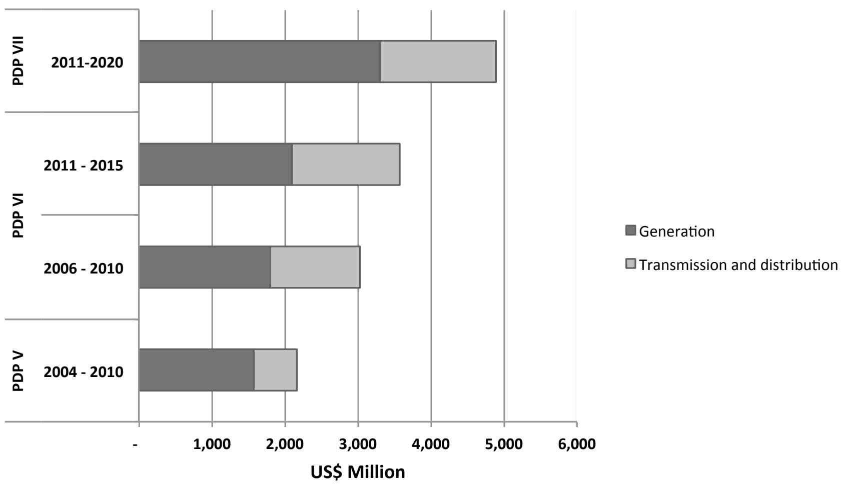
Exponetial demand growth and the large capital needs this implied for the ESI compounded the need to seek financing from new sources. EVN sought to borrow from increasingly diverse sources, including ODA, ECAs, commercial borrowings from domestic and international banks, and bond issues. At the same, EVN's restructuring facilitated the equitization of subsidiaries, and the development of new JSCs as special purpose vehicles for project development with other equity holders. Reforms that had been made to the sector also paved the way for an explosion of small IPPs in the hydropower sector, typically developing units below 30 MW in size. Larger IPPs were developed primarily by the other energy parastatals with TKV and PVN investing in significant amounts of new capacity, both on their own but also as shareholders in joint stock companies. New FDI, by contrast, was until the end of the 2000s almost totally absent. The investment landscape was becoming increasing complex, creating important new vested interests in the ESI.[226] The sector continued to be dominated by EVN, the increasing autonomy of its actions and the pursuit of its own interests lead to a growing potential for conflict in the sector. It also meant that in some respects the political settlement that had characterised the sector and the Vietnamese polity more widely was being gradually eroded.

Plans to further encourage the entry of IPPs into electricity generation to meet around 30% of the 2006 – 2010 investment needs, did little to ease EVN's escalating investment needs. The sixth power development plan (PDP VI) - published in 2007 - forecast capital investment requirements of US$ 15.6 billion between 2006 and 2010 a significant

[225] Source 9 Annex A6.4.
[226] Source 9 Annex A6.4.

increase on the former plan which forecast requirements of US$ 11.9 billion over the period (World Bank 2006, IE 2005) (Figure 6.13). The sharp increase in investment needs left EVN with an estimated capital shortfall of US$ 3 billion by 2005 (Viet Nam News 2005g). Up until the mid-2000s EVN had been able to maintain relatively sound financial position despite low tariff levels, meeting capital investment requirements through self-financing and moderate levels of borrowing from ECAs, ODA and domestic sources (World Bank 2006a; World Bank 2006b).[227] Bourgeoning capital investment needs however, forced EVN to increase borrowing and seek alternative sources of funding.

Figure 6.12. EVN estimated average annual capital investment needs PDP V, PDP VI and PDP VII



Source: IE 2007, World Bank 2006, Kadono & Au Minh 2012

EVN has relied on bond issues to fund capital investment projects since the early 1990s, with approximately US$ 67.6 million was raised for ESI investment through three domestic bond issues in the 12 years between 1992 and 2004.[228] Bond issueance saw a dramatic increase in subsequent years, with US$ 685.3 million raised through 13 domestic bond issues in the six years between 2005 and 2010 EVN (Vuong & Tran 2010).

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227 Indeed as mentioned above it was the ability to fund projects with ECA backing more cheaply than BOTs that lead the government to prefer this option.

228 Including two tranches by EVN and one by Ya Ly hydropower company a 100% owned subsidiary of EVN.

EVN was also able to raise a significant amount of capital in borrowings from domestic banks. Between 2001 and 2005 EVN had reportedly borrowed approximately US$ 625 million from domestic commercial banks. As with bond issues this borrowing accelerated rapidly in the late 2000s. For example, in 2006 EVN reached an agreement to borrow up to US$ 2.7 billion on preferential terms between 2006 and 2010 from a consortium of SOCBs including Vietnam Industrial and Commercial Bank (Incombank), the Bank for Foreign Trade of Vietnam (Vietcombank), the Bank for Investment and Development of Vietnam at preferential (BIDV), and the Bank for Agriculture and Rural Development (Agribank) (Viet Nam News 2006i). However, prior to 2006 prudential regulation had limited bank lending to a single borrower to 15% of bank equity, apparently in a move to enable EVN borrowing from SOCBs the PM intervied to raise the lending limit with respect to EVN (Viet Nam News 2006j, 2007g).[229] EVN was also able to reach loan deals with international investors, such as in the agreement with AB Bank (in which it held a 30% stake), PVN Finance, Deutsche Bank and Vinacapital[230] for a loan of US$ 460 million in 2006 (Viet Nam News 2006k).

ECAs and bilateral ODA also provided significant amounts of credit often on concessional terms to EVN.[231] Japan, Korea and China were particularly active in providing finance for power sector projects. For example, from the early 2000s onwards China Export-Import bank along with other Chinese financial institutions acted to lend capital and in some cases offer partial risk cover for an increasing number of power plants in Vietnam. This was typically related to the procurement of EPC services and Chinese capital goods for the construction of new hydropower and coal-fired thermal power plants (such as the Quang Ninh I coal fired power plant) (BMI 2007, 2010; Tien Phong 2010). Japanese ODA had been an important source of loans EVN's power projects since the early 1990s, with concessional lending amounting to about US$ 2.9 billion between 1993 and 2004. Japanese ODA continued to be the single largest source of capital for EVN making an additional US$ 2.1 billion in loans between 2005 and 2013 (JBIC 2008; Vietnam Investment Review 2013). This lending has also typically been linked to the procurement of capital goods and services from Japanese firms. EVN also received a considerable amount of funding from World Bank and ADB. Up to 2005 the

[229] The SBV also made a similar concession to Petrolimex the gasoline importer and distributor, and the other of Vietnam's heavily subsidised energy companies in the same year, but in Petrolimex the provision only applied for Vietcombank (Viet Nam News2006).
[230] An AIM listed investment fund.
[231] Funds from ECAs are tied to the procurement of engineering services and capital goods (which typically constitute 80-90% of costs) purchased from these countries.

World Bank had leant a total of US$ 1,339 million to EVN and ADB US$ 650 million. However, these loans came with their own conditions, and as Vietnam reached 'middle-income' status it would not longer be eligible for concessional loans with the lowsest rates of interest (EVN 2006; World Bank 2008; Kadono & Au Minh 2012).

Borrowing had its limitations. Debts would need to be repaid and debt service would place increasing strains on EVN's budget, further limiting its ability to finance much needed capital investments. Moreover, most loans from foreign sources had strings attached, whether they were the need for government guarantee racking up contingent liabilities, procurement requirements as with much ECA and bilateral ODA lending, or the conditionality imposed by IFIs. EVN did not face such stringent conditions in the domestic market, where it was able to trade on its political importance and close connections with government, banks and other large SOEs to obtain preferential bank loans from SOCBs in particular.[232] Indeed, one of the reasons EVN claimed it bought AB Bank was to enable it to obtain loans from the bank when it was having difficulty raising funds elsewhere (Nguyen 2010).[233] Close relationships with domestic financial instititions and political power were also key to enabling EVN's series of successful bond issues, as Vuong & Tran (2010) note:

"The only way to secure the funding from bond issues for an issuer is to build close relationships with financial powerhouses that could help prearrange the required finance prior to the actual announcement of bond issues; and we clearly cannot regard this act as arm's-length transaction, since the opportunity is not equal among enterprises and does not depend on the only basis of financial viability of issuers." (Vuong & Tran 2010: 15)

By contrast the one international bond issue EVN attempted in 2007 targeting between US$ 300 – 500 million failed (Vuong & Tran 2010).

Thus EVN was still a long way from being able to raise financing for the sector on the basis of its balance sheet alone. Debt that was raised either came with government guarantees, was effectively policy lending (from SOCB and ODA sources), relied on close patronage relationships between EVN and the lender, or in the case of ECA

232 Source 9,22,30 Annex A6.4.

233 The Minister of Industry told the National Assembly in 2007 that "EVN invested in An Binh Bank but only in order to borrow from the bank while other banks turn down EVN's requests" (Nguyen 2010).

lending and risk guarantees effectively represented policy lending to source country industries.

Table 6.1. EVN IPOs 2005 - 2010

Company name	IPO year	MW	Type	US$ million
Khanh Hoa Power Company	2005	11.2	Distribution	1.8
Pha Lai Electricty JSC	2005	1,040	Coal	-
Thac Ba Hydropower JSC	2005	108	Hydro	10.6
Vinh Son - Song Hinh Hydropower JSC	2005	138	Hydro	29.5
Ninh Binh JSC	2006	100	Coal	-
Ba Ria Thermal power plant JSC	2007	388	Natural gas	-
Thac Mo Hydrpower JSC	2007	150	Hydro	59
Da Nhim-Ham Thuan-Da Mi Hydropower JSC	2010	80	Hydro	71.2

Source: PPAIF database, various news reports

At the same time EVN also expected to earn around US$ 688 million between 2005 and 2008 through a programme of equitizationm(Viet Nam News 2007h). EVN had partially divested a number of subsidiary companies prior to the second round of sector reforms in 2005, but most of these were in non-core activities and not related to core functions of the electricity utility. The first electricity companies to be partially divested were three generation companies (Vinh Son-Song Hinh Hydroelectricity JSC, Phai Lai Thermal Power JSC and Thac Ba Hydropower JSC) and the Khanh Hoa Electricity JSC distribution company raising around US$82 million in 2005 (EVN 2006; Table 6.4). This was followed by further tranches of shares in these companies, and the divestment of equity in a further four generation-companies between 2006 and 2010. EVN also had plans to equitize other distribution companies although these were shelved in 2007 as deteriorating stock market conditions in 2008 meant most further equitizations were put-off (Mathaba 2007). EVN also developed a three large greenfield coal fired power plants in Quang Ninh and Hai Phong through JSC's with TKV and other large Vietnamese SOEs as equity holders. All of these plants also had Chinese EPCs and were supported through lending from Chinese banks and ECAs.

In principle, equitization also served ESi reform objectives aside from releasing EVN's equity for reinvestment in system expansion. By creating new IPPs it served the horizontal unbundling of the generation sector and created conditions for a competitive market. If the newly created generation companies were structured correctly it would also act to bring other potentially strategic investors into the sector and provide much needed additional investment capital.[234] In the case of Vietnam, this meant investment by the large SOEs and SEGs, and potentially other entities such as the State Capital Investment Corporation (SCIC).[235]

In practice, equitization in electricity utility assets was only partial. As per government requirements the state retained a 51% stake in all generation JSCs, therefore retaining effective control the companies (World Bank 2009). In most cases this stake remained with EVN. However, in 2008 EVN divested equity in three power JSCs to the SCIC.[236] Typically EVN had agreed only relatively short term PPAs with these companies. For example, the PPAs of Pha Lai Thermal Power JSC and Ba Ria Thermal Power JSC's PPAs both expired in 2010 and that of Vinh-Son Song-Hinh Hydroelectric JSC expired in 2009 (Mekong Securities 2008; Nguyen 2009; Le et al 2012; Vietnam Investment Review 2013). Given EVN's dominant position in the electricity market as sole buyer and with ownership of large generation assets there was the obvious opportunity for it to abuse its market power and screw down off-take tariffs below the LRMC of production. This had the disadvantage of leaving the newly formed JSCs without the financial wherewithal to play the role of long-term 'strategic investors' and would leave them unable to expand generation capacity. Such activity was further incentivised by continuing controls on tariff levels, which remained below EVN's LRMC of supply (Figure 6.17)[237].

The case of the Vinh-Son Song Hinh Hydroelectric JSC (VSH), one of the first to be equitized is illuminating. VSH's PPA ran out in 2009 and it was unable to reach agreement with EVN over an off-take tariff. From EVN's perspective VSH had already paid down any debt and fully amortised its investment, and could stand a lower off-take tariff. The generation company however required a higher price to enable it to raise capital to fund the construction of the Thuong Kon Tum hydropower project expected to cost around US$ 280 million. In 2012, after three years of negotiations EVN and VSH were still unable to reach an agreement (Le et al 2012; Deloitte 2013). In contrast, Pha Lai Thermal Power JSC reported it was able to reach agreement with EVN over a four-year PPA, in this case 52% of the JSC shares are held by EVN and 12% by EVN

[234] Source 7,17 Annex A6.4.
[235] Vietnam's nascent sovereign wealth fund.
[236] These were Vinh Son – Song Hinh Hydropower JSC, Thac Ba Hydropower JSC and Hai Phong Thermal Power JSC.
[237] Source 24, 27 Annex A6.4.

Finance, compared to VSH in which SCIC held the majority of equity since 2008 (Vietnam Business News 2011; Eng 2012).[238]

Aside from the increasingly diverse sources of financing for EVN's investments over the course of the 2000s, encouraged by government, domestic IPPs became increasingly common (Viet Nam News 2007i). The vast majority of these IPP projects were small-scale hydropower projects (2-30 MW). Available data suggests that between 2005 and 2012 34 of these projects reached financial closure with total installed capacity of around 590 MW. Investors were quite diverse including construction companies (both provincial and national, such as Song Da and EVN itself) and specially formed JSCs. Equity in these JSCs was frequently held by a number of companies, often-large corporations such as the state owned Vietnam Rubber Group or private owned corporations such as Hong Anh Gai Lai Group and Mai Linh Corporation.[239] Small hydropower projects were attractive to investors because they required a lower initial capital investment than larger projects, they could utilize relatively cheap Chinese turbines and generators. From a political perspective, the developers were likely to have close relationships with the provincial authorities, which were in turn typically responsible for authorising smaller projects. Off-take agreements were negotiated *ad hoc* with EVN until the introduction of the standard 'avoided cost' tariff in 2009. While this did not significantly raise the average off-take tariff level for these plants, it did seem to have facilitated the negotiation of projects with a significant increase in the number reaching financial close since the regulations were adopted (Meier 2013; World Bank 2013). Despite the large number of these projects, given their small size, they contributed a relatively small amount of additional capacity to the system.

Over the same period, more significant capacity investments were being made by large SOEs, and in particular TKV, PVN and Song Da Corporation[240] – all SOEs with close links to the power sector (Table 6.6) (Viet Nam News 2007i, 2007j). Some of these were developed as projects in which these parastatals held 100% of the equity, such as Nhon Trac 1 developed by PV Power (a subsidiary of PVN) and Son Dong owned by TKV. Others have been developed as JSCs, such as Cam Pha and Nong Son coal plants in

238 Source 19 Annex A6.4.
239 See table A6.1 in annex for a full list of projects.
240 Song Da corporation is a large construction company under the Ministry of Construction (MoC), a number of other hydropower developers are also under MoC including LICOGI, Construction Corporation No. 1 and IDICO.

which TKV held a controlling stake, and Nhon Trac 2 and Dak Drinh in which PVN holds 63% and 93% of the equity respectively (PVN 2012).

In all three cases the immediate inclination of these firms was to invest in generation technologies with which they held a competitive advantage. All three companies invested in hydropower projects, but the construction company Song Da with a long experience of hydro-projects was by far the most involved in this technology (BMI 2007, 2010). Similarly, most power sector investments by TKV were in mine-mouth coal thermal plants, typically using Chinese EPCs, capital goods and loans from Chinese ECAs (Thao 2004).[241] PVN initially developed large CCGT complexes at Nhon Trac and Ca Mau linked to its off-shore gas development activities. But better access to capital seems to have enabled PVN to expand more aggressively into the sector, more recently developing 6,000 MW of large coal fired thermal projects that will use both coal sourced from TKV but also imports (PVN 2012).

Needless to say, these investments were endorsed by a government well aware that EVN was unable to meet the investment needs of the sector. These large SOEs enjoyed apparent advantages over EVN in raising capital. PVN and TKV, in particular, with access to significant mineral resources represented less of a risk to lenders. PVN and TKV also offered a more attractive risk profile to investors when compared to other potential project developers. This was because in many cases they enjoyed control over fuel supplies to their projects, which served to lessen risk perceptions. Like EVN, PVN, TKV and Song Da Corporation also enjoyed close connections to powerful players in government, in particular TKV and PVN which, as SEGs, were directly under the authority of the PM. All three therefore enjoyed preferential access to financial resources, but also good political connections, which they were also able to leverage to mitigate investment risk.[242]

Despite the significant advantages these firms possessed in terms of political leverage, they faced difficulties similar to other investors in developing power sector projects, and above all else they faced problems negotiating PPAs or other off-take agreements with EVN. A slew of power plants that were commissioned by PVN and TKV in the late 2000s had great difficulty concluding PPA negotiations with EVN. For example, in the

[241] Source 10,14 Annex A6.4.
[242] Source 21, 25, 26 Annex A6.4.

case of the Son Dong coal plant, TKV had still not been able to reach agreement over the off-take tariff for the PPA with EVN after more than a year of negotiations during 2008-2009.[243] TKV was forced to appeal to directly to MoIT to arbitrate an agreement with EVN before operations could begin (VietNamNet Bridge 2009). Almost two years later, in 2011, Vu Manh Hung, the then Vice CEO of TKV, also complained that price negotiations had delayed the development of a number of projects jointly developed with EVN, and off-take agreements for the Son Dong (COD 2009) and Cam Pha (COD 2010) projects were *still* under negotiation (Vietnam Business News 2011; VietNamNet Bridge 2011b).

Table 6.2. Power plants developed by TKV, PVN and Song Da 2000 - 2012

Name	Financial closure	Capacity (MW)	Technology	Main Investor
Con Don	2000	72	Hydro	Song Da
Huong Son	2001	32	Hydro	Song Da
Cao Ngan	2002	100	Coal	TKV
Se San 3A	2003	108	Hydro	Song Da
Son Dong	2004	220	Coal	TKV
Dam Phu My	2005	20	Natural gas	PV Power
Na Duong	2005	111	Coal	TKV
Ca Mau 1	2005	771	Natural gas	PV Power
Ca Mau 2	2005	771	Natural gas	PV Power
Cam Pha	2006	660	Coal	TKV
Nong Son	2007	30	Coal	TKV
Nhon Trac 1	2007	450	Natural gas	PV Power
Dung Quat	2008	84	HFO	PV Power
Huan Nha	2008	180	Hydro	PV Power
Dak Drinh	2009	125	Hydro	PV Power
Mao Khe	2009	440	Coal	TKV
Nhon Trac 2	2009	750	Natural gas	PV Power
Long Phu 1	2009	1,200	Coal	PV Power
Thac Xang	2010	20	Hydro	Song Da
Vinacomin Dong Nai V	2011	150	Hydro	TKV
Quang Trach 1	2011	1,200	Coal	PV power
Song Hau 1	2011	1,200	Coal	PV Power
Thai Binh 2	2011	1,200	Coal	PV Power
Vung Anh 1	2011	1,200	Coal	PV Power
Nam Xay Noi II	2012	12	Hydro	Song Da
Song Chay V	2012	16	Hydro	Song Da

Source: World Bank 2013a, 2013b; Various press reports and interviews

243 Source 15, 22, 30 Annex A6.4

PVN faced similar problems. Off-take prices at its large Nhon Trac and Ca Mau CCGT plants were relatively high and it proved difficult to reach an agreement with EVN (Vinacomin 2012). For a number of plants temporary agreements were reached in lieu of a longer term PPAs, for example Nhon Trac 2 which came into operation in 2011 but still had not finalised a PPA with EVN by the middle of 2013 (Ha Noi Moi 2013). Worse still, reports from PVN suggested that EVN would rather engage in load shedding than dispatch expensive electricity from its plants. In 2009, it complained that despite power shortages nationally EVN had chosen not to dispatch available capacity at Nhon Trac 1 (VietNamNet Bridge 2009).[244] The same report also mentioned that EVN's official dispatch planning for the second quarter of the year, which suggested 2.1 TWh would be dispatched from the Nhon Trac plant were different from the agreement made between PVN and EVN to dispatch only 0.9 TWh over the same period. Suggesting, that EVN was reluctant to dispatch electricity from this source.

Even the very large energy parastatals were facing something of an obsolescing bargain. Price controls on end-use tariffs meant EVN stood to lose revenue when it purchased expensive power from these sources. *In extemis*, it seemed that EVN was even prepared to see blackouts and brownouts rather than take losses on expensively purchased power. Fines of around US$ 2,100 a time for power cuts in 2010 represented very small beer indeed besides the losses EVN would make on unfavourable PPAs (Financial Times 2010). The knock-on implication was that IPPs deals were difficult to reach and fraught price negotiations delayed the implementation of projects further exasperating capacity shortfalls (VietNamNet Bridge 2009; VietNamNet Bridge 2011a). The situation also speaks of the inability of MoIT, the PM or government more widely to co-ordinate the operations of the SEGs in the energy sector, the continuing dominance of the ESI by EVN, and its increasing willingness to put its balance sheet before the delivery of a public good.[245]

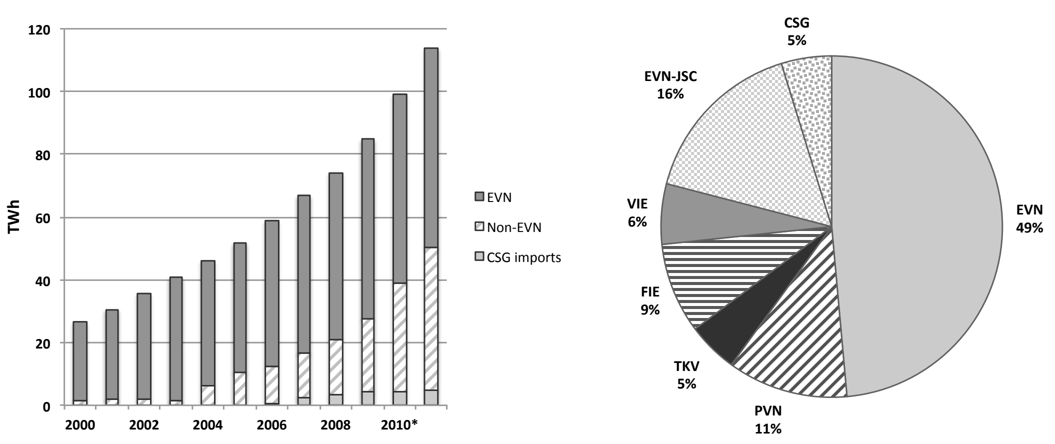
Notwithstanding the problems faced by IPPs in investing in the Vietnamese ESI, the ownership situation in the sector between 2000 and 2011 had changed dramatically (Figure 6.14). EVN still accounted for around half the power generated in 2011, including the JSCs over which it had control that moved up to around 65%. Other state owned groups accounted for about 16% of generation, whereas FDI invested projects

[244] Source 15 Annex A6.4
[245] Source 11, 18, 22, 26, 30 Annex A6.4

and domestic IPPs (many of these were effectively controlled by SOEs) accounted for only 15% of generation. EVN still undoubtedly dominated the sector with effective control over power purchase and dispatch, and a monopoly in transmission and distribution. But its position in generation had been eroded essentially by its inability to raise capital on its own account, which in turn, was largely attributable to the political inertia increasing power tariffs faced.[246]

As noted above project development in the ESI was plagued by delays. As a result the planned roll-out of projects fell behind schedule, resulting in regular power shortages and load shedding. The extent of this problem is indicated by consideration of national power development plans (PDPs). According to the revised master plan published in 2007 all scheduled development project were on time.[247] However, by 2010 while around 2,780 MW identified in the PDP was commissioned, a further 4,840 MW was delayed (Figure 6.14). Of the 14,581 MW approved for construction between 2006 and 2010, only 10,081 MW (69%) actually reached commissioning (JETRO 2010). Reports also suggested that EVN was only able to build about half of the transmission lines envisaged by the PDP (Thanh Nien News 2011).

Figure 6.13. Increased generation from non-EVN sources 2000 – 2011 (left) generation share by ownership 2011 (right)



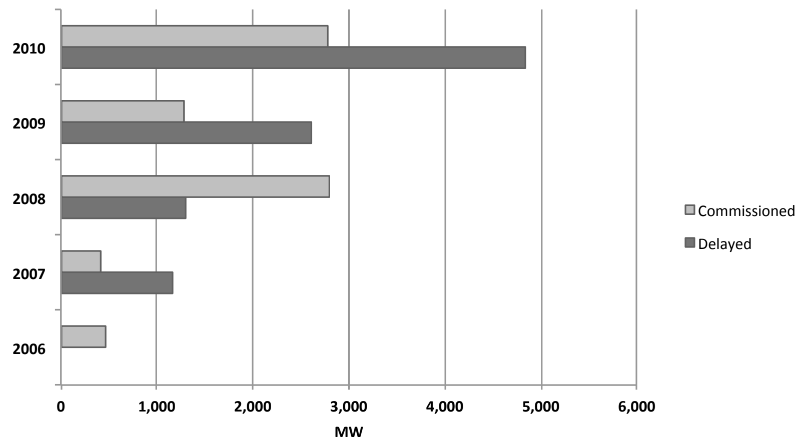
Note: CSG – China Southern Grid imports; EVN – Electricity Vietnam; PVN – Petrovietnam; TKV – Vinacomin; FIE – Direct foreign investment; VIE – other domestic investment; EVN – JSC – Electricity Vietnam Group subsidiaries (>51%).

[246] Source 16,22,25 Annex A6.4

[247] Largely due to the fact that the plan had just been revised to take account of previous delays in commissioning.

Source: EVN 2011 (* figures for 2010 interpolated)

Figure 6.14. PDP VI - capacity additions commissioned and delayed 2006 - 2010



Source: Table A6.3, Annex A6.3

A number of reasons were mooted for delays in project development. These included the competency of EPC contractors, with a number of opinion pieces and reports blaming the slow progress at some plants on the use of 'cheap Chinese contractors' (Tien Phong 2010; Tuoi Tre 2012).[248] Land clearance and compensation issues were also cited, as were issues with the provision of supporting infrastructure such as railway lines, gas pipelines and transmission lines, and the application of new technologies (Asia Times 2012). Nevertheless, these factors were relatively minor when compared to the chronic structural issues faced by the ESI in general, and in which EVN was closely implicated. Foremost amongst these had been the difficulty IPPs had with negotiating PPAs with EVN. Trouble with PPAs, and the continuing perception of significant risks in the sector also meant that for both IPPs and EVN there were difficulties in achieving the financial closure of projects.[249]

EVN's problems with raising finance for projects came to a head in August 2008 it was forced to withdraw from the development of 13 coal thermal plants representing about 13,800 MW of new capacity that it had been expected to develop (Thanh Nien News

[248] These reports should be taken with a large pinch of salt. There is considerable animosity towards China in the press reflecting continuing territorial disputes but also the role played by China in Vietnam's recent history. This is reflected in press reports. It is difficult to believe that such reports are even handed. Barely a week goes by when reports of faulty or sub-standard Chinese goods is not reported in the press, indeed Vietnam compared unfavorably to China in the time needed to construct coal plants, with plants in the former taking on average 5 years and in the latter around 18 months (Asia Times 2012).
[249] Source 22, 26 Annex A6.4

2011). EVN withdrew from these projects as it was unable to raise the financing required, which in turn it blamed on the low average tariff levels it faced. In the end, eleven projects were taken up by other developers including PVN, which continued to aggressively expand into the generation sector, other domestic SOEs (TKV and Lilama), and, more significantly, a number of other consortia including both regional foreign investors and Vietnamese SOEs (Vietnam Investment Review 2008).

This represented something of a watershed and forced the government to reconsider its reluctance to offer guarantees to foreign investment projects in the sector. The structural pressures on the ESI and the desire of foreign financiers and ESI TNCs to invest in Vietnam's rapidly growing power sector had remained pretty much constant. The persistent stream of commentary from foreign business interests and the expansion of the number of international law firms based in Hanoi and Ho Chi Minh City specialising in project development indicated a continuing interest in ESI investment - if conditions were right. The massive prospective expansion of the ESI and the need for foreign capital continued to be perceived as presenting an attractive opportunity to many international investors (Power Engineering International 2013). Foreign firms continued to be involved in the sector through engineering and procurement contracts, often supported by ECAs, but as noted earlier, between 2005 and 2010 there had been practically no significant FDI financed projects.

After the large Phu My plants, as we have seen, there was very limited appetite in government or EVN for FDI in the ESI, or at least not on the terms that were on offer. The failure of EVN to generate the capital needed for the expansion of the ESI was critical, and it became immediately apparent that other sources of funding would need to be found. The surge of FDI projects that have progressed in Vietnam in more recent years suggests that conditions have become much more favourable since 2008 (Table 6.7).

While there had been gradual improvements in the legislative and institutional environment surrounding BOT projects, what seems to be crucial in attracting investors to the sector was a renewed willingness of the government to offer guarantees to projects and increasingly serious commitments to raise the power price.[250] This was all the more necessary as a number of these projects (Nghi Son 2, Mong Duong and Hai Duong) will rely partly on imported coal, requiring rock-solid foreign exchange and counterparty guarantees (Gibson et al 2013).[251] In 2010 the PM also instructed EVN to offer a 'fair return' on investment in new power plants (Asia Times 2012). At the same time, in the aftermath of the Global Financial Crisis, the very low interest rates and lax monetary policy in the US meant that a significant amount of foreign capital was flowing into emerging economies.

An increasingly common project development strategy that emerged alongside the renewed interest of foreign investors in the ESI, was the development of project partnerships between foreign firms seeking to mitigate political and counterparty risks and Vietnamese firms (Asian Power 2009). Vietnamese firms, and especially the large SOEs, have significant political leverage and are familiar with navigating the opaque patronage networks that characterise Vietnam's institutional environment.[252] Thus these partnerships could act to substantially reduce risk perceptions. Examples include Vinh Tan 1 developed by CSG and China Power in which TKV has a 5% equity stake, Vinh Tan 3 in which EVN has a minority stake, and Vung Anh 2 which is being developed by companies from the UK, Hong Kong and the Vietnamese REE corporation (Table 6.7). Although the recently completed Mong Duong 2 is completely foreign owned, during development TKV held a minority stake but withdrew partway through negotiations, the plant is now owned by the American AES, South Korea's Posco Power and China Investment Corporation (CIC) (Press Release 2011).

Another notable characteristic of the new wave of FDI investment was the extent to which regional investors were involved, including companies from China, Malaysia, Korea, Hong Kong, Singapore and, of course, Japan. In particular, the extent of Chinese investment to the ESI has increased substantially. With direct investment by powerful Chinese parastatals such as China Power and CSG, as well as the Chinese sovereign wealth fund (CIC). In addition, Chinese lending to the sector has also increased, with

[250] The concession framework relating to BOT, BOO, BTO and other similarly structured projects and the more recent PPP framework have been in more or less constant flux since the early 2000s.
[251] Source 26, 27 Annex A6.4
[252] As Laykin puts it, "The typical approach for foreign investors is to mitigate risk of bad faith while navigating Vietnam's development mine-fields by partnering with an SOE." (Asian Power 2009: 10)

Chinese EPCs and ECAs playing an increasingly important role (Vietnam Investment Review 2013; Power Insider 2013).[253]

Table 6.7. Foreign generation project pipeline in June 2013

Project	Pipeline stage	Capacity (MW)	Type	Developer (country)	Investment (US$ million)
Mong Duong II	COD (2013)	1,200	Coal	AES/Posco Power/CIC (USA/China/Korea)	1,600
Soc Trang Wind Farm	FC (2012)	30	Wind	EAB New Energy GmbH (Germany)	45
Phuoc Nam Wind & Solar Plant	FC (2012)	125	Wind	Enfinity (Belgium)	248
Dung Quat	BOT	1,200	Coal	Sembcorp (Singapore)	2,000
Duyen Hai 2	BOT	1,200	Coal	Janakuasa Sdn Bhd. (Malaysia)	2,000
Hai Duong	BOT	1,200	Coal	JAKS Resources /Wuhan Kaidi Electric Power (Malaysia/PRC)	2,250
Quang Tri	BOT	1,200	Coal	EGATI (Thailand)	2,260
Vung Anh 2	BOT	1,200	Coal	Mitsubishi/One Energy/REE (Japan/Hong Kong/Vietnam)	1,600
Van Phong 1	BOT	1,320	Coal	Sumitomo (Japan)	2,000
Song Hau 2	BOT	2,000	Coal	Toyo ink (Malaysia)	3.5
Vinh Tan 3	BOT	2,000	Coal	VTEC, CLP Holdings Mitsubishi Corp, EVN, Pacific Corporation (Vietnam/Hong Kong/Japan)	N/K
Vinh Tan 1	BOT	1,200	Coal	CSG/China Power/ TKV (China/Vietnam)	1,650
Nghi Son 2	BOT	1,200	Coal	Marubeni/KEPCO (Japan/Korea)	2,300
Nam Dinh	MOU	2,400	Coal	Teakwang Group (Korea)	4,500

Source: Various press sources cited in text, interviews Note: FC – Financial closure; COD – commercial operations date; BOT – BOT agreement signed; MOU – memorandum of understanding signed.

What is striking about the evolving patterns of investment in Vietnam's ESI is the apparent weakness of government in developing a coordinated strategy and reigning in the powerful vested interest presented by EVN. The indications are that other investors, be they small hydropower producers, other powerful SOEs or even minority shareholders in EVN subsidiaries, face an obsolescing bargain. The capital is sunk and EVN has seemingly systematically used its position as the single buyer to drive down prices (or indeed in many cases has failed to pay at all (see following section)). Even

[253] Despite the renaissance in FDI projects problems with delays in project negotiations persist, Mong Duong 2 - like the Phu My plants before it - reportedly took 8 years to finalise.

more egregiously, there is a strong suspicion that EVN has preferred power cuts purchasing expensive power from new capacity. The incentives for doing this are very clear. Power prices are too low. EVN operates at a loss. Only *in extremis* when the boarder public good, and hence the government's and the CP's legitimacy has been substantially threatened has the government been forced to take more drastic action, such seems to have been the case with EVN's failure to raise financing in 2008. As we shall see in the following section, the reluctant and reactive role the government has taken also seems to be the case with the serious restructuring of EVN and the sector.

6.3.8 EVN threatens the whole show

In the last years of the decade, the economic boom that Vietnam enjoyed started to come unstuck. The economic over-heating caused by an influx foreign capital forced the government to raise interest rates in 2008 to address high inflation. By 2009 the Global Financial Crisis had forced significant government intervention again, this time to spur investment in the face of falling demand for manufactures and commodity exports (Pincus 2009). This second round of stimulus again lead to sharply rising inflation in 2010 and 2011, which necessitated a further round of tightening. As noted already, SOEs had been using privileged access to credit at domestic banks to invest in non-core, often-speculative business activities. When higher interest rate came, many of these speculative ventures in the booming sectors came unstuck, this in turn left the banks with mounting bad debts and left economy at risk of a fully-fledged banking crisis (New York Times 2012; East Asia Forum 2013; Fforde 2013).

The evolving macro-economic crisis was closely linked to what was an emerging political crisis. Indeed, as Vuving (2010) and others pointed out the 'rent-seekers' in government were increasingly in the ascendant. Press reports in 2011 point to the blatant cronyism of the PM in the political appointment of his son to the position of Vice Minister, and the support of the his daughter's investment firm by state owned banks as it moved into the banking sector (Financial Times 2011). It was commonly believed that PM had supported the emergence of an oligarchic elite with extensive interests in real estate and finance, but also closely linked to the SEGs (Fforde 2011). In the face of widespread economic mismanagement, a vote to officially censure the PM in late 2012 was almost passed.

The disequilibrium that had developed between the dynamics of the political settlement and the sustained functioning of the economic system seemed to be reaching a head. The SEGs, including EVN were at the heart of the problem. The most high profile case involved state owned ship builder Vinashin, which ran up over US$ 4 billion in debt. Vinashin eventually defaulted on repayments to a US$ 600 million loan to Credit Suisse, resulting in Vietnam's sovereign debt being downgraded by rating agencies. Later investigations found mismanagement and corruption that lead to criminal proceedings against a number of former executives. Reports of poor investment choices, mismanagement, financial losses and large-scale corruption at large state owned banks and other enterprises were increasingly common. A number of SEGs including PVN and Song Da were involved in high-level corruption scandals (Financial Times 2012; Viet Nam News 2012a; SaigonTimes 2012). With continuing macro economic problems, and daily news on mismanagement and corruption at state owned businesses, it comes as little surprise that a World Bank sponsored survey in 2011 most people stated a preference for private as opposed to state ownership (World Bank 2011b). These were the more obvious symptoms of a wider political malaise and what Fforde (2013) described as the collapse of coherent government:

"From around 2007…the VCP has increasingly been unable to meet its systemic political responsibilities. With the rise of powerful national commercial interests, macroeconomic stability was lost in 2007 when large state-owned enterprises (SOEs) ignored State Bank orders on liquidity. In general, local provincial and sub-provincial establishments have suffered: through 2011 and 2012, small and medium firms (SMEs) have been starved of bank credit, many have gone under, and perhaps a million jobs have been lost. *It has been increasingly obvious that the VCP has been unable to deal with major political questions: corruption, SOE and bank restructuring, and reforms to public health and education. Nagging fears of Chinese penetration persist. The collapse of authority is clear from a wide range of sources*." [emphasis added] (Fforde 2013: 102-103)

EVN was probably more unpopular than the other large SOEs.[254] Its performance failures were apparent for everyone to see in the shape of the reliability of the electricity supply and the size of their electricity bill. The failure to mobilise sufficient investment continued to lead to insufficient reserve capacity and power shortages and under-investment in the T&D infrastructure led to continuing system reliability problems (Dung & Tuan 2011; VietNamNet Bridge 2012a). On the other hand, price increases from an average tariff of around 870 VND/kWh in 2008 to over 1,500 VND/kWh in

[254] Source 9 Annex A6.4

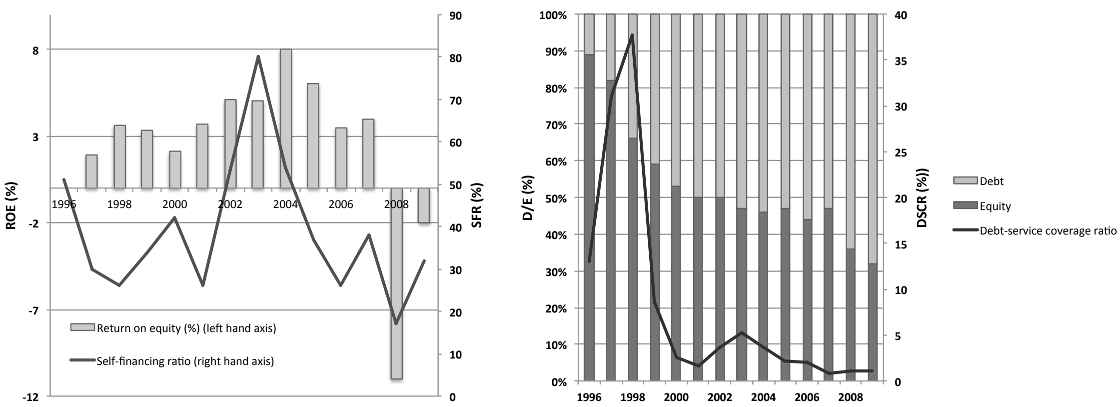
2013 were highly unpopular, both amongst the public and in energy intensive industries. Many commentators questioned tariff levels and argued that they did not reflect costs, referring to the average costs of supply EVN typically faced. In general there was a high level of suspicion about EVN's pricing rationale and monopoly, even while EVN and other ESI players pushed for higher prices (VietNamNet Bridge 2009; Viet Nam News 2012b; Thanh Nien 2012; Indochina Energy 2013).

To add fuel to fire, EVN's investment in real estate, financial services, and telecoms had been disastrous. EVN Telecom had failed to make much headway and by 2010 was making a loss of around US$ 57 million a year (Viet Nam News 2012c). EVN's investments in real estate and securities had proved no more profitable. Adding to the public opprobrium, EVN was also accused of - amongst other things - overpaying staff (even when it was loss making), failing to pay debts to fuel suppliers and other generation companies, using its market power to drive down electricity purchase prices and last but not least, running up huge debts (Dan Tri 2011; Tuoi Tre 2011; Viet Nam News 2012c). Its prestigious new twin towers built in the heart of Hanoi caught fire before they were completed and stood derelict, a potent symbol of what many saw as at best the hubris of the state giant and at worst the systematic mismanagement and corruption that lay at the heart of EVN (Bloomberg News 2012). While the media reports should be taken with a pinch of salt, it remains clear that EVN was increasingly unpopular amongst the general public.

EVN was also becoming the focus for more vocal complaints from other industry players stemming from its monopoly in the sector. EVN had run up large debts to other parastatals. In 2011 it owed the other two large utilities PVN and TKV around US$ 680 and US$ 98 million respectively. Many of these debts were cleared in 2012 following a bumper year for hydropower, only for them to emerge again in July 2013 when PVN reported that EVN owed it US$ 440 million (Saigon Times 2013). These circular SOE debts had hitherto been consistently paid off by EVN, but it says something that these large influential parastatals have had to turn to the media to attempt to influence EVN. Other generators were not so lucky, with the first foreign invested IPP at Hiep Phuoc forced out of business in 2012 with a US$ 40 million invoice to EVN still outstanding (VietNamNet Bridge 2012b). In another example, small hydropower producers faced with rising interest costs complained that they had been unable to reach an agreement on higher off-take tariffs with EVN (Saigon Giai Phong 2012). Similar complaints lead a small hydropower plant in northern Vietnam to launch a challenge against the EPTC through the Vietnam Competiveness Authority, accusing it of favouring EVN owned plants over IPPs (Saigon Times 2013).

EVN's ill-fated adventures into non-core sectors and domestic debts aside, the financial sustainability of its core activities in the ESI were looking increasingly precarious. The rising costs of the investment program had not been matched by tariff increases. As predicted in the World Bank's Power Strategy published in 2006 (World Bank 2006b), this meant that debts were spiralling, debt service increasing and the ability to finance capacity expansion declining (Figure 6.15). EVN was also stymied by the high proportion of foreign denominated debt, revenues were in Dong and the devaluations that took place in 2009 (5%), 2010 (9%) and 2011 (10%) lead to effectively greater debt-service (Spencer 2011).

Figure 6.15. EVN key financial indicators 1996 - 2009



Source: (Krishnaswamy & Stuggins 2007; Spencer 2011)

By the end of the decade EVN was reportedly making significant losses. Reports are sketchy and EVN published figures are reputedly unreliable. For example, an official audit reported that the company only lost US$ 0.18 million in 2011, but many commentators raised questions about the accuracy of these figures with other estimates suggesting cumulative losses between 2009 and 2011 reaching US$ 975 million (Reuters

2012; Thanh Nien 2013; Power Insider 2013).[255] Debts also remain something of a mystery, while EVN reported debts of US$ 2.5 billion in 2012 (RFA 2013), a widely cited leaked report by the independent state auditors estimated EVN's total debt of US$ 11.5 billion in 2010. By this time and in the wake of the losses at Vinashin, EVN's poor financial state and the threat it posed for the wider Vietnamese economy was being widely discussed in the international media (Financial Times 2012; Reuters 2012; The Economist 2013).[256]

In many ways the government response to the crisis of legitimacy that EVN's poor performance and mammoth debts posed had already started in 2008, with the renewed willingness to offer guarantees to investors.[257] Importantly, power price reform also started in earnest at around the same time with an increase in nominal dollar terms of around 36% between 2008 and 2013. Continuing difficulties at EVN (in common with other large SOEs), coupled with the increasing unpopularity of the firm seem to have forced the government's hand when in February 2012 EVN's chairman, Da Vang Hung, was fired for 'mismanagement' associated with EVN's hapless foray into telecoms (Thanh Nien 2012). Following this sacking, in February 2012 the PM issued an instruction for EVN to divest all its non-core businesses by 2015 (Indochina Energy 2012; Tuoi Tre 2012; DTI News 2012).

In addition, the government moved to speed up the equitization and unbundling of EVN. In early 2013 MoIT gave the go ahead for EVN to divest all but 17-18% of generation capacity (the remainder composed of strategically important hydropower and planned nuclear plants) by 2015. Three generation-companies were formed in 2012, which would be fully equitized and separated from EVN by 2015 (Asian Power 2012; DTI News 2013). Plans were also tabled to separate transmission, dispatch and the EPTC from EVN and speed up the implementation of the road map for a competitive power market in the sector (Viet Nam News 2012d). At the same time moves were a foot to form an official alliance between the squabbling energy parastatals (EVN, PVN and TKV), with a strategic cooperation agreement being signed by all three companies in February 2013 (VietnamNet Bridge 2013;Viet Nam News 2013). The idea being to better

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255 As in 2006, losses were closely related the to performance of EVN's hydropower generation portfolio which still dominated its generation assets. In 2010 EVN reported a loss of US$ 484 million and US$ 170 in the first 6 months of 2011 (Dan Tri 2011).

256 Source 29, 30 Annex A6.4

257 Something which would be necessary for any foreign credit to be extended, especially following the difficulties creditors had in getting the government to honour its 'letter of comfort' guaranteeing Vinashin's ill fated bond issue.

coordinate the development of energy resources in order to ensure that electricity generation and distribution needs could be met.

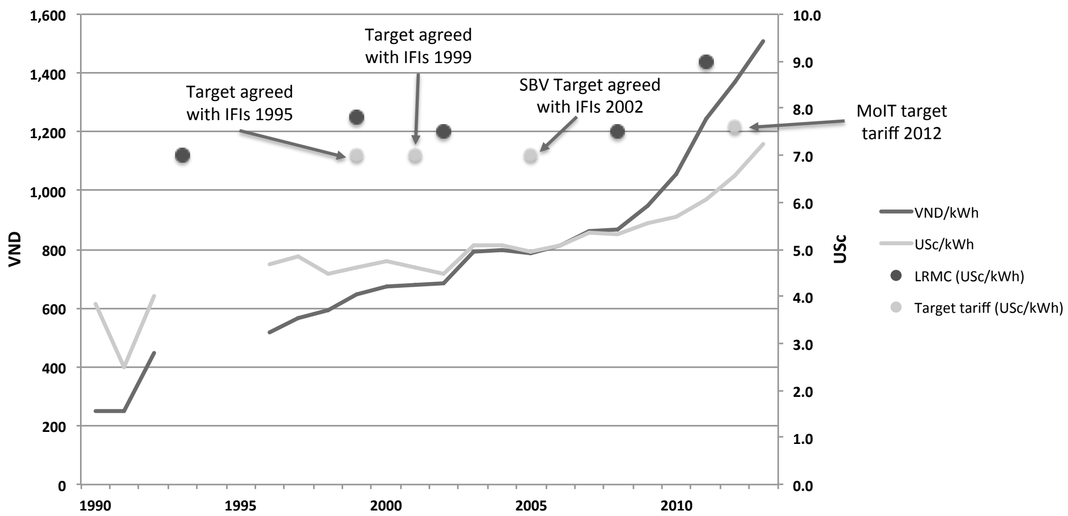
As always it is difficult to interpret Vietnam's *de jure* policy proclamations. With commitment to divestment and unbundling, but at the same time the creation of a potentially even more potent energy cartel amongst the energy parastatals. The development of a cooperation agreement has not resolved on-going disputes between the three parastatals surrounding EVN's unpaid debts, fuel price and EVN's reluctance to agree PPAs with the other two. It is difficult to avoid the conclusion that the political economy remains unable to meet the growing needs of the ESI.

6.4 The tariff rises

IFIs had encouraged cost-reflective price levels right from their earliest engagement with Vietnam in the 1990s, and by the mid-1990s the achievement of cost-reflective tariff targets were a condition of IFI loans extended to the EVN (World Bank 1993, 1995, 1997). However, tariff levels repeatedly fell short of these targets and the LRMC of supply (Figure 6.17). This lead to less than satisfactory project evaluations by both the World Bank and ADB (World Bank 2002; ADB 2008a, 2008b). But it did not seem to have lead to any reluctance to engage with the sector on the part of the IFIs. Tariff reform remains a target for the IFIs, but more recent project documents are more circumspect, shying away from hard targets, talking more generally about tariff reform and relying on altogether less direct metrics (World Bank 2009, 2012). Again this is indicative of the relative impotence of the IFIs in Vietnam in their attempts to influence policy where that stands in opposition to important vested interests and broader considerations of political legitimacy.

Aside from the policy pressures exherted by IFIs, more recent years have seen increased autonomy at EVN and the entry of important IPPs to the generation sector (including powerful SOEs and a vocal international investment community). This has ratcheted up the pressure to allow tariffs to rise and enable investment in the ESI. PVN and TKV as up-stream energy producers, while less vocal than EVN in their demands have also been keen to see a higher power price. The current situation where coal is sold to EVN at controlled prices which do not reflect the steadily increasing costs of production[258] - let alone international prices - does not serve the industry well, hobbling TKV's ambitions to invest more in the development of Vietnam's extensive coal resources (Baruya 2010; Tran & Jones 2011). Similarly, in order to sufficiently incentivise the risky business of off-shore gas exploration and field development PVN requires a stable market for gas at a price that can serve to incentivise up-stream resource development activities (World Bank 2010a).

Figure 6.17. Average electricity tariffs, LRMC and tariff targets 1990 - 2013



Source: World Bank 1993, 1997, 2002, 2003, 2012a; England & Kammen 1993; ADB 2003; Nguyen 2008; Nguyen 2012; Indochina Energy 2013

Nevertheless, tariff hikes have in the past been successfully obstructed by a number of important groups, forcing proposed tariff rises to be reduced or shelved altogether on a regular basis (Wyatt 2002; Lao Dong 2005;Vov 2010; Viet Nam News 2011a, 2011b). Tariff levels are controlled by MoF, whose remit includes maintaining macro-economic stability. Destabilising inflation plagued the Vietnamese economy in the late 1980s, early 1990s, and more recently in 2008 and 2010-2011. This seriously threatened the CPs grip on power and has remained a perennial cause for concern in government.[259] When setting price levels for electricity, MoF's overriding concerns seem to have been macro-economic, to control price inflation, rather than to enable EVN to operate on a sustainable financial basis. Indeed control over EVN (and other large SOEs) and price

258 This reflects the need to develop coal resources using shaft mines which are much more expensive than open-cast mining techniques.
259 Source 9,18, 22 Annex A6.4

level remains a fundamental means by which the state seeks to exercise macro-economic control.

Energy intensive industries, including the steel and cement sectors were also highly sensitive to increases in energy prices, and reflect important interest groups. Steel producers in particular have opposed electricity price rises while increasing their consumption of electricity over time (Tran & Jones 2011). However, above all the residential sector constituted the single largest barrier to power price increases. The reasons for public distaste for power price increases were not simply a matter of not wanting to pay more, although this too was an important factor. The perception was that EVN was exploiting its monopoly, was deeply corrupt, provided a poor service and had been mismanaged.[260] As such tariff increases have been deeply unpopular and met with intense suspicion by the general public (Indochina Energy 2013; Thanh Nien 2013; Power Insider 2013)

The moves to raise the average tariff decisively in real terms from around 2008 onwards despite high inflation and despite objections from the public and energy intensive industries, in one sense reflects the belated realisation of material realities, and that the financial position of EVN was not sustainable. It also reflects the effective contraction of the 'fiscal space' control over ample natural resource rents had allowed. It becomes clear that the redistribution of natural resource rents had been an important part of the political settlement. The undermining of this threatened the whole settlement. Making noises about disciplining the SEGs is a price that needs to be paid for tariff increases and reflects an attempt by the elites to rebalance the political settlement. On the other hand, the glacial pace of the reaction speaks of the inertia of a ruling elite that is fractured, with power fragmented amongst various factional interests.[261]

6.5 Conclusion

In this chapter we have sought to elaborate the broad political economy dynamics of the ESI in Vietnam though an analysis of available empirical evidence. In many ways the dynamics of the ESI in Vietnam are typical and closely reflect the position that emerged from Chapter 4. Firstly, at the most general level we have stressed, that in the post-

[260] Source 9, 13, 17, 21, 27 Annex A6.4

[261] In this context recent reports from the IEA's Southeast Asia Energy outlook that there are concrete plans to reduce subsidy levels in Vietnam and the government "Plans to introduce a roadmap for the phase-out of fossil-fuel subsidies," that is the government plans to plan energy subsidy reduction is unintentionally humorous (IEA 2013).

colonial context the ideology of nation building, and the need for economic modernisation and development leant authority and legitimacy to the emerging nation states, and an important impetus to the development of the ESI in East Asian countries (Williams & Dubash 2004 see also section 4.2.2). This is a reflexive relationship, the other side to maintaining the authority and legitimacy of those in power was the actual provision of developmental public goods. In terms of the ESI this implied affordable access to electrical power for the general population, and indirectly, the promotion of industrial development through the provision of relatively cheap electrical power to industrial production. This is understood in the literature as a (largely tacit) bargain, a social contract or compact (Jaccard 1995; Williams & Dubash 2004; Victor & Heller 2007).[262] In short, the promise of modernity and development empowered the political elites, but they had to deliver. Vietnam has been a typical case of this kind dynamic until relatively recently when the material needs of the ESI came into conflict with the social contract.

Secondly, the characteristic political economy dynamics that emerge from the sector are dominated by the opaque costs structures of the ESI and pressures unique to rapidly expanding ESI's. EVN has been squeezed between public expectations of low power prices, which are often anchored by references to SRMCs or average costs, and the LRMC of supply. In Vietnam's context the gap between the two is especially large as it benefited from cheap domesticly available hydropower and coal resources. At the same time EVN has suffered from the perception of poor technical and economic performance in its core utility businesses. The primary cause of this has been inadequate capacity expansion in terms of generation and T&D assets, and the historical legacy of an over reliance on hydropower, leading to frequent power cuts and system instability. This has placed EVN under greater political pressure. This is typical of the vicious cycle of public suspicion of utilities, the political difficulties in raising prices, the resultant failure to invest and declining performance identified by Hausman et al (2008) and Victor & Heller (2007). The major difference in this case is that the utility is owned by the state and not the private sector.

Thirdly, we can also see the development of what Victor & Heller (2007) term a dual-market, with state owned and private sector firms. FDI has been concentrated in new

262 Chapter 4, a similar and analogous 'social contract' is also posited in the descriptions of developmental states, see Chapter 3.

technologies. By 2015, if the restructuring plans go ahead there will be a state owned rump of the sector under EVN, along with three new ESI parastatals in the form of the new generation companies, and large generation assets held by TKV and PVN.

Table 6.8: Main economic rents associated with the ESI in Vietnam, technologies and groups

Rent	Description	Typically accrue to which groups?
Natural resource rents	Difference between the cost of extraction, processing and transport and consumptive value.	Hydropower (water) - developers and operators, in particular EVN, S Coal – directly to TKV, indirectly though controlled coal prices to E Gas – PVN, energy TNCs developing Vietnam's gas fields (e.g. BP, C The Vietnamese government also generates a significant portion of land, coal), however in the ESI they are limited to revenues from tax In Vietnam end-users typically capture a large proportion of these re
Monopoly rents	Difference between the long- term marginal cost of supply of the utility and the long- term marginal cost of supply for the customer.	EVN would in principle be able to appropriate these rents, in p monopoly rents through supressing competition in generation and monopoly rents are off-set by effective electricity price subsidies anc supply for EVN.
Quasi-rents	Difference in long-run marginal cost and short-run marginal cost. Appropriable in short to medium term.	Quasi-rents generated at the system level though average tariffs set b consumers of subsidised electricity (i.e. poor households, householc energy intensive industries). Quasi-rents are generated at the project level through EVN's monc forcing down the price paid for electricity from IPPs (e.g. VSH), part
Rents for innovation and learning	Cost or quality advantage yielding higher return not achievable by the owners of the next best technology.	These rents are not particularly relevant to the Vietnamese context. rents generated by technology suppliers for the power sector, rent technical know-how and rents generated by operators of new/impr are available in Vietnam they are likely to accrue to the suppliers of f
Rent based transfers	Transfers of other rents appropriated through the political system (formal and informal).	These are extensive in the ESI. The most significant transfer are t controls. In Vietnam these include energy intensive or otherwis production, other manufacturing). Low income households and hou some extent rural households. Rent like transfers are also important in the process of competitiv networks. These include any kick-backs and side-payments made by at SOEs and the lack of competitive tendering for power projects mainly to senior officials in government and the energy parastatals.

Moreover, a significant proportion of investment will take the form of joint ventures between Vietnamese SOEs and foreign investors seeking to mitigate risks.

Fourthly, interest groups that emerge within the sector that are closely linked to particular techno-economic paradigms. At EVN, Soviet trained engineers, with a preference for hydropower. And at MPI, MoF, ERAV and CIEM the growing influence of western-trained economists and lawyers with close connections to IFIs and international consultants steeped in the standard model of ESI reform.

There are also a number of characteristics of the political economy of the Vietnamese ESI which remain highly idiosyncratic, and related to the wider political economy, these are the weakness of policy, the fragmentary nature of the political elites and the dominance of the polity by powerful vested interests. Firstly, policy commitments mean very little. Even at the national level policy in the ESI is often incomplete and unimplemented. As the experience of both foreign and domestic IPPs show, policy is frequently unclear, incomplete and unworkable and wherever possible trumped by the exercise of political and economic power.

Secondly, the tussles over IPPs, power price and institutional reform are indicative of a fragmented, rather than monolithic polity. While the central government retains the ability to act decisively in extreme situations, generally it appears as weak and unable to discipline factional interests. This is the case even in the ESI, perhaps the one sector where due to its strategic importance, the centralised nature of its technology and the reliance on the state for inputs (natural resources, capital etc.) one might believe government authority could be effectively exercised. Thirdly, related to the previous point, the political and economic power of large corporations and the important patronage links to the political elite. If anything institutional changes in the wider economy and the ESI in particular have further enabled the exercise of power by these groups, as Fforde notes:

"These groups, with … typically hazy formal powers (apart from key and important rights, such as to move capital between their constituent SOEs), followed a quite different logic, where economic power is sited, not within state bodies, as such, but within large commercial units. In the world economy of the late 1990s and early 2000s, it was perhaps clear that such bodies could hope to free themselves from local state control, to an important degree, through direct access to foreign capital, technology and markets through various mechanisms such as a stock market. They therefore offered a potential basis for political power *independent* from the state apparatus. This is, of course, the stuff of high politics."(Fforde 2007: 219)

What we see playing out in Vietnam's ESI are general trends reminiscent of the political economy of ESI reform in other countries, which in turn reflects the fundamental nature of the technology and its place in modern society. But also a more particularistic political economy, which reflects the idiosyncratic disposition of power within a particular country. The dynamic outcomes of the interaction of these different factors determine outcomes in the sector. These are neither determined purely by the political nor purely by techno-economic factors, but some combination of the two. In the final Chapter of this thesis we elaborate how these emerging dynamics have played out to influence technology choice.

Chapter 7: Analysis and conclusions. The political economy of technology choice in Vietnam's power sector

7.1 Introduction

Climate change is perhaps the most pressing problem facing policy makers in the energy sector. Reducing GHG emissions from the sector will require significant change from incumbent technologies and technological systems. While there has been a great deal of research conducted on technological change looking at various technological, economic, social and cultural aspects of that change, we have argued that there has been a failure to adequately address the role of political economy in technology choice. To address this issue and investigate the role of political economy considerations in the process of technological change we have developed an approach that places the political economy at the centre of considerations of technological change.

Firstly, in Chapter 2, we argued that evolutionary economics approaches offer a productive and realistic way of approaching issues related to technological change. Evolutionary economics offers particularly strong causal analysis of the process of technological change. In particular, evolutionary economics approaches emphasise the emergence of barriers to technological change that cannot necessarility be reduced to neo-classical notions of 'market-failures' and 'externalities'. The emphasis of evolutionary economics dynamics, the role of institutions and their co-development with technological systems offers a nuanced account that accords well with the empirical record on technological change. Importantly, Chapter 2 showed that despite good *prima facie* theoretical reasons for expecting political economy considerations to be important in the process of technological change, evolutionary theory fails to adequately address these issues.

Secondly, Chapter 3 argued that from the perspective of economic development and industrialisation there is a consensus that political economy variables are fundamental (if not determinate) in creating a context in which technological change can take place. Third, Chapter 4 built on the arguments presented in Chapters 2 and 3, examining the role of political economy considerations in the development of the ESI, with a particular emphasis on co-development of technologies and institutions. Finally, Chapters 5 and 6 presented a detailed empirical case study of the political economy of ESI development in Vietnam.

The strategy has thus been to move from the most general theoretical level, and 'drill-down' in the application of the argument first in terms of considerations of economic development, then the ESI, then in the case of a specific country case study. This final chapter seeks to reverse this process, by moving back up, from the specific case study to more general considerations. Firstly, in section 7.2 we elaborate the linkages between technology choice and the political economy that emerged from the case study of Vietnam's ESI and looks at what these political economy considerations may mean for technological change in Vietnam, particularly relating to the potential scope for serious climate change mitigation activities in Vietnam's ESI. Section 7.3 moves on to draw more general conclusions relating political economy considerations to technological change in the ESI. Section 7.4 makes observations as regards more general theoretical approaches to the political economy of technology change, the final section, 7.5 makes recommendations for future research.

7.2 The political economy of technology choice in Vietnam's ESI

In the previous chapter we examined the development of Vietnam's ESI, its technologies and institutions and set out how the development of the ESI related to the wider political economy. We found that in many ways the development of the ESI had been typical of that in rapidly industrialising countries, dominated by fundamental technical and economic issues relating to capital investment needs, costs, and the security and reliability of supply. These issues have, in turn, been related to the perennial political economy problems associated with the ESI identified in Chapter 4, the opacity of costs, the obsolescing bargain faced by investors in capital-intensive infrastructure and issues relating to the legitimacy of the utility in the provision of essential public goods.

Different types of technologies will have different rents accruing to them, the ability of the owners of those technologies to appropriate these rents will, fundamentally, be dependant upon the structure of rights or institutions (formal and informal) in a particular context. This section seeks to investigate in more detail the vested interests and rents associated with ESI *technologies* in Vietnam. Seeking to elaborate rents associated with particular technologies, how are they appropriated, and assess the extent to which this is likely to affect technology choice.

To enable us to do this in the following four sections (7.2.1 – 8) we investigate the particular political economy dynamics, and importantly rents associated with different technologies and institutional arrangements and comment on how they seem to have influenced technological change.

7.2.1 Rents, institutions and political economy in Vietnam's ESI

At the most general level we have seen that the development of Vietnam's ESI is subject to important influences emerging out of political economy arrangements. We have seen how, in a context of competitive clientism, vested interests in the ESI have been given considerable latitude to pursue their own interests (Chapter 6). In part, this is an issue of a lack institutional capacity amongst formal institutions leading to poor corporate governance and corruption (Chapter 6, section 6.3.8). More fundamentally, it is a reflection of the particular informal institutional arrangements in Vietnam. In particular, the operation of patron-client relationships, resulting in a fragmented state in which elites compete against one another for rents. We have sought to stress that the sheer amount of resources and large benefit streams associated with the ESI means there is a lot at stake, and that it should not be surprising that Vietnam's ESI (in common with the sector elsewhere in the world) is an important locus of rent contestation.

To be sure, rent appropriation happens through official channels, as for example, property rights are granted over natural resources, supply and off-take agreements are signed, electricity connections are established and end-users pay their bills. These rents are contested though formal political processes, as higher tariff levels are resisted or compensation for involuntary resettlement negotiated. However, given the importance client-patron relationships in Vietnam we should also expect to see ESI related rents appropriated through informal institutional arrangements.

Chapter 6 illustrated the importance of rent-based transfers in the ESI at a general level. First, the transfer of natural resource rents generated by the ESI, largely appropriated by the state and other groups with effective ownership rights over them. A large proportion of these rents are distributed to end users through subsidised electricity prices. Second, quasi-rents are also important at the system level, this time rents are available as the result of differentials between SRMC and LRMC. Again the most visible of these quasi-rents have been transferred to end-users through tariffs set at levels below the LRMC of supply (although arguably EVN has also been able to capture some portion of these rents). Third, monopoly rents generated by EVN and illustrated through its behaviour in negotiating off-take tariffs with generators.

These rents are important at the general level and are dependant upon the overall institutional make up of the ESI. As mentioned in Chapter 2 and Chapter 3, to some extent they may be fungible with respect to the productive processes upon which they supervene. Nevertheless, in some cases they are likely to be closely linked to the technologies from which they are produced. In the following section we briefly discuss important rents associated with the main technologies in Vietnam's ESI and discuss the rents and institutional dynamics likely to be associated with them.

7.2.2 Ownership profile and technologies

Turning first to the technology-ownership profile of installed capacity in 2011 (Table 7.2), this reflects the discussion in Chapter 6. A distinct pattern has emerged in the type of technology predominating in the different ownership sectors. EVNs installed capacity is still dominated by hydropower, with coal and gas contributing approximately equal shares. Non-EVN capacity, by contrast is dominated by natural gas owned by PVN and other IPPs, although TKV owned coal plants are also important. This distribution of technologies by ownership reflects in part the respective technological competencies of the different plant owners (e.g. EVN in hydropower and coal, foreign investors in CCGTs), but also access to fuel supplies (e.g. PVN's access to gas and TKV's access to coal) which serves to mitigate potential contractual and coordination issues.

This ownership profile will change with the development of new capacity much of which is likely to be owned by generation companies independent of EVN. If and when EVN is forced to divest its generation assets this will also have a significant impact on the ownership profile. The only assets expected to remain under EVN control in the long-term are those deemed to raise broader strategic considerations such as large multiple use hydropower plants (Hoa Binh, Son La, Ya Ly and in the future Lai Chau) and the planned nuclear plants. Nevertheless, as we shall see access to key rents from different generation resources seems to have been important in shaping technology choice.

Table 7.2. Installed capacity by ownership and type December 2011

Ownership	Type	Capacity	Proportion (%)

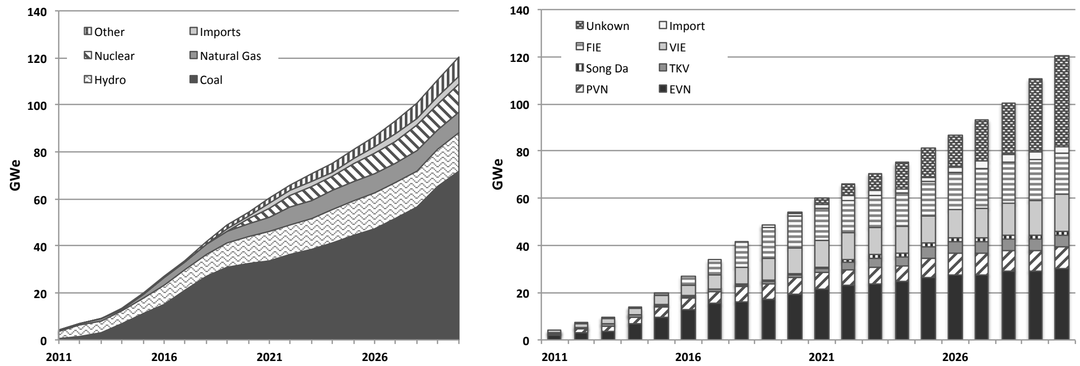
		(MW)	Of national total	Of ownership share
Total	Total	22,852	100	-
	Hydropower	10,100	44.2	-
	Coal	4,151	18.2	-
	Natural Gas	7,527	32.9	-
	Oil	537	2.3	-
	Other	538	2.4	-
EVN (including subsidiaries)	Total	16,630	72.8	100.0
	Hydropower	9,351	40.9	56.2
	Coal	3,045	13.3	18.3
	Natural Gas	3,197	14.0	19.2
	Oil	537	2.3	3.2
	Other	500	2.2	3.0
Non-EVN	Total	6,898	30.2	100.0
	Hydropower	749	3.3	10.9
	Coal	1,781	7.8	25.8
	Natural Gas	4,330	18.9	62.8
	Oil	-	0.0	0.0
	Other	38	0.2	0.5

Note: Other – designates diesel, small hydropower, and other renewables. The table also excludes imports from China. Not all off-grid isolated generation is included.

Source: EVN, various sources

The PDP VII developed by the Institute of Energy for MoIT envisages an almost seven-fold increase in capacity from around 23 GW in 2011 to approximately 143 GW by 2030 (Figure 7.1). The plan identifies generation plants by planned commissioning dates and identified prospective plant owners. In terms of technologies, generation from coal is expected to expand dramatically, reflected both expanded production from domestic resources and plants using imported coal from Indonesia and Australia (Batuya 2010). Hydropower capacity is expected to expand but its share in total capacity will decline from 44% in 2011 to around 18% of total capacity in 2030. This reflects the limited amount of remaining hydropower sources in Vietnam. Indeed, by 2030 the hydropower total includes eight enclave projects, two in Cambodia (240 MW) and six in Laos (1,200 MW) developed by Vietnamese companies including EVN International. Gas capacity is also expected to expand modestly, being limited by domestic gas resources and import capacity. Vietnam also plans to build its first nuclear plant by 2020 and have installed 12 GW by 2030. Finally, renewables are excluded from the above schedule which does not include plants with a caapcuty of less than 30 MW. Nevertheless, renewables are expected to expand from around 3.5% of electricity production in 2011 to 6% by 2030.

Figure 7.1. Cumulative planned capacity expansion in Vietnam's PDP VII by technology (left) and ownership (right) 2011 - 2030



Note: Plants below 30 MW are not included (including renewables). Other – type not defined in the plan; Imports - imports from CSG and Laos, but excludes enclave hydropower projects developed by Vietnamese companies in Laos and Cambodia; Unknown - projects for which prospective investors are unkown; FIE – FDI invested plants; VIE – domestically invested IPPs; EVN – includes both EVN and EVN joint stock companies.

Source: MOIT 2011

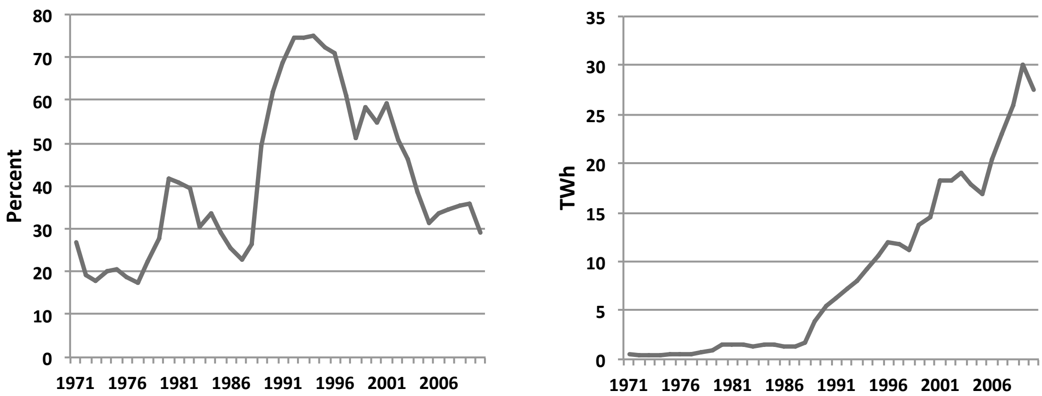
Details of the likely ownership structure in the generation sector are sketchy with the plans yet to identify likely investors for many plants especially past 2020. Moreover, the planned structural changes to the ESI are likely to herald large changes in the future ownership of plants. Nevertheless, to the extent that the development plan is indicative of government intentions in the ESI we can see a number of trends emerging. First, EVN continues to dominate, owning all new nuclear capacity, 54% of new hydropower, 18% of new natural gas and 12% of new coal capacity. Secondly, foreign invested projects are expected to account for 20% of new coal and 33% of new natural gas capacity. Third, the two other energy parastatals PVN and TKV are together expected to account for around 18% of new coal, and PVN around 9% of new gas. Finally, other Vietnamese companies (including Song Da) are expected to account for around 10% of new coal and 29% of new hydropower (Figure 7.1).

To a large extent this represents a continuation of ownership patterns that emerged during the 2000s (Chapter 6). While EVN sees its dominant share in generation eroded in other technologies, it retains its dominance in hydropower as well as the proposed nuclear plants. PVN and TKV continue making in-roads into power generation particularly as regards coal plants. There is expected to be an increase in imports from both CSG and enclave projects. Other Vietnamese firms are expected to invest in hydropower and coal plants, and foreign invested plants are also expected to increase in importance.

7.2.3 Hydropower

We noted in Chapter 4 (section 4.2) that where hydropower resources have been available and there have been sufficient capital resources for their development, hydropower generation technologies have typically been utilised early. Vietnam is no exception to this trend. Hydropower has been an important part of Vietnam's generation mix since very early on. By 1971 it accounted for around 28% of electricity production. With the commissioning of the large Soviet planned and financed plants in the late 1980s hydropower came to dominate Vietnam's power generation. Hydropower accounted for over 50% of power generation from the commissioning of the first turbines at Hoa Binh in the late 1980s until the commissioning of the first of the CCGT at Phu My in the early 2000s. Since then, as the best hydropower resources have been utilised and other domestic enrgy sources have become available the share of hydropower in the generation mix has declined (Chapter 6, section 6.2.3; Figure 6.4; Figure 7.2).

Figure 7.2. Hydropower electricity production as a proportion of national electricity production (left) and in absolute terms (right) 1971 - 2010



Source: IEA 2013

There are a number of factors influencing this dominance. Firstly, from a technical perspective hydropower can perform valuable ancillary functions in an electricity system and be managed to maintain system stability (Chapter 4). Secondly, hydropower was attractive from an economic perspective as despite relatively high up-front capital costs relative to other forms of electricity generation (MRC 2009; IEA 2012c), realtively low operations and maintenance costs, and zero fuel costs meant that the best hydropower was frequently cheaper than alternative technologies. Thirdly, hydropower also offered potential benefits to multiple sectors in terms of flood control, improved water supply for irrigation and better navigability of water-ways in some circumstances (Thai 2000; WCD 2000). Finally, the large civil works component of hydropower could generate a large amount of domestic employment and domestic input use relative to the construction of other types of generation capacity.

These benefits aside, as Quinn (1998) and others have pointed out, there are indications that the ESI had overbuilt hydropower making the electricity supply vulnerable to hydrological risks in the dry season (Chapter 6, section 6.2.4, 6.3.4; England & Kammen 1993). This suggests that considerations other than those of technological and economic benefits were influencing the choice of hydropower generation capacity. Indeed, by the 1990s there are a number of reasons to believe that there was an institutional bias towards hydropower development.

Prior to 1990, ESI development plans were created under the guidance of Soviet planners the material resources for which were provided by the USSR and countries in its sphere of influence (World bank 1993). As emphasised in Chapter 4 (section 4.2.3) and Chapter 6 (section 6.2.3) large hydropower projects had important ideological functions, having a long association with socialist central planning and nation building in post-colonial states. At the same time, the emphasis of Soviet planners on hydropower development in Vietnam and the construction of several large plants, generated significant domestic capabilities in hydropower design, construction and operations. Both EVN and the Institute of Energy have influential hydropower departments, whose senior staff are often Soviet trained hydropower engineers (Chapter 6, section 6.2.3). The technical capabilities developed around hydropower thus meant that there was an institutional bias toward the promotion of hydropower in development plans (Quinn 1998).

The development of technical capabilities also extended to firms active in hydropower construction. The core capabilities of a number of important construction companies were bound-up with the construction of hydropower plants. For example, by far the largest is Song Da Corporation[263] (an SOE under the Ministry of Construction) which has taken part in a range of infrastructure construction projects including the construction of factories, industrial infrastructure, transportation infrastructure, and above all in the ESI (including generation plans, transmissions lines and distribution infrastructure). The company was involved in the construction of around 60% of the hydropower capacity in Vietnam including the very large plants at Hoa Binh, Son La, and Ya Ly. In recent years it has increasingly been involved in the development of hydropower as project propolent and developer, as well as being involved in the construction of a number of projects in Lao PDR (Song Da Corporation 2013). EVN's own construction subsidiaries have also been disproportionately involved in hydropower construction relative to other types of power plant. These powerful companies thus have a significant vested interest in promoting hydropower development relative to other sources of electricity generation.

Thus not only did hydropower have well understood technical and economic characteristics, it was in line with the technological capabilities of important ESI institutions. From the perspective of rents associated with hydropower (Table 6.8), the potential for significant rent based transfers, quasi-rents and the generation of natural resource rents, and the ability of different groups to appropriate them or otherwise distribute them to maintain their holding power, have arguably also had an impact on the choice of hydropower.

Firstly, natural resource rents generated from hydropower are significant. Typical levilized costs for large hydropower projects range from USc 2 – 12 /kWh, cost ranges in Vietnam are likely to be lower with some rough estimates indicating that levelized costs range roughly between USc 2 – 6 /kWh (MRC 2009; REN21 2013). With T&D costs added this is still lower than benefits end-users can derive from electricity. This means that there is ample scope for natural resource rent generation. Unlike fossil fuel technologies, where fuel suppliers can frequently capture a large portion of natural resource rents, the project developer is typically able to capture a larger share of this rent.

Second, the large civil works components in hydropower projects, typically absorbing around two thirds of construction budgets, meant that the portion of the contract which

263 Literally, the Da river corportation, the Da river system being that on which the large Son La and Hoa Binh dams have been constructed and on which the Lai Chau project planned.

could be captured by large construction companies is much larger for hydropower projects that for other types of generation capacity (ICEM 2008; Pauschert 2009; ICEM 2010). In the case of Vietnam's large hydropower construction companies (owned by EVN and Song Da), this adds an additional incentive to promote the development of hydropower. It should also be borne in mind that the large civil works components, and the difficulty in monitoring the costs of these, gives greater scope for the generation of informal transfers and corruption.

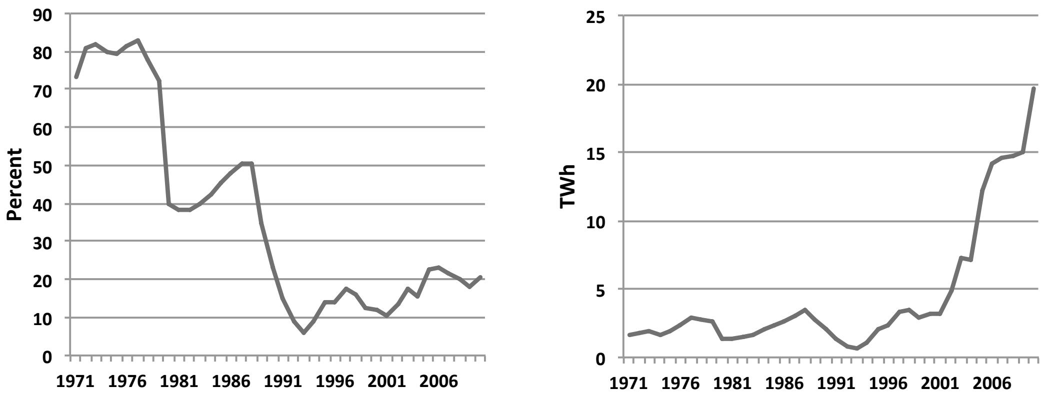
Third, there is a significant potential for the generation of what we have termed quasi-rents in the hydropower sector. That is to say, the difference between LRMC (i.e. the costs of constructing new capacity) and SRMC (the operational costs) is large, with almost all hydropower's costs being in the initial capital investments. This large difference means there is significant potential for the generation of quasi-rents, or short-term rents by driving down the tariff levels to the SRMC of production, which for hydro is very small.

Thus political economy considerations seem to have played an important part both in the adoption of hydropower technology in the first place, and in the dominance of hydropower in the ESI until relatively recently. In general, it is difficult to get away from the impression that hydropower has been given priority in the ESI, even to the detriment of system operations. And that political economy, alongside other factors has played an important role in this. Hydropower's relative importance in the future will almost certainly decline as economically attractive hydropower resources are fully utilised. Nevertheless, PDP VII indicates the intention to pursue the continued development of hydropower where possible. PDP VII also contains more details than for other technologies as regards which plants are allocated to which developers. EVN and Song Da continue to dominate the provision of large hydropower (Figure 7.1), including a number of enclave projects in Cambodia and Lao PDR. This suggests that for these potentially lucrative projects rents are being divied-up between important vested interests. The priority given to these developers is indicative of their continuing political influence, and a preference for hydropower linked to this.

7.2.4 Coal

As with hydropower, coal in Vietnam has been an important power generation technology from early on in the development of the ESI (Chapter 5, section 5.3). The contribution of coal fired generation declined rapidly from the 1970s as a result of the construction of a large number of hydropower projects, and in the 2000s CCGT capacity (Chapter 6, section 6.2.3; World Bank 1993). In absolute terms, coal thermal generation was almost stagnant between the mid-1970s and the mid-1990s despite rapidly rising demand. It was only with the commissioning of Pha Lai 2 in 2001-2 that coal fired generation started to increase and maintain its share of national power generation.

Figure 7.3. Coal fired thermal electricity production as a proportion of national electricity production (left) and in absolute terms (right) 1971 - 2010



Source: IEA 2013

Coal thermal generation, like hydropower was initially developed with resources from the Soviet Union (Chapter 6, section 6.2.2). Coal thermal generation typically represents a more expensive source of electricity than hydropower, and as a result seems to have developed much more slowly partly as a response to the priority that cheaper multiple-use hydropower projects recieved. The big potential technical advantage coal-fired generation has over hydropower is its non-seasonality and that it is not vulnerable to hydrological risks. Notwithstanding breakdowns and temporary shutdowns for maintenance, so long as fuel is available coal plants can generate electricity (Chapter 4, section 4.2.1).

The underinvestment in coal-fired electricity generation was the corollary of over investment in hydropower. In part the underinvestment can be explained through the domination of hydropower, ideologically, institutionally, and in terms of rents available to EVN and project developers. By contrast the control of rents associated with coal were spread more widely and not concentrated with project developers as with hydropower. Firstly, natural resource rents did not in general accrue to TKV (which accounts for 95% of domestic coal production). The price at which domestic coal was supplied to generators was controlled, and actually below the cost of supply (MoIT 2011; Tran and Jones 2011; Baruya 2010). As a result, wherever possible TKV has preferred to supply coal to the Chinese market, predominantly for thermal power generation in Guangxi and Guangdong. This market grew to about 18 Mt a year by 2008 (Baruya 2010). Most Vietnamese coal is produced in Quang Ninh province which borders on Guangxi. Baruya (2010) notes this close proximity coupled with the price differentials between domestic and export prices for coal resulted in wholesale smuggling, some of it reputedly involving TKV staff. Nevertheless, in the case of the formal transfer of the natural resource rents associated with coal fired power generation, these where wholly passed to and controlled by the ESI. Indeed, given the losses incurred due to coal price levels for domestic electricity generation held below the cost of production, coal supplies to the ESI were effectively cross-subsidised by coal exports. In the end, much of this rent would have been transferred to end users by means of controlled electricity tariffs.

Secondly, the potential for generating short-term rents accruing to domestic construction companies seem to have been lower compared to hydropower, which as pointed out above had been able to make extensive use of domestic inputs. This is in part a consequence of the lower share of civil works in coal construction costs,[264] imported heavy engineering goods forming a larger portion of the capital expenditure on coal plants. At the same time, capital costs tend to be lower than those for hydropower meaning that there is less scope for generating rents from plant construction. Foreign construction firms and engineering contractors have been more widely involved in coal plant construction than has been in case for hydropower. Much of the new coal capacity has been funded using capital from foreign ECAs, this has frequently been tied to the purchase of capital goods or construction services (particularly from China and Japan), again limiting the role for domestic Vietnamese firms (Chapter 6, section 6.3.7, 6.3.8). However, the recent influx of FDI into the ESI has largely been concentrated on coal plants – which will again diminish the involvement of Vietnamese companies in plant

264 According to Pauschert (2009) around 5% of total costs for comparable plants in India.

construction. This contrasts with the hydropower sector, which remains dominated by Vietnamese firms and EVN in particular.

Finally, it should be noted that the ability of the government to transfer coal rents though cheaper prices is being squeezed as domestic coal production is forced to rely more heavily on coal that is more expensive to obtain (i.e. though shaft mining as opposed to open-cast), and as the country becomes a net importer of coal – effectively undermining the cross subsidy between generation supply and exports (Annex A5.1; Baruya 2010).

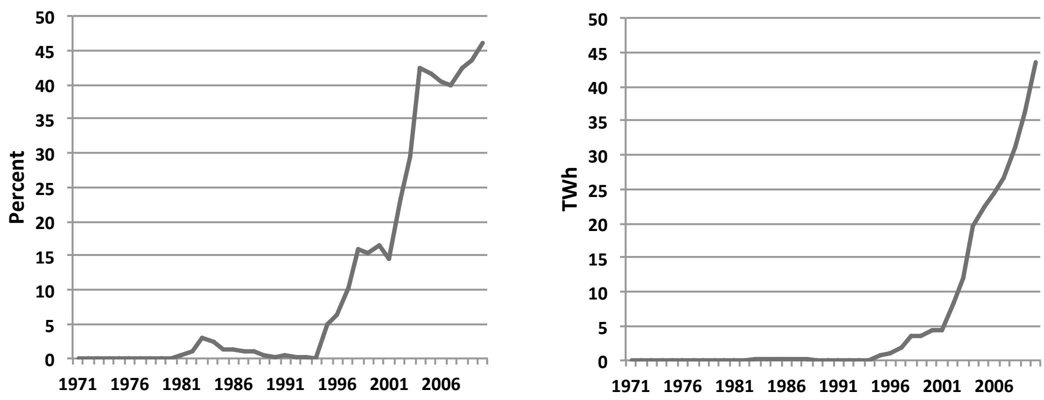
Coal technologies do not seem to have been associated to the same extent as hydropower with domestic vested interests in the ESI. In contrast, the division of control over the supply-chain in coal thermal power generation between TKV and (predominantly) EVN has lead to competition for coal rents between these two SEGs. The contestation of coal rents will continue for as long as a differential exists between international market-based coal prices and the controlled prices at which generators are supplied. Nevertheless, the bulk of these rents essentially continue to be passed on to electricity consumers.

Considering the choice of coal in the future, PDP VII envisages a dramatic increase in coal thermal capacity, reflecting the need to supply power as cost effectively as possible, and to this extent the political imperative for effective provision of low cost electricity as a public good. Domestic political economy considerations are perhaps less influential in the choice of this technology, although they are likely to play out in the allocation of projects to preferred developers, the choice of EPC contractors and technology suppliers. Although in many cases, given the increasing role ECAs seem to be playing, political economy considerations of importance are likely encompass that of industrial policy in countries that supply funds for these projects, including Japan, China and Korea in particular.

7.2.5 Natural Gas

Natural gas has only relatively recently become an important source of electricity generation in Vietnam, with the development of large complexes at pipeline terminals in Phu My, Nhon Trac, O Mon and Ca Mau (Figure 7.3). As with hydropower and coal, natural gas fired generation has been dependant upon the availability of domestic resources. Unlike hydropower and coal, Vietnam has been much more dependant upon the expertise of foreign energy companies in exploting domestic gas resources. In terms of the development of both associated and non-associated gas, PVN has sought to partner with and draw upon the capital and expertise of foreign companies such as BP and Chevron. Development of large gas generation capacity has therefore been tied to the development of a network of gas pipelines (World Bank 2010a).

Figure 7.3. Natural gas thermal electricity production as a proportion of national electricity production (left) and in absolute terms (right) 1971 - 2010



Source: IEA 2013

Gas has rapidly grown in importance since the early 2000s with the commissioning of the two large foreign owned Phu My plants. While some gas-fired generation is owned by EVN, it has largely been developed by foreign IPP investors and more recently by PVN. As noted in the previous chapter the perception in government was that the FDI plants at Phu My did not perform as well as hoped (Chapter 6, section 6.3.4).

The risky and expensive nature of off-shore gas exploration and exploitation means that a greater share of natural resource rents would need to be returned to field developers including PVN, any foreign equity holders and foreign exploration companies. Gas supply agreements are negotiated between PVN and generators on a bilateral basis for power projects, with the seeming objective of maintaining low electricity prices (World Bank 2010a).[265] Thus the policy objective seems to be, in as far as is possible, for natural

[265] In a recent report the World Bank (2010c) suggests: "Existing gas pricing appears to be driven to the extent possible by a perceived need to achieve low electricity prices and to confer subsidies on gas consumption in the fertilizer sector." (xiv)

resource rents to be transferred to end-users as with hydropower and coal. Nevertheless, gas represents a more expensive alternative to either hydropower or coal generation. Moreover, as in the coal sector, there is some evidence of quasi-rents, as lower gas prices have stymied investment in the development of the sector. Again this represents a politically motivated trade-off between short-term cost considerations against those of long-term development (World Bank 2010c).

For CCGT plants civil works tend to compose an even smaller portion of capital costs. Indeed, one of the main advantages of CCGT technologies is that the technology has a smaller efficient economic scale and is modular in nature. As a result most of the capital costs are composed of engineering costs. This means that a greater proportion of capital costs would go to technology providers - as a technology rent - and there is less potential for the capture of rents or rent-based transfers by domestic companies (Pauschert 2009). At the same time, these cost attributes made this technology attractive for IPPs (Chapter 4, section 4.2.6). In addition, the relatively high fuel costs and relatively low capital costs mean that CCGT generators have higher SRMCs relative to LRMCs, leaving less scope for the creation of quasi-rents. This too represents a somewhat reduced risk for investors relative to projects which have greater up-front capital costs.

Political economy has been less important in determining the diffusion of CCGTs in Vietnam than other technologies. Where diffusion of this technology became viable was where investors were afforded protection from the risks posed by counterparties in their pursuit of rents, particularly in Vietnam's lax regularory environment. Initially the resistance to these technologies related more to resistance to IPPs (and the associated protection of EVN rents), and foreign IPPs in particular. Foreign CCGT IPP's seemed to be effectively protected from EVN's use of its monopolistic power. However, those owned by PVN did not seem to enjoy the same protection, with issues emerging relating to the payment of fuel bills and the willingness of EVN to dispatch (expensive) electricity from these plants (Chapter 6, section 6.3.8). As with coal, most political economy issues relate to natural resource rents generated up-stream and the distribution of these rents between key players, in this case PVN's foreign partners, PVN and EVN.

According to PDP VII, CCGT capacity is expected to increase by 8 GW by 2030, with ownership of these new plants spread between EVN, foreign investors, PVN and some as yet to be identified developers.

7.2.6 Renewables

Renewables have not been widely adopted in Vietnam with around 714 MW installed by 2010, around 85% of which has been small hydropower (<30 MW), 12% biomass and biogas, 4% wind and less than 1% solar PV both off-grid and on-grid (Nguyen 2013).

Small hydropower has been far the most important source of renewable power generation. As explained in section 6.3.7, small hydropower is a relatively cheap and well-understood technology. Vietnamese developers, construction firms and provincial authorities saw significant potential to capture both natural resource rents, and in all likely-hood transfers. The small hydropower boom in the 2000s saw a varied range of investors become involved in the development of small hydropower capacity as IPPs. These developments were also popular with provincial authorities, with whom the right to grant concessions rested, which thus opened up the possibility of generating licit (natural resource taxes and payments land use rights) and illicit (kick-backs and bribes for concession grants) rent based transfers. Local (as well as national) construction companies with provincial connections also stood to benefit from providing the substantial civil works associated with these projects at the provincial level, in much the same way that EVN and Song Da were able to at the national level. Finally, the boom consisted of opportunistic investment by a variety of investors enjoying cheap, privileged access to capital (typically from domestic banks) or privileged access to concessions.

From the perspective of EVN, additional cheap capacity was welcomed to the extent that low off-take tariffs allowed EVN to capture a good proportion of the natural resource rents, which could help cross subsidise end-user tariffs. As with other IPPs EVN was able to generate quasi-rents by driving off-take tariffs down towards the SRMC of production. As noted above, this acted as an important brake on the further development of 'strategic investors' in the ESI with the compunction and financial wherewithal to invest in additional capacity, which would require off-take tariffs closer to the LRMC of production (Chapter 6, section 6.3.7; section 7.2.3; Table A6.3). Overall, the low off-take tariffs relative to other available technologies made small hydropower attractive to EVN.

However, small hydropower plants with smaller water storage capacity are more vulnerable to hydrological risks, compounding the dry seasons risks already experienced by the hydropower dominated ESI. Moreover, small hydropower plants faced less stringent environmental and social safeguards than larger plants. They have also been frequently built by less experienced contractors and with limited operational oversight (Meier 2013). From around 2010 onwards these plants were increasingly criticised by the press for thier social and environmental impacts, including instances of shoddy construction, and poor uncoordinated operations leading allegations of exasperating downstream flooding during periods of heavy rainfall (Thanh Nien News 2012; Thanh Nien Daily 2012; Saigon Daily 2013). As early as 2010, MoIT was advising provinces to pay more attention to the negative environmental impacts of these small hydropower plants (DTI News 2010).

Other renewables developments have been very limited, but where developments have taken place they have also been developed by IPPs. As noted in Chapter 6, for off-grid applications renewables have made some in-roads, for example in the combustion of biomass (e.g. Bourbon sugar Mill in Tay Ninh province Chapter 6, section 6.3.4) and in remote locations the development of wind power (e.g. Ba Ria Vung Tau wind farm, Chapter 6, section 6.3.4). However, on-grid development has been extremely slow to emerge. The development of suitable grid codes, ensuring priority dispatch, net metering and a subsidised off-take tariff (by way of a feed-in-tariff (FiTs)) all imply greater costs for EVN, which has lead to significant reluctance on the part of EVN to agree the development of these projects. With a few exceptions, FiTs that have been agreed for these renewables have generally not been sufficient to attract investment. Even where agreements have been reached - the difficulty IPPs have faced with enforcing PPAs have added further disincentives.

Thus, while PDP VII has relatively ambitious targets for the expansion of renewables (an additional 3 GW by 2020 and 6.7 GW by 2030 (Nguyen 2013)), technical issues, and the policy and political economy environment mean that without significant and effective changes in the regulatory environment and the political will to achieve these this target is unlikely to be achieved.

7.2.7 Nuclear

While Vietnam currently has no nuclear generation installed, plans for nuclear generation have been afoot since at least 1996 (Le 2012). PDP VII envisages an extremely ambitious programme of nuclear expansion, with a total of around 12 GW installed by 2030 and the first 1 GW nuclear plant scheduled for commissioning by 2020 (Figure 7.1). This first plant will use Russian technology supplied by Rosatom, a Russian EPC and will be largely bankrolled using concessional Russian lending to the tune of US$ 8-9 billion for the first plant. A second plant is to be provided by Japan, again tied to ECA loans to the tune of US$ 8-9 billion using Japanese technologies and contractors. A possible third plant using Korean technology has also been mooted (Hechtr 2010; The New York Times 2012; Asian Power 2012). Other countries such as Canada, China, France and the US have also been involved in nuclear agreements and negotiations on civilian applications with Vietnam (Le 2012).

The choice of nuclear power is interesting as it is likely to be considerably more expensive than the alternatives (with the possible expection of some renewables). The technical requirements for the construction and safe operations of nuclear technologies are also significant (Kessides 2012a; Vujic et al 2012). Form a technical and economic perspective this choice seems to be driven by concerns relating to future energy security in Vietnam given its rapidly expanding electricity needs, but also by the availability of technologies and finance from other countries seeking markets for their domestic nuclear power industries (Hechtr 2010; The New York Times 2012). As we noted in Chapter 4, in the case of the development of nuclear power elsewhere, nuclear power probably also represents a good fit in terms of Vietnam's centralised development model (section 4.2.3).

Rents in the short term are largely likely to be technology rents or rents for learning, accruing to technology providers and EPCs. Nuclear power (like hydropower) also has a significant civil works component, meaning that large specialist construction companies may be well placed to appropriate rents derived from the large capital expenditures associated with these plants. It is unclear to what extent Vietnamese companies would have the specialist skills available to allow them to appropriate a share of these rents. Indeed, it is likely that these plants would need to be effectively cross-subsidised by other generation plants in the ESI, given EVN's (post divestment rump) likely future portfolio including a number of fully depreciated large hydropower plants, this may be possible within the company itself.

Possibly the most important implication of the development of nuclear power in Vietnam relates to the implications for the ownership structure of the ESI as a whole. Given that large proposed nuclear capacity remaining under the management and ownership of EVN it is likely to mean that EVN remains in a dominant position in the Vietnamese ESI. Thus the choice of nuclear power is also understandable as a means of maintaining EVNs dominance in the ESI. The ostensive justification in what is envisaged as an otherwise liberalised ESI would be the 'strategic' nature of the technology.

7.3 Conclusions on the political economy of technology choice in Vietnam

In a recent consultancy report for the World Bank, Pereira (2008) notes that given rapidly growing electricity demand, Vietnam has limited choices when considering future electricity generation technologies:

> "…generation planning in Vietnam does not have many degrees of freedom. The basic options (in increasing order of attractiveness) are hydro imports (defined by MoUs between governments); local hydro (not a large potential); local coal (not high quality, located in the North region); natural gas (fields in the South region, in the process of being developed) and imported coal. Given the above constraints, planning becomes more a question of defining the entrance dates of the (few) available projects, rather than an economic choice from a very large number of options." (Pereira 2008: 6)

Greater choice was arguably available to Vietnam in the course of the development of the ESI, such as that between hydropower and coal in the 1980s and 1990s. However, once we consider the institutional and political economy context we see the technological options are narrowed. In the course of the 1980s technology choice was largely the result of Soviet plans, technologies and resources, leaving little latitude for the exercise of domestic political economy dynamics. With the liberalisation of the 1990s, the scope for technology choice in the sector opened up, as did the scope for the exercise of political economy factors. In particular, the balance between the contestation of various rents between elite interest groups, and the broader political need to ensure the public good of cheap electricity and reliable supply against the background of changing resource constraints and costs.

The availability of various rents and quasi-rents to various groups in the ESI has arguably influenced technology choice and the ownership of technologies. Firstly, at the most general level, the need to maintain low end-user tariffs, both as a tool to promote industrial development and as a social policy tool has been a key concern. This reflects both rational public policy, but also the need to maintain state legitimacy through the provision of a public good. This has been reflected in the choice of hydropower in the past, and in the future the planned development of coal fired generation. Secondly, the dual role of EVN, which is both the institutional means by which the important public good of cheap, reliable electricity is delivered, but also functions as an important locus for the generation of rents for key elites. Indeed the evidence suggests that EVN has often put the goal of short-term rent generation above that of its public good role. For example, in seeking to maintain streams of rents and quasi-rents by squeezing existing IPPs, frustrating the development of the IPP sector, in giving preference to its own project development (and other favoured developers) and dispatch, and thought utilising privileged access to funding to engage in speculative, non-core investments (Chapter 6, section 6.3 – 6.4). This affected technology choice indirectly through the imperative EVN faced to maintain low off-take costs meaning it was reluctant to develop more expensive generation technologies, and directly through promotion of technologies which it could maintain control (large hydropower and nuclear), that offered it greater control over natural resource rents (hydropower and coal) and which created significant opportunities for other kinds of rent and rent-based transfers (hydropower)(sections 7.2.3 – 7).

Thirdly, the other energy parastatals have been able to leverage their effective control over fossil fuel resources to enter generation and through the development of associated technologies (coal and CCGT). The weakness of central control and competitive clientism has allowed EVN to obstruct and contest the entry of PVN and TKV. Through its monopoly position in the power sector EVN has been able to control a portion of coal and gas resource rents. Thus, to this extent the diffusion of technologies associated with these fuels (CCGT and sub-critical coal) have been stymied. Finally, more generally technologies with higher costs and in which EVN did not enjoy core competencies (CCGT and renewables) have been typically provided by IPPs. These potentially threatened EVN's control over the sector and higher off-take tariffs also threatened EVN's financial position. Again the obstruction of technological diffusion is as much about obstructing IPPs as about the particular technology in question.

7.4 Holding power, political settlements and rents in the Vietnamese power sector

We are now in a position to realte the case study to the more general analytical framework we developed in sections 3.3.1 and 3.3.2. The Vietnam case study clearly illustrates the importance of the distribution of holding power in the Vietnamese political economy in understanding broader outcomes in the ESI. The concentration of holding power at EVN can be inferred through its ability to delay the formal adoption of reforms in the sector, to influence the direction of reform (such as the controversy over the design of a single buyer, and the shape of divertment and sector restructuring), and to subvert some aspects of the reform process (such as through non-payment of bills, foot-dragging in PPA negotiation and grid interconnection, failure to dispatch non-EVN generation capacity and large-scale investment in non-core activities). These actions seem to have been undertaken to protect EVN's rents in the sector. Moreover, other important vested interests have seemingly been able to draw on their influence and informal patronage networks to enable the continuing capture of various rents. We can infer that this is the case through consideration of allocation of potentially lucrative projects to important vested interests (such as hydropower projects to Song Da Corporation and EVN amongst others).[266]

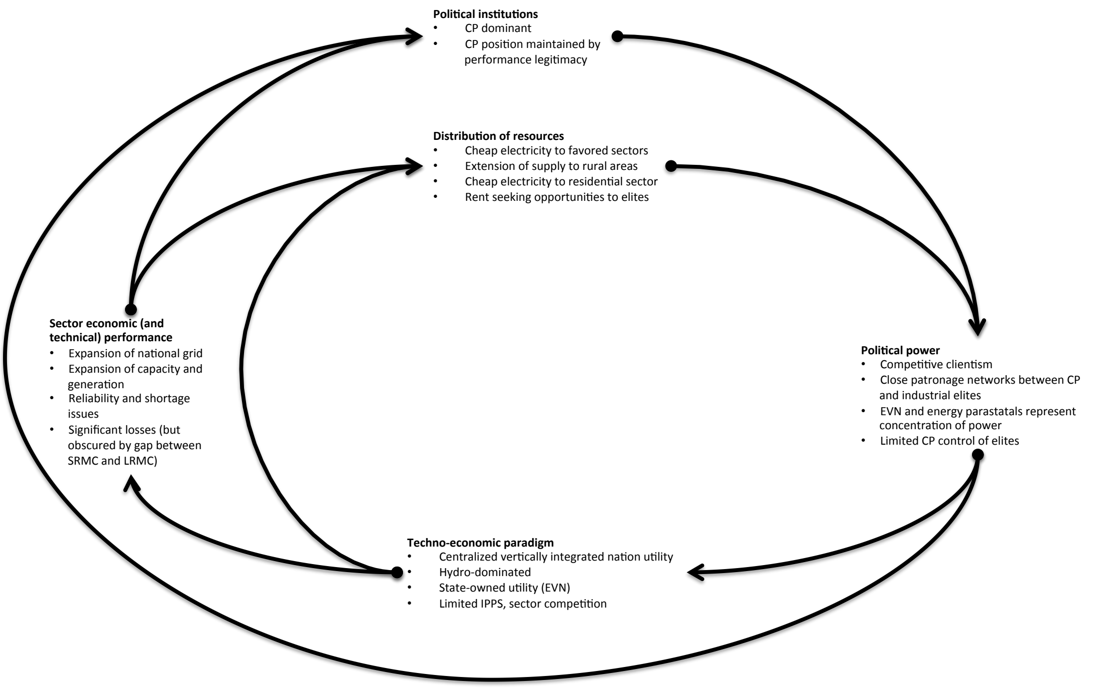
At the same time, the case study illustrates the limits to the holding power of EVN (and the other energy parastatals). Their luckless pursuit of increased power tariffs serves to emphasise the continuing importance other vested interests, importantly the need for the CP to maintain legitimacy and thus its position of power (and the rents that go with it). As argued above, this has been managed through the provision of pubic goods such as

[266] What is more, the relative impotence of the IFIs also stands out, their ability to force the pace of reform and direction of policy has been limited. Vietnam has relied on ODA for a considerable portion of capital investment in the ESI, it has been able to aquire donor commitments without needing to make to many concessions in terms of actual reform. Changes to policy have largely been driven by domestic pressures and more recently the need to encourage foreign investment in the ESI.

cheap electricity and macro-econmic stability. The current situation developed over a period when the ample domestic resource base (the abundance of hydropower in particular) and foreign capital made available on concessional terms (from the USSR and latterly ODA) made a high level of trasfers to end users feasible. This exemplifies the way in which dispositions of holding power are both enabled and constrained by a techno-economic system.

Turning to the broader political economy framework (elaborated in Figure 7.4 below), the elites in EVN and the large parastatals through ownership and control of the ESI (and associated technology, resources and capital) have by and large controlled political institutions and policy formation to ensure the maintainence of their privelidged position in the ESI. They have been able to accomplish this through close patronage networks with the CP and the administrative arms of state (Ministries, Peoples Committees etc). The interests of EVN have been closely realted to the techno-economic paradigm, in that a vertically integrated, monopolistic, expansionary and hydro-centric model of ESI development has enabled the generation of significant rents. The provision of cheap capital for system expansion (from policy lending, ODA and before that the USSR) and the large gap between LRMC and SRMC in the sector (particulalrly in the case of hydropower). Thus in as far as has been possible EVN has sought to promote its preferred technology (hydropower) and its preferred economic institutions (vertically integrated monopoly). This has also implied the suppression of IPPs, unbundling and other reforms. At the same time, by and large, EVN has fulfilled its developmental function with the expansion of the grid, increased electricity supply and imporved quality of service. Thereby legitimising (to some extent) the institutional set up of the ESI and more broadly the role of the CP in the economy.

Figure 7.4. Linking politics and the techno-economic paradigm in Vietnam's ESI



All this points to the second important point, that the bigger picture is one in which the disposition of holding power has not been consistent with the long-term financial sustainability of the power sector. This implies that in the longer term that the current distribution of rents is not sustainable, with knock-on implications for the sustainability of the political settlement.

7.5 Implications for climate change mitigation in Vietnam

The implications for climate change mitigation in Vietnam's ESI are not encouraging. First, cost is a likely to be critical consideration. Even in relatively well-managed, open, democratic polities, there has been significant opposition to energy price increases both from the public at large and from interest groups in energy intensive industries. The essential nature of the public good, the opacity of cost structures in the ESI (the very same that allow the generation of quasi-rents), the visibility of electricity prices and (despite liberalisation) the concentration of market power amongst a few large ESI utility companies, mean that the sector remains politically fraught, as Pollitt comments in relation to climate change mitigation in the ESI:

"In the end, as the incomplete progress of liberalisation around the world demonstrates, it is not liberalisation per se that will determine the movement towards a low carbon energy transition, but the willingness of societies to bear the cost, which will be significant no matter what the extent of liberalisation." (Pollitt 2012: 8)

All the more so in Vietnam, where oversight is lacking, public trust in state institutions limited and corruption reputedly commonplace. Notwithstanding some low-hanging fruit (such as more efficient power plant operations, reducing T&D losses and end-user energy efficiency), climate change mitigation will not be cheap, and in the long term energy users will need to pay for it. To the extent that mitigation is likely to imply higher short-term costs in Vietnam, it is likely to be untenable unless external funding sources (such as carbon finance and clean technology funding) are made available to off-set the cost increases implied by mitigation efforts.

Nevertheless, there may be scope for more aggressive climate change mitigation in the ESI to the extent it is in line with existing vested interests. In the case of the nuclear option EVN has a clear interest in promoting this technology despite its higher cost. If other low-carbon technologies could find similar incumbent constituencies which enjoy political influence, and whose influence they could serve to enhance (e.g. domestic technology suppliers), or if such interest groups could be created through the creation of rental streams associated with climate change mitigation then mitigation may be possible, even with raised end-user tariffs. However, as with industrial policy, such rents for climate change mitigation would require significant government capability to effectively monitor these rents. Given current conditions in Vietnam this would not seem to be a feasible approach. In the future, with stronger central institutions and the power of the parastatals in particular curbed such an approach may be feasible, at the moment this seems a distant prospect.

7.6 Caveats and limitations

Political economy processes are notoriously complex and difficult processes to study. Identifying the implied causal role played by implied concentrations of power means direct evidence is rarely available, and any account we are able to construct is bound to be significantly underdetermined by the available evidence. In the political context of Vietnam, formal institutions and processes are opaque, ostensively public information is generally not publicly available and stakeholders feel unable to speak freely relating to political issues. Moreover, the scope and importance of informal processes and the political economy artefacts associated with them such as patronage networks and the flow of rents, by their nature are not available to the researcher. This means that it is difficult deriving a robust basis for empirical claims about the political economy process, these difficulties are widely recognised by researchers on Vietnam (Gainsborough 2010).

The upshot of all this is that the standard of proof regarding the empirical claims made here is necessarily lower than for studies, which have ample empirical evidence connecting well-defined, causally contiguous phenomena. We have sought to address this through the use of a longitudinal case study of the ESI, by drawing on a variety of sources and data to generate a convincing narrative, and seeking verification of the narrative from key informants with in-depth knowledge of the sector. There are clear dangers with this approach. But we have not sought to obscure the uncertainty regarding key elements of the account. We have also sought to guard against over-interpretation of the evidence.

Finally, we feel the empirical difficulties of this approach are greatly outweighed by the value of the resarch. That a research question presents a topic that is difficult to address does not mean that it should not be investigated. In this case, we approached a topic (the political economy of technological change) that is highly relevant to issues of climate change mitigation, but has received very little attention. Similarly, in the case of Vietnam, we approach a topic (the political economy of the ESI), which has not really been investigated, but is critically important to understanding the scope for mitigation policy. Furthermore, while some objects of research are amenable to division into discrete, easily tractable questions, this is not always the case. As Simon's (1962) work on hierarchical complexity served to emphasise, even in complex systems relatively independent subsystems are likely to develop (Chapter 2, section 2.4.2), these may be amenable to separate study. The ESI and its relationship to the national policy are a different proposition, and as we have tried to show in this thesis, when considering system wide technological change we need an approach that will enable us to capture the fundamental dynamics of such a process, this necessarily incorporates system wide issues and the national polity.

7.7 Recommendations for future study

The research leaves many questions unanswered and many others requiring the development of a more robust evidence base. Key recommendations for future research relate to more general theoretical issues, research on the ESI and other technological systems, and research on Vietnam in particular. First, considering theory, there is a considerable amount of work needed in linking evolutionary economic approaches to political theory, specifically as relates to technological change. We have identified possible reasons for better considering the linkages between political economy and technological change but it remains under theorised. In particular, as it relates to general-purpose technologies and systematic technological change. In a similar vein, there is a need for evolutionary economists to engage more seriously with the issue of economic development.

Second, concerning research on technological systems, there is a serious need for the development of more country case studies exploring the linkages between technological systems and change in these systems and the political economy context. Emerging economies which are seeing rapid development of technological systems would be good candidates for study (such as Turkey, Colombia, Nigeria, Indonesia etc.). This is especially urgent as we have argued the political economy context is likely to determine to a significant extent the possibility for serious climate change mitigation efforts. Finally, as regards Vietnam, with a few notable exceptions (Fforde and Gainsborough being prime examples), there is a paucity of work looking at linkages between the political economy and the process of development. Given Vietnam's experience of rapid development and its popularity amongst donors as a glib example of a developmentally effective state, there is a need to understand the dynamics of its development – and the political economy of its development better.

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Annexes

A2 Annexes to Chapter 2

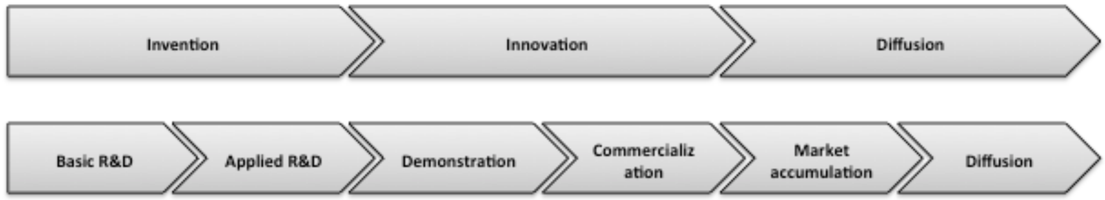
A2.1 Linear accounts of technological change: from 'supply-push' to 'demand-pull'

Schumpeter has been perhaps the most influential account of technological change, in terms of both this analysis of the process of technological innovation and of the role it played in understanding economic growth and the business cycle (Foxon 2003). Schumpeter stressed the 'creative destruction' that accompanies technological change as old firms lumbered with incumbent technologies are replaced by new firms and technologies (Schumpeter 1934; Schumpeter 1939). Positing a three-stage process of technological development, composed of invention, innovation and diffusion stages. The process of technological diffusion was characterized by an S-shaped (sigmoid) curve, with slow uptake of technologies in the initial stages of development followed by a period of exponential growth, slowing down once again when the market approaches saturation (Figure 2.2). Schumpeter regarded the invention stage as a creative process, and exogenous to the economic process. Innovation and diffusion, however, were both considered to involve economic decisions made by the firm (Schumpeter 1934). It was not until the 1950s with the development of greater interest in the causes of productivity growth and technological change, that the first, three-stage linear model of technological change emerged and the theoretical work began in earnest (Godin 2006).[267]

The simple linear model of innovation that emerged in the 1950s and 1960s suggested a sequential process leading from investment in research and development, through a process of commercialisation, which culminated in bringing a new technology to market and leading to the broader diffusion of the technology through market accumulation (Figure A2.1) (Godin 2006).

[267] Although the origins of the linear model are somewhat nebulous and unclear, Godin (2006) argues convincingly that the linear model developed as a rhetorical device used in advocacy by various different interest groups in their competition for resources. The linear model persists despite its inadequacies as it has become embedded in the statistical practices of such organisations as the OECD.

Figure A2.1: Simple linear model of technological change



Note: Schumpeterian technological change shown as a three-step process of invention, innovation and diffusion. In recent years, while maintaining the suggestion of discrete-chorological steps in a linear process, the number of steps have been elaborated and increased.

Initially, there were two main ways in which the causal processes behind this model were interpreted. One emphasised a supply-push, where investment in research was deemed to be a sufficient condition for the development of new technologies and therefore technological change. The second emphasising 'demand-pull', that is the importance of market demand in stimulating the development of new technology.[268] The fundamental difference between the theories lay in the extent to which the innovation process was considered independent of short-run changes in the economic environment (Dosi 1982; Ruttan 1997). Or, more simply put, the difference lies in the emphasis placed on the role of *market forces* in the innovation process.

A simplified supply-push approach suggests that scientific research plays the primary causal role in generating innovation and technological change, albeit with some lag. This account was found to be unsatisfactory, as demand-side factors seemed to have a clear role in technological innovation, which a simple supply-push theory cannot incorporate. In contrast, the demand-pull (induced innovation) account was motivated by the notion that technological development is responsive to market demand, and that market demand 'induces' innovation. The induced innovation account relied upon a conventional economic account where technological change was the response of economic agents to a market signal. The induced innovation account suggests that the innovation process is driven *primarily* by market demand, that is to say market demand is the primary *cause* of innovation. A version of this approach is attributed to Hicks (1932), in his suggestion that demand for new technology may be led by changing factor prices:

[268] This is a rather crude characterization here they are used in a purely instrumental manner to aid exegesis.

"A change in the relative prices of factors of production is itself a spur to innovation and to inventions of a particular kind - directed at economising the use of a factor which has become relatively expensive" (Hicks 1932: 124-5).

Dosi (1982) drew attention to three main theoretical weaknesses in the simple version of induced innovation account presented here. Firstly, the account sees technological change as a purely mechanical reaction to market conditions.[269] Secondly, the account is incapable of explaining why a particular technology appears at a particular time, given that there are a potentially infinite number of needs to be met (i.e. there is no well-defined choice set). Finally, the account says nothing about changes in the ability to invent overtime which may have no direct relationship to market demand. Ruttan (1997) acknowledges the failings of the induced innovation approach, echoing Dosi's criticisms:

"The major limitation of the microeconomic version is that its *internal mechanism* - the learning, search and formal R&D processes - *remains inside a black box*. The model is driven by exogenous changes in the economic environment in which the firm (or public research agency) finds itself."[emphasis added](Ruttan 1997: 1521)

More nuanced induced innovation accounts allow for pervasive market failures associated with the innovation process and the possibility of dynamic increasing returns, both of which can explain inertia in the technological system. These accounts are of particular relevance to this research as they have been highly influential in guiding the development of policies to address environmental externalities, and climate change in particular. A paradigm example is found the discussion of Jaffe et al (2002; 2005) on policy to promote environmental technological change.

Relying heavily on an induced innovation account, Jaffe (Jaffe et al 2005) and Popp (Popp 2010) both suggest that dealing with long-term environmental externalities requires both policies to generate demand for environmental technologies through internalisation of environmental costs (ideally through market based instruments), and instruments to address market failures associated with the innovation process.[270] Jaffe

269 As Mowery and Rosenberg put it "…innovations are in some sense 'called forth' or 'triggered' in response to demands for the satisfaction of certain classes of needs.'" ("{Mowery & Rosenberg 1979:\: 104)\}

270 The distinction drawn here is that between market based and command-and-control policy instruments. In principle the former are least cost, at least when polluters face heterogeneous cost curves and the possibility of government failure is high ({Jaffe et al 2002;Hepburn 2010}

distinguishes between market failures associated with the innovation process within the firm, and those associated with the wider diffusion of technology in the market.

As regards innovation, there are knowledge externalities and financial market failures associated with investment in R&D, which mean that it is likely to be undersupplied by firms. Firstly, the end product of R&D activities is knowledge mainly about the process of manufacturing a product.[271] Once such knowledge is created it is difficult to prevent 'spill over' to other firms or consumers who can benefit from this knowledge. Thus firms that invest in R&D are unlikely to be able to capture all or even most of the benefits associated with that investment. Investment is therefore likely to be undersupplied relative to the social optimum (Martin & Scott 2000; Jaffe et al 2002; Foxon 2003). Secondly, unlike investments in capital equipment, investments in R&D have unpredictable returns, where much of the investment value may result from low probability high value outcomes. The asset created by R&D activity is also 'specialised, sunk and intangible', which means it cannot be collateralised as debt. Both of these characteristics of R&D make it difficult to finance externally, particularly a barrier for small firms with limited internal financial resources (Jaffe et al 2002).[272]

The market failure stemming from positive externalities to the production of knowledge and financial market failures resulting from the intrinsic uncertainty and inappropriability of the investment in R&D, together mean that R&D investment is below the social optimum, and that there is thus a *prima facie* case for public intervention to promote R&D (Martin & Scott 2000).

Similarly, in relation to the process of diffusion of an innovation in the wider market, Jaffe et al (Jaffe et al 2002; Jaffe et al 2005) note that dynamic increasing returns are associated with the scale of adoption of a new technology. These are understood as the result of positive knowledge externalities relating to learning-by-doing, learning-by-using, or the formation of networks.[273] Learning-by-doing has already been addressed above, suffice to say this kind of knowledge externality relates to the incremental development of tacit knowledge of the production process garnered only by engaging in the process itself. Learning-by-using is usually associated with capital goods and relates to knowledge

[271] 'Learning-by-doing' see (Arrow 1962)
[272] Dosi (1988) expands on the possible market failures in relation to R&D in greater detail.
[273] There is an important literature on learning curves and learning rates, which seek to formalize these concepts (e.g. McDonald & Schrattenholzer 2001).

gained through use of an item, this is the demand-side equivalent of learning-by-doing (Jaffe et al 2005b).[274][275] In both cases, early adopters create a positive knowledge spill-over which makes adoption less uncertain and more effective for later adopters. Asymmetrical knowledge may also mean it is more difficult for early adopters to finance investments in new technologies. Potential investors may not possess adequate knowledge about new technologies and perceive them to be more risky than proven incumbent technologies, as knowledge of a new technology becomes more widely available, this knowledge asymmetry will decrease and financing investment in the technology is likely to become easier. Finally, network externalities result from a technology becoming more valuable to a user as more people adopt it, phone, computer and electricity networks are examples of technological systems which show these characteristics (Jaffe et al 2005).[276]

It should be noted that while Jaffe identified these as market failures stemming from knowledge externalities and asymmetric knowledge, this may not be the case. Early adopters also run the very real risk of adopting a technology that quickly becomes obsolete. Incremental improvements are often made to technologies as they develop as a result cost and functionality can increase quite dramatically. Conversely, some innovations turn out to be technological dead ends, which may have limited future value (Soete 1985). This means there is likely to be an option value associated with delaying investment decisions in new technologies (Ansar & Sparks 2009). Indeed, both these risks associated with the early adoption of technologies form an important part of 'late-comer' advantage (Chapter 3, section 3.2).[277] It would seem Jaffe does not consider these as they do not fall easily into his taxonomy of market failures.[278] Jaffe also fails to draw

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[274] While there is a distinction to be made between knowledge of a process of production as in Arrow's learning-by-doing, and knowledge of how to use a particular machine or device as in Rosenberg's learning-by-using, but it also should be clear that this distinction is not clear-cut. One man's learning-by-doing (production) is another man's learning-by-using (consumption).

[275] This process it thought to be particularly relevant for long-lived durable goods and goods that form part of a complex technological system (Rosenberg 1982).

[276] Other market failures are also possible in explaining the relatively slow uptake of some technologies. For example, energy efficiency technology for homes is subject to a principle/agent problem. In that in the case of a rented property, the tenant pays the energy bills, whereas the landlord pays for energy efficiency investments (Jaffe & Stavins 1994).

[277] Jaffe, however, considers these in an earlier paper identifying barriers to technology adoption, which are not best characterised as market failures, including high discount rates and private information costs in the case of energy efficiency technology. They go on to argue that these barriers do not constitute a good reason for government intervention, but does not present a reason why they think this. It must be assumed that they are arguing that given fundamental economic assumptions relating to the rationality of individuals, these barriers do not justify government intervention. They also consider heterogeneity amongst the cost structures of potential adopters as potential reason for the slow diffusion of energy efficiency technology – although this is best not regarded as a barrier to adoption rather as a reason for different rates of adoption (Jaffe & Stavins 1994).

any further implications from the acknowledgement of increasing marginal returns to adoption of a technology, save the reductive assumption that they can be explained by positive externalities (which can be reductively internalised by providing the right price signals to economic agents). In a similar vein, in a recent review of the literature, Newell (2010) also notes the possibility of dynamic increasing returns to the adoption of technologies, possibly leading to 'lock-in', but fails to draw any further conclusions from this.

Although there is a general agreement that demand has an important role to play in innovation process, and may even be a necessary condition for innovation, there are good *prima facie* reasons to believe that an induced innovation account does not represent a particularly powerful or enlightening account of the innovation process. On this account, bounded by the micro-economic canon, the innovation process remains a 'black-box' and identifiable market failures remain - if not the sole factors obstructing innovation – the only suitable levers for policy intervention (Newell 2010). The approach fails to adequately address the possibility of technological lock-in or that of radical, non-linear technological change. Nevertheless, the question is an empirical one and the subject of induced innovation has been a fertile area of empirical research generating a large empirical literature.

Before going on to look at the empirical work it is important to note that the induced innovation account has been highly influential in the design of environmental policy, and in recent years, the design of climate change mitigation policy. At its simplest the induced innovation account suggests that to encourage the innovation of environmental technologies market demand for these technologies needs to be created, as Newell (2010) notes:

"Since environmental policy implicitly or explicitly makes environmental inputs more expensive, the "induced innovation" hypothesis suggests an important pathway for the interaction of environmental policy and technology, and for the introduction of impacts on technological change as a criterion for evaluation of different policy instruments." (Newell 2010: 12)

Given the more sophisticated account, which acknowledges pervasive market failures there is also a role for policy in supporting environmental R&D. The faith in the efficacy of market mechanisms for delivering environmental technological change goes further. If polluters face heterogeneous cost structures and heterogeneous abatement costs, they are likely to know much better how to reduce these costs than an outside regulator. Therefore - from a static-allocative perspective - flexible, price based instruments that allow polluters to reduce their pollution in the most cost-effective way, rather than more rigid environmental performance or technology standards are likely to be preferable (Kerr & Newell 2003; Hepburn 2010b). As regards innovation, price incentives are also claimed to offer a dynamic incentive for technological innovation that does not exist with regulatory instruments – thus not only resulting in a higher quantity of environmental innovation but also a higher quality (Popp 2005). Essentially, the message is that the best possible outcome can be achieved by correcting market failures and getting the prices right.

Although there is a close relationship between the induced innovation literature and the case for market based environmental policy instruments, the latter does not necessarily imply the former. The case for the primacy market-based policies can be rejected while maintaining an induced innovation without inconsistency. A weak version of the induced innovation hypothesis would only suggest that demand (no matter how it is created) is necessary for innovation but only as part of a broader set of conditions. Conversely, it is difficult to see how the induced innovation account could be rejected without also rejecting the case for the necessary primacy of market based environmental policy. If we accept that the process might be more complex than the induced innovation account suggests, then it is unlikely that the innovation and diffusion of technology will respond to market signals in a straightforward way. More specifically, technological change might not respond to marginal changes in price in a linear way, and lock-in to technologies may be pervasive (Unruh 2000; Anderson & Winne 2007).[279] This is especially the case for the radical technological change that is likely to be needed to address the impending climate crisis (Sanden & Azar 2005).

A2.2 Review of empirical evidence on induced innovation

There is a large empirical literature on technological innovation and change, which precludes more detailed or systematic analysis here. The objective is rather to assess the

[279] To put it another way, short-term price elasticities for pollution might be very low, there is a distinct possibility that for a number of reasons the rate of response may be non-linear over time. Alternatively price elasticities might not be constant over all changes in price. It may take a large price hike in the cost of pollution to illicit any change in behaviour, that is the supply curve for pollution maybe non-linear. Mickwitz et al (2008) makes a similar observation, "Whether economic instruments are efficient means of supporting the emergence or diffusion of environmental friendlier technologies largely depends on whether it is politically feasible to set them at sufficiently high levels."(169)

weight of the empirical evidence *in favour* of an induced innovation account of technological change. The literature of interest falls into two main areas, that which seeks to test the induced innovation account more generally, and a more recent literature relating to environmental technological change.

A2.2.1 The empirical evidence on induced innovation

In terms the general empirical literature supporting the induced innovation account, early studies by Griliches (1957) and Schmookler (1962) both found evidence of the importance of market demand in spurring innovative activity. These studies generated a significant related literature. Schmookler's approach using patent information to examine the relationship between changes in market demand and innovative activity has been particularly influential. Scherer (1982) in a similar study of patents finds qualified support for the induced innovation account:

> "Markets work, both internally and externally, in transmitting demand-pull stimuli. Both the pull of demand and differences in technological opportunity, which determine the specific industries in which inventive activity is concentrated, must be taken into account for an adequate conception of how technological change occurs." (Scherer 1982: 236-7)

While Scherer found that patenting in capital goods sectors and market demand is closely correlated, the evidence for a demand-pull in the industrial materials sector was much weaker. This result may be due to the nature of materials innovations, typically being the result of pure R&D, whereas R&D into capital goods is usually applied, aimed at incremental innovations and addressing an existing market need.

In a later empirical paper Kleinknecht & Verspagen (1989) found nothing to support Schmookler's 'unidirectional' demand-pull hypothesis. Using evidence from R&D expenditure in a sample of firms in the Netherlands, they found evidence of mutual dependence between innovation and demand, supporting the notion of a more nuanced relationship.

An earlier review of the induced innovation literature by Mowery and Rosenberg (1979) argues that the empirical studies suffer from methodological and conceptual problems. They conclude, in a similar vein to Kleinknecht and Verspagen (1989), that although demand is an important factor in explaining innovation:

"…the primacy of market demand forces within the innovation process is simply not demonstrated. At a more general level, however, the weaknesses of the broad conceptual framework of the studies become clear; the uncritical appeal to market demand as the governing influence in the innovation process simply does not yield useful insights into the complexities of that process." (Mowery and Rosenberg 1979: 139)

Cidamber & Kon (1994), in their review of eight key empirical studies on innovation research also find similar results to those of Mowery & Rosenberg (1979) suggesting that the evidence for the primacy of either demand-pull or technology-push factors in influencing technological innovation is inconclusive. Similarly, Becheikh et al (2006) in a recent systematic review of the empirical literature on innovation in the manufacturing sector published between 1993 and 2003 found support for the induced innovation hypothesis, qualified by the observation that innovation seems to be the product of a wide range of different factors both internal to the firm and external, contextual factors. For example, factors internal to the firm included age, size, ownership, firm strategy, firm management, culture and structure, and past performance. External factors included location, sector, competition in the sector, suppliers, customers, level of firm concentration as well as market demand growth (Becheikh et al 2006).

A2.2.2 Empirical evidence on induced innovation and environmental technological change

The debate relating to induced innovation has important implications for policy to promote environmental technological change. In recent years, a significant and influential literature has developed specifically relating to environmental technological change and its determinants, and the efficacy, or otherwise, of different policy approaches. Again, it is not the intention to survey the literature, the objective is simply to establish the strength of evidence in support of the induced innovation account, and the environmental policy this perspective implies. [280]

The evidence broadly in support of a relatively strong version of the induced innovation account is dominated by econometric studies using large datasets to establish correlation between innovation and market demand. This literature, in line with Jaffe et al (2005), frequently distinguishes between innovation of technology and the diffusion of technology.

[280] More through reviews of the literature is available elsewhere such as in Popp et al (2009), Harrington et al (2004) , Vollebergh (2007) and Kemp and Pontoglio (2011).

Lanjouw & Mody (1996) look at patenting of environmental technologies in Germany, Japan and the USA and 14 low and middle-income countries, in response to changes in pollution abatement capital expenditures (PACE) during the 1970s and 1980s. They found environmental patents increased with increases in PACE. In their study of US industry between 1974 – 1991, Jaffe & Palmer (1997) also using PACE to proxy demand-pull incentives, and a combination of patents and R&D expenditures as indicators of innovative activity, found no connection between PACE and patenting, but found a significant relationship between PACE and R&D expenditure. Hamamoto (2006) in a study of Japanese industry between 1966 and 1976, also found a significant relationship between PACE and R&D expenditure supporting a demand-pull hypothesis.

Studies by Newell et al (1998), Popp (2002), Verdolini & Galeotti (2011) and Cheon & Urpelainen (2012) investigate the impact of changing energy prices on the rate of environmental technological change. Popp (2002) uses US patent data from 1970 - 1994 to measure the impact on innovative activity of changes in energy prices, finding that innovative activity responds rapidly to changes in energy prices. He also found that existing knowledge stocks were an important determinant of innovation, but that there were also signs of decreasing marginal returns to innovative activity within a particular field, explaining the decline overtime of patenting in response to a change in energy prices. Newell et al (1998) using US data on technology characteristics and energy prices between 1958 – 1993 found that technological change (in terms of the innovation and the diffusion of technology) was responsive to both regulation and change in price levels, but that a large proportion of technological change over time was 'autonomous,' that is it remained unexplained in their model.

More recent studies by Verdolini & Galeotti (2011) and Cheon & Urpelainen (2012) find that energy technology innovation does respond to changes in price levels but with some important caveats. In a cross country study of technology diffusion across 38 countries Verdolini & Galeotti (2011) found that demand-pull in the form of energy prices is a significant determinant of environmental technology diffusion for a selected sample of energy technologies. Both energy prices and value-added had a positive effect on innovation. Moreover, government commitment to energy efficiency and state R&D funding were also associated with higher levels of innovation. They also found that geographical distance acts to limit diffusion of technologies, the initial stock of domestic knowledge is an important determinant of technology diffusion.

Cheon & Urpelainen (2012) investigated the impact of changing energy prices on R&D expenditure and patents in the renewable energy sector. They found evidence to suggest that there is a significant technology response to a demand-pull from increased energy prices. They noted, supporting the evidence from Popp (2002), and Verdolini & Galeotti (2011) that the ability of countries to respond was dependant on existing knowledge stocks, or in this case was strongly dependent upon the existing capabilities. Elaborating on this they suggest that, "….only effective innovation systems for renewable energy can sustain a powerful political–economic response to changes in international oil prices." (Cheon & Urpelainen 2012: 407)

On the basis of their results they argue that while demand does have a significant role to play in generating innovation it also depends crucially on existing national technological capabilities. Thus their findings suggest that the notion of induced innovation is consistent with accounts of path-dependency, a position also taken by Ruttan (1997). Before going on to look at the implications of this literature, we first take a brief look at the parallel literature on environmental policy and technological change.

The large literature on environmental policy choice is reviewed in Harrington et al (2004), Vollebergh (2007), Popp et al (2009), Newell (2010), Popp (2010). These reviews generally suggest that environmental regulation has demonstrable impact on environmental technological change. Popp et al (2009), Newell (2010) and Popp (2010) generally seem to find (qualified) support for an induced innovation account, augmented with an understanding of the market failures associated with environmental pollution and technological change.[281] Concomitant with this finding, based upon empirical studies they also suggest that market-based environmental policy (as opposed to regulatory, or command-and-control policy) is the most effective in generating technological change.

While supporting the induced innovation, market-based policy account, in his wide-ranging review of environmental policy in OECD countries, Vollebergh (2007) is equivocal about the empirical evidence for the primacy given to market-based policies.

[281] For a recent study typical of the literature see Johnstone et al (2009).

He finds little evidence to support the supposed primacy of market-based environmental policies, as in practice policies are frequently tailored to fit particular conditions on the ground, with many overlapping instruments, exemptions and differing applications over different sectors, jurisdictions and time periods. Moreover, the distinction between command-and-control and market based policies is misleading as many instruments have elements of both.

On one hand, evidence for a weak induced innovation account seems relatively strong. The empirical evidence suggests that market demand of some sort is an important factor in understanding technological change. In this we would agree with Ruttan (1997), that the intuition that market demand must play a role is correct. On the other hand, the evidence for a relatively strong induced innovation account, where market demand is the primary (if not the only) cause of technological innovation is highly equivocal. Other factors are important, at least including knowledge stocks or capabilities – already identified in the literature. Kemp & Pontoglio (2011), amongst others, detect a systematic bias in the literature towards both an induced innovation account and market-based policy instruments, which is in turn closely related to the methodological approaches taken in much of the quantitative empirical work.

Criticisms have focused on the methodology and the conceptualization of the innovation process, which belies it (Mowery & Rosenberg 1979; Becheikh et al 2006). Methodologically, the use of indirect proxies for innovative activity is problematic. Patent information has been questioned as it is deemed to be a poor indicator of innovative activity for a number of reasons. First, patenting is not innovation. Patent information might illustrate in inventive response to market demand, but this does not equal innovation as not all patents result in innovation – to assume this is to revert to a simplistic linear model of the innovation process (Mowery & Rosenberg 1979; Basberg 1987). Second, not all innovations are patented; other methods to protect rents from innovation are used such as maintaining a lead over competitors, technological complexity and industrial secrets. Third, the propensity to patent differs between sectors (Becheikh et al 2006). Fourth, patenting practices and legislation differ across countries meaning that they are not all directly comparable. A number of studies also use R&D measures, but these are also unreliable as for similar reasons. That is, not all R&D

expenditures result in innovation, and the measure tends to be bias against small firms, which may not have a dedicated R&D budget (Becheikh et al 2006).

Moreover, there is a question about the interpretation of coefficients in the results of the statistical analysis. In complex systems, where contingent causation is the norm, an outcome of a process is often in response to the interaction of many causal factors. Even those that contributed 'less' to the process could nevertheless be necessary. In such a circumstance, interpreting the causal significance of coefficients is problematic, statistical correlation is not the same as causal efficacy.

An important point raised by both Mowery & Rosenburg (1979), Cidamber & Kon (1994) and in a recent review paper by Kemp & Pontoglio (2011) point to a close relationship between methodology and underlying conceptual frameworks. Setting aside, for now, concerns with the proxy variables, if the process is linear, and driven primarily by a demand-pull then what is inside the 'black-box' does not matter, the firm is reduced to an innovation production function, where "….inputs are mysteriously transformed into outputs."(Cidamber & Kon 1994: 17).

Cidamber & Kon (1994) point out that to make *any generalisation* about the innovation process, or any other process for that matter, necessarily abstracts from the particular and to a greater or lesser extent results in a 'black-box'. Inevitably the very detailed information that would allow us to trace every step in the causal chain is not always available. Case studies, for example, allow us to do just this sort of detailed causal analysis, but are only feasible in a very limited number of cases due to logistical and resource constraints, and suffer from the inability to produce useful generalizations. There is thus an inevitable tension between the general and the particular, which is hard to reconcile. On the other hand, the criticism of a 'black-box' approach, might not be the box itself, but the relative extent to which the process is hidden from us. The answer to this dilemma is probably to adopt a more eclectic approach to methodology. Both Kemp & Pontoglio (2011) and Cidamber & Kon (1994) suggest the use of mixed methods combining case studies, quantitative surveys and statistical examination of large secondary data sets is warranted in the study of innovation.

Returning to the topic of induced innovation, as a number of reviews have pointed out, when comparing the evidence for the induced innovation account to other accounts the results are ambiguous. The ways in which innovation is conceived of conceptually do not map well across the differing accounts, and a weaker version of the induced innovation account may be compatible with other accounts in the literature (Ruttan 1997). Although we have seen ample evidence in the empirical work to suggest that the innovation process is more complex than conceived of in a simple linear account and a strong induced innovation account, we can conclude at this stage with Mowey & Rosenberg, that:

> "….the role of demand has been overextended and misrepresented, with serious possible consequences for our understanding of the innovative process and of appropriate government policy alternatives to foster innovation. Both the underlying, evolving knowledge base of science and technology, as well as the structure of market demand, play central roles in innovation in an interactive fashion, and neglect of either is bound to lead to faulty conclusions and policies." (Mowery & Rosenberg 1979: 105)

From the point of view of environmental policy a rejection of the strong version of the induced innovation account means that demand-side policies are unlikely to be sufficient. However, it is difficult to come to any more determinant conclusions without a better account of the process of technological change. As we shall argue, however, the conception of technological change that is adopted has important consequences for policy.

Additionally, we have raised doubts about method, the clear co-determination of method and theory is visible – but with the former in a worryingly dominant position. The weakness of the induced innovation account, even when embellished with the accoutrements of market failure, also suggests an over reliance on the economic canon. These are both themes that will recur in this research. Dissatisfaction with the micro-economic account of the innovation process has lead most innovation theorists away from the mainstream economic canon, and forced a re-think on the micro-foundations of economic theory.

Table A2.1. Kondratiev long waves and techno-economic paradigms

Wave	Decisive innovation	Carrier Branches	Core input(s)	Infrastructure	Managem organisati
1. Water powered mechanisation of industry	Arkwright's Mill 1771	Cotton spinning Iron	Iron Cotton Coal	Canals Turnpike roads Sailing ships	Factory syste Entrepreneu Partnerships
2. Steam powered mechanisation of transport and industry	Manchester-Liverpool Railway 1830	Railways Steam engines Machine tools Alkali industry	Iron Coal	Railways Telegraph Steamships	Joint stock companies Sub-contracti craft workers
3. Electrification of industry, transport and home	Bessemer Steam process 1875 Edison's Electric power plant 1882	Electrical equipment Heavy engineering Chemicals Steel products	Steel Copper Metal alloys	Steel railways Steel ships Telephone	Specialised professional management systems Taylorism Giant firms
4. Motorisation	Ford's assembly line 1914 Burton process for cracking 1913	Cars Aircraft Internal combustion engines Oil refining	Oil Gas Synthetic materials	Radio Motorways Airports Airlines	Mass produc and consump Fordism Hierarchies
5. Computerisation of the economy	IBM computers 1960s Intel processors 1972	Computers Software Telecommunicatio ns equipment	Silicon Chips (integrated circuits)	Internet	Networks: internal, local global

Source: Feeman & Perez 2000

A3 Annexes to Chapter 3

A3.1 Technological catch-up: 'Hard-slog' or 'Leap-frog'?

Sustained aggregate productivity growth per capita is dependant upon productivity enhancing technological change (Kaldor 1967; Lipsey 2009; Lin 2011). The historical record of the late modern period illustrates numerous examples of countries that have been able to catch-up to the technological leaders though the adoption of advanced technologies (Maddison 1997). Table A3.1, based upon figures developed by the Groningen Growth and Development Centre, shows the rapid catch-up with the technological leader amongst some Western European countries and the USA during the second half of the nineteenth century and the early twentieth century.[282]

Table A3.1. Early examples of catch-up (proportion of GDP per capita of world leader)[283]

Country	1850	1880	1910
Belgium	79	88	88
France	69	61	64
Germany	61	57	73
Netherlands	102	88	82
Switzerland	64	70	94
United Kingdom	100	100	100
United States	77	92	108

Source: (Smits et al 2008)

In the post war period a number of East Asian countries have managed remarkable levels of economic growth. Japan managed rapid economic growth in the period immediately following the war until the oil crisis of the mid 1970s. Subsequently, in the 1970s and 1980s Taiwan, the Republic of Korea, Singapore and Hong Kong engineered similarly impressive growth. From 1970s to the 1990s Thailand, Malaysia and Indonesia also saw periods of rapid catch-up, this was curtailed by the Asian Financial Crisis in 1997-1999 (see e.g. Palma 2009) but by the mid-2000s these countries returned to high but somewhat moderated levels of economic growth.

[282] Of note but not included here, as mentioned in the previous chapter between the end of the civil war in 1922 and the time it joined the Second World War in 1940, the USSR has been able to increase its GDP per capita from 20 per cent of that in the USA to 31 per cent, through a process best characterised as 'forced industrialisation'.

[283] For this analysis the 'world leader' is deemed to be the UK, although by the early 20th century it had clearly been overtaken by the USA.

Table A3.2. Later instances of catch-up in East Asia (proportion GDP per capita of world leader)

Country	1960	1980	2000	2008
China	6	6	12	22
India	7	5	7	10
Indonesia*	9	10	12	14
Japan	35	72	73	73
South Korea	11	22	50	63
Thailand	10	14	22	28
Taiwan	12	28	59	67
Hong Kong	28	57	82	102
Malaysia	14	20	29	33
Singapore	20	49	79	90
Vietnam	7	4	6	10
United States	100	100	100	100

Source: (Smits et al 2008) * including Timor until 1999

Over the last decades countries which seem to be undergoing a relatively successful period of late industrialisation include China, India, Brazil, Bangladesh, Vietnam, Turkey, Egypt and Botswana. Many other countries have been unable to realise these high levels of economic growth, nevertheless, the essential message is clear, economic catch-up is possible. The descriptive statistics (Tables A3.1, A3.2 and A3.3) are fairly conclusive.

Looking in greater detail, as described originally in Lewis' two-sector model, rapid productivity growth seen in instances of sustained catch-up is a process of structural change, as labour shifts from the agricultural sector, which has typically low levels of labour productivity to the higher productivity industrial sector (and to a lesser extent service sector) (Lewis 1954; Kaldor 1967; McMillan & Rodrik 2011; Szirmai 2011). Higher productivity in the industrial sector is explained, in part, by the accumulation of capital goods allowing the application of greater levels of physical capital per worker than in the traditional sector. The process by which greater levels of capital intensity can be brought to bear by labour to achieve increased levels of productivity is crucially dependant upon the application of knowledge or technology. Whether this be embodied in capital goods, in the know-how of skilled labour, in various processes of production and trade, or in the institutions which support them. In a field where consensus is rare, there is general agreement on the broad brush-stokes of this story. Disagreements tend to turn not on the description of what are generally accepted historical facts, but on the relative importance of the different causal factors, which lie behind productivity growth and the implications these have for the process of catch-up.

More specifically, the central disagreement relates to the extent to which high productivity technologies used in countries at the technological frontier are available to latecomer countries. Gerschenkron (1962) famously argued in his analysis of catch-up, that latecomer countries could enjoy certain 'advantages of backwardness' in that they can enjoy access to advanced technologies developed in the industrial leaders, without needing to spend time and resources, or bear the considerable risks involved in developing new technologies. If the conditions are right to enable the up-take of advanced technology in developing countries, then the process of catch-up could be increasingly rapid.[284] Indeed, experiences of catch-up have led to increasingly rapid periods of economic development in latecomer countries, as illustrated in the higher levels of GDP growth in instances of late catch-up, compared to earlier examples (Table A3.3), this 'technological leapfrogging' is described by Seote:

"...the opportunities offered by the international diffusion of technology to jump particular technological paradigms and import the more if not the most, sophisticated technologies that will neither displace the capital invested nor the skilled labour of the previous technological paradigm, constitute one of the most crucial advantages of newly industrialising countries in their bid for rapid industrialisation." (Soete 1985:416)

Nevertheless, as Soete (2007) points out in a later article, Gerschenkron was also concerned with the barriers to the process of technological catch-up that might emerge for latecomer countries. For example, during the early stages of the Industrial Revolution in Great Britain, industrial technology tended to be small scale and labour intensive, as such it could be self-financed by firms. Over time economies of scale meant that technologies became much more capital intensive. By the time of Germany's catch-up, new institutions needed to be developed to enable the mobilization of resources and allow technological acquisition that could not be managed by firms alone.[285] Similar arguments have also been made relating to the process of catch-up in East Asian countries (e.g. Johnson 1982; Amsden 1992; Wade 2004). In short, Gerschenkron's insight was that initial conditions determining the ability of countries to make use of new technology are important, and that these conditions likely change over time.

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[284] See Szirmai (2011) and Pritchett (2000) for recent statistical evidence on periods of catch-up.
[285] See also Freeman (1995) for an account of German catch-up.

Table A3.3. Catch-up in selected countries since 1820

Country	Period	Growth of GDP	Growth of GDP per capita	Rate of catch -up
1820 - 1905				
USA	1820-1905	4.1	1.5	1.3
Germany	1880 - 1913	3.1	1.9	1.8
Russia	1900 - 1913	3.2	1.4	2.0
Japan	1870 - 1913	2.5	1.5	1.5
United Kingdom	1820 - 1913	2.0	1.1	
World average	1820 - 1913	1.5	0.9	
1950 - 2006				
China	1978 - 2006	8.1	6.9	3.6
West Germany	1950 - 1973	6.0	5.0	2.7
India	1994 - 2006	6.7	5.1	2.4
Indonesia	1967 - 1997	6.8	4.8	2.4
Ireland	1995 - 2006	6.2	6.2	2.8
Japan	1946 - 1973	9.3	8.0	3.6
Korea	1952 - 1997	8.2	6.3	3.0
Malaysia	1968 - 1997	7.5	5.1	2.6
Russia	1998 - 2005	7.2	7.2	3.9
Singapore	1960 - 1973	10.0	7.6	2.5
Taiwan	1962 - 1973	11.4	8.7	2.8
Thailand	1973 - 1996	7.6	5.8	3.2
Viet Nam	1992 - 2005	7.6	6.1	2.9
World average	1950 - 1973	4.9	2.9	
World average	1973 - 1997	3.1	1.4	
World Average	1997 - 2003	3.5	2.3	

Source: Szirmai (2011), based upon figures from Maddison. Note: Periods are chosen the maximise sustained high growth rates over an extended period. Rates of catch-up are assessed with reference to the technological leaders at the time, in the 1820 – 1913 period taken to be the United Kingdom, in the 1950 – 2006 period taken to be the USA.

Abramovitz (1986), in his discussion of absorptive capacity, also emphasised the importance of initial conditions in latecomer countries in determining their ability to draw on the knowledge of countries at the technological frontier.[286] Absorptive capacity could be usefully thought of as being composed of two elements, 'technological congruence' and 'social capability'. According to Abramovitz, technological congruence consists of factors such as market size and natural resource endowments, and social capability consists of the given institutional, infrastructural and technological capabilities of a latecomer, and the efforts the country is able to make in pursuing catch-up. Thus

[286] A concept which was subsequently taken up by many writers (e.g. Li 2011; and as relates to green technology Walz & Marscheider-Weidermann 2011).

Abramovtitz takes care to stress the importance of historical, institutional and technological contingencies that are likely to affect the possibility of catch-up:

> "The state of a country's capability to exploit emerging technological opportunity depends on a social history that is particular to itself and that may not be closely bound to its existing level of productivity. And there are changes in the character of technological advance that make it more congruent with the resources and institutional outfits of some countries but less congruent with those of others." (Abramovitz 1986: 406)

The debate relating to technological catch-up has turned on the relative emphasis placed upon, either i) the ability of developing countries to draw on advanced technology developed elsewhere; or, ii) the role of a country's absorptive capacity - and in particular, institutional arrangements - in determining conditions for catch-up. There is a wide spectrum of opinion in the literature, but the debate has been characterised between those accounts that present technological change and economic catch-up as a more or less automatic consequence of investment and capital accumulation. And those accounts, on the other hand, which recognise the importance of capital accumulation, but also emphasise the importance of Abramovitz's social capabilities and the development of complementary capabilities to allow the assimilation of new technologies.

In the following sections we outline the main contours of the debate surrounding accounts of economic growth and technological change, and the resulting policy implications. Our objective is not to give anything other than an instrumental account of what is an otherwise large literature. We simply seek to present the essential elements of the literature in such a way to facilitate the development of our argument.

A3.1.1 Neoclassical growth theory

The orthodox account of economic growth has its origins in the Solow-Swan model. This model is based upon constant returns to scale and an aggregate production function, which describes, for a particular capital/labour ratio the maximum possible outputs. Long-term growth rates themselves are exogenous to the model and determined by long-run rates of productivity enhancing technological change. For a given level of savings (investment) and labour technological advance allows higher levels of labour productivity and consumption (Solow 1956). Solow's 1957 paper applied this model to explain change in labour productivity in the US between 1909 and 1949. The empirical approach attempted a disaggregation of economic growth into components due to labour, capital (i.e. factor accumulation or movement along the production function) and technological change (movement of the production function itself). To the surprise of the academic community at the time, this study estimated that only around 20% of productivity growth was attributable to factor accumulation, the residual 80% according to the model was deemed to be attributable to technological change (Solow 1957). Although later authors have pointed out that the residual simply represents that element of growth that cannot be accounted for by factor accumulation, whatever it may be.

Various attempts were made to clarify what the residual represented, and with them the notion of 'total factor productivity' (TFP) and TFP growth were developed. There remains little agreement in the literature. However, a common and useful way of thinking about what TFP is likely to represent is a measure of the sum of externalities associated with technological, organisational and institutional change once all the other input endowments have been accounted for (Hulten 2001). Refinements to the model in subsequent decades have taken the form of attempts to further disaggregate the residual and express in somewhat greater detail the components of productivity growth, such as by including human capital, structural change, trade liberalization, energy price effects etc. (Mankiw et al 1992; Maddison 1997).[287] Within the contemporary growth accounting, development accounting and Cliometric literatures, TFP continues to be seen as an important means of empirically identifying the sources of economic growth (Hulten 2001; Bosworth & Collins 2003; Caselli 2005; Aghion & Howitt 2007; Crafts 2010).

The main problem facing exogenous growth theory was the lack of explanatory power of a growth model that relegated the largest portion of productivity growth to the unexplained and exogenously determined 'residual' (Srinivasan 1995).[288] Even if we accept the theoretical premises behind the growth accounting story, it is fair to say that its explanatory power is quite limited. Despite efforts to further decompose and interpret the residual it (and the process of economic growth and technological change) remains, for the most part, unexplained:

287 With these further efforts to disaggregate TFP, the empirical method moved beyond the Solow model to the extent that some critics have suggested the concept of TFP is a-theoretical (Felipe & McCombie 2007).

288 It should be noted that Solow was not denying that technological change could be part of an economic process, but it was treated as exogenous because he was not sure how it could be accounted for within a model, "It would be very odd indeed if all that activity had nothing to do with the actual achievement of technological progress. The question is whether one has any- thing useful to say about the process, in a form that can be made part of an aggregative growth model." (Solow 1994: 48)

"It is noteworthy, therefore, that despite all the effort to make the "residual" go away it still is very much with us…[…]…And despite all the effort to give substance to its interpretation as "technological advance," or "advance of knowledge," that interpretation is far from persuasive. Everybody knows that the residual accounts for a hodgepodge of factors, but these are difficult to sort out. If this "measure of our ignorance" is not completely mysterious, it certainly is not well understood." (Nelson 1981: 1035).

Felipe & McCombie (2007) make a similar point, casting doubt on the very notion of TFP. They argue that it is not useful as an explanatory concept as it emerges solely as a consequence of the growth accounting method, and is essentially just an accounting identity. Barnett (2004) also notes fundamental problems with interpreting the notion of TFP.

Leaving these criticisms aside there are three main implications of exogenous growth theory (and the associated growth accounting literature) for technological catch-up and understanding technological change. Firstly, that in a particular circumstance where economic growth is dependent upon capital accumulation alone, it is unlikely to be sustainable in the long-term due to decreasing returns to capital, technological change or TFP growth, is needed for sustainable long-term growth (Krugman 1994). On the other hand, this decomposition also suggests, to the extent that technology is embodied in capital stock, technological leapfrog is possible. Secondly, to the extent that economic growth can be attributed to the accumulation of capital stock – and in later interpretations human capital - other externalities associated with technological change are not important for developing countries. If the accumulation of capital stock is sufficient to explain the rates of economic growth that have been experienced, then all that is needed for increased productivity is investment:

"The neoclassical growth model of Robert Solow highlights the importance of technological change as the primary determinant of long-run, steady-state growth. However, by assuming that everyone has access to the same technology, the model also assigns a large role to the accumulation of physical and human capital for countries that are in a transitional or catch-up phase" (emphasis added Bosworth & Collins 2003: 124)

This implies that developing countries do not need policy interventions to allow the internalisation of the positive learning externalities associated with technological change, innovation or entrepreneurship, they simply need to be able to access the global technology stock and encourage investment (Nelson & Pack 1999). Finally, and perhaps most significantly, all other things being equal, long-term convergence in productivity between countries is predicted, as greater returns to capital are available in countries with a lower capital-labour ratio (the so called process of 'capital deepening'). Therefore, capital seeking higher returns will flow to these countries (Ruttan 2001).

Endogenous growth theory was largely as a response to some of the key failures of exogenous growth theory, which had been unable to explain either i) the absence of evidence of convergence towards steady state growth between economies predicted by the theory; or ii) persistent differences in incomes and income growth rates between countries (Romer 1994; Ruttan 1998; Easterly & Levine 2001; Kenny & Williams 2001).[289] Endogenous growth theory, as its name suggests, endeavours to account for all aspects of economic development within a single model, by incorporating those factors attributed in exogenous theory to the residual. Of particular interest to our concerns, it is a theory that attempts to account for technological change (Bardhan 1995).

The first models of endogenous growth theory by writers such as Romer (1986; 1989; 1991) and Lucas (1988) drew on micro-economic theory relating to market failures and thus sought to introduce knowledge externalities, scale effects and human capital into the modelling exercise (Fine 2000). As Ruttan (2001) points out, from a perspective to technological change, these models lead to an important result:

"….when investment takes place in an economic environment with increasing returns to scale the marginal product of capital need not, as in the neoclassical model, decline over time to the level of the discount rate. Thus, at least in the model, the incentive to enhance the quality of human and physical capital may permanently raise the long-run rate of growth in per capita income. This means it is possible for government to permanently increase the rate of economic growth, and not just the level of per capita income, by pursuing an active technology policy." (Ruttan 2001: 28)

Positive externalities to the creation of knowledge and human capital lie at the heart of endogenous growth theory. The creation of new knowledge though R&D investment or the accumulation of human capital can therefore explain persistently high productivity growth rates and the failure of economies to converge in the long-run. This also suggests a role for the institutional environment shaping the investment decisions of firms.

289 As mentioned above the endogenous growth literature is used here in a purely instrumental way to develop the argument, it is not the purpose of this section to give anything approaching an overview of the literature. Comprehensive reviews can be found in (Ruttan 1998; Temple 1999; Kenny & Williams 2001; Rogers 2003).

Intellectual property legislation, for example, can incentivize firm investment in R&D and raise the long run growth rate. As regards developing countries human capital and R&D models are not particularly relevant, neo-Schumpeterian models relating to trade and the international diffusion of technology are of much greater importance (Bardhan 1995; Kong 2007; Cesaratto 2010).

As the endogenous growth project has progressed, models have increased the range of explanatory variables beyond the initial focus on physical capital, to include - in rough chronological order - human capital, policy reform, institutional reform, 'social development' and political economy (Kenny & Williams 2001). We return specifically to the inclusion of the seemingly less tractable institutional variables in Chapter 3, section 3.2, here it is relevant to note the ever-increasing scope of the literature, which has moved considerably beyond a narrowly economic focus (Fine 2000).

As a number of authors have pointed out in many ways endogenous growth theory is best understood as an elaboration of exogenous growth theory, incorporating insights from micro-economics relating to technological change that were previously relegated to the residual and not explicitly modelled:

"As recognised by many of its practitioners, it is simply a market imperfections theory of technical change in which, in contrast to static general equilibrium or exogenous growth theory, the impact of the imperfections is felt on the rate of growth rather than upon the level of output or welfare for a given rate of growth. The last point, the transformation from level to rate of growth of output, is the only novelty. For market imperfections are now deemed to have cumulative effects over time." (Fine 2000: 250)

As such, there is a legitimate question as to how much endogenous growth theory has added to our knowledge of the process of technological catch-up and economic development, and indeed the extent to which the formalism and empirical approaches adopted by endogenous growth theory obscure important lessons obtained by other, less formal means (Bardhan 1995; Fine 2000).

The theoretical work on both exogenous and endogenous growth theory has motivated the extensive use of cross-country econometric analysis in attempts to identify the proximate causes of economic growth. Much of this empirical work has been highly influential – and controversial - in international development policy (Young 1995; Sachs

& Warner 1997; Dollar & Kraay 2002).[290] The veracity of the empirical work has been challenged by a number of authors citing problems with data and model specification problems, questions surrounding the development of proxy indicators for many of the factors that this analysis attempts to capture,[291] and above all the inability of the work to generate true predictions of growth (Levine & Renelt 1991, 1992; Solow 1994; Bardhan 1995; Srinivasan 1995; Pritchett 1997, 2000; Kenny & Williams 2001; Rodrik 2006, 2007b; Nelson 2008). To cite Kenny & Williams:

"…the econometric study of growth, different formulations, different proxies and different combinations of a wide range of factors have been subjected to many millions of tests in many thousands of papers produced using cross country growth regressions. A list of variables that have been put into modern cross country growth regressions would include well over 100 overlapping economic, policy, structural, sociological, geographical and historical factors seen to influence economic growth directly or indirectly. Yet a brief survey of surveys appears to suggest that the results of all this computation have been disappointing…"(Kenny & Williams 2001: 8)[292]

Endogenous growth theory and the associated voluminous cross-country literature has not been particularly successful at explaining the process of long-term economic growth. Reviews of the empirical literature have shown only investment and institutional variables to be robust to statistical tests (Levine & Renelt 1992; Kenny & Williams 2001), even Gregory Mankiw, a doyen of neo-classical economics has shown scepticism about the empirical work:

"Using these regressions to decide how to foster growth is also most likely a hopeless task. Simultaneity, multi-collinearity, and limited degrees of freedom are important practical problems for anyone trying to draw inferences from international data. Policymakers who want to promote growth would not go far wrong ignoring most of the vast literature reporting growth regressions. Basic theory, shrewd observation, and common sense are surely more reliable guides for policy." (Mankiw et al 1995: 307-8)

There is a growing consensus that this lack of success is due to deep-seated theoretical and associated methodological problems with the neo-classical growth research.

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[290] For further commentary on this see Rodrik (2006).

[291] Solow seems to agree with these comments on the empirical literature, "I do not find this a confidence-inspiring project. It seems altogether too vulnerable to bias from omitted variables, to reverse causation, and above all to the recurrent suspicion that the experiences of various national economies are not to be explained as if they represent different 'points' on some well-defined surface." (Solow 1994:51)

[292] In recent years, the recognition that institutions are important for economic growth and development – greatly influenced by the work of Douglas North – have lead to the incorporation of a institutional indicators in the empirical work (Acemoglu et al 2000; Rodrik et al 2002; Evans 2006). We return to the issue of the 'institutional turn' in development economics in section 3.2 Chapter 3.

The main criticisms relate to i) the assumption of an aggregate global production function; and, related to this ii) the commitment to an epistemic 'universalism'. Firstly, the assumption that the capital stock of an economy can be usefully represented in an aggregate production function has been challenged. Opponents have suggested that such an assumption represents an example of the 'fallacy of composition', in that differentiated capital stock cannot be represented as an aggregate of homogenous units of capital. This was the subject to a long running debate, which while never reaching a satisfactory conclusion and rather inexplicably, has not been seriously addressed in the economic canon (Cohen & Harcourt 2003; Temple 2006; Felipe & McCombie 2010).[293] A related point of criticism is the belief that the stock of available technology can be characterised through the supposition of a *global* production function (Kenny & Williams 2001). The assumption is that all other things being equal these stocks of technology are equally available to all countries.

Secondly, and of greater significance to our argument here, is the implicit commitment to epistemological universalism inherent in both neo-classical growth theory and the empirical literature it has generated. That is to say, the assumption that the same factors of production enter into economic growth in the same way across the whole population of countries (Fine 2000; Fforde 2005; Rodrik 2007b; Fforde 2011).[294]

This commitment to a universally applicable model of economic growth has allowed the generation of a large literature. The attraction is that from a number of stylized facts, tractable within the economic canon a series of plausible models can be generated. Empirical work was also able to progress though the ability to include more and more cross-country data. Although, as noted by Nelson (2008), and Felipe & McCombie (2007) amongst others, the empirical work using cross-country data and growth accounting methodologies has moved a considerable way beyond the limits of formal theory. As indicated above, the limited findings of the empirical work allow the identification of some key variables but are plagued by problems of endogeneity, in short it is not clear that in a complex open system this method is able to reliably identify causal

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293 The notion is that factors of production are complements not substitutes, it is therefore not clear how we can think of attributing 'shares' of productivity to factor endowments if a combination of them is necessary for production. The failure of neo-classical account to take this damaging criticism on board, leads one to query clams to methodological rigor.

294 This, of course, is also related to the assumption of the aggregate production function. If we conceive of the world as constructed of undifferentiated, substitutable aggregates, then the very lack of differentiation and structure suggests common ways in which these aggregates interact, that is a common production function.

patterns. What is more, the failure of the empirical work to arrive at universal characterizations of the process of economic growth itself, as we have argued, should be some indication that the theorizing has gone wrong somewhere.[295] Here it is suffice to note that in parallel with the concerns expressed relating to the neo-classical micro-foundations of technological change observed in Annex A2, in neo-classical growth theory, the commitment to abstract, universal models, and the absence of historical contingency and uncertainty seems somewhat problematic.

Despite the concerns relating to neo-classical growth theory, this naïve universalism has been influential in development policy debates (Rodrik 2006; Rodrik 2010b). Playing an important role in the debate on specific growth policies. As we noted earlier, exogenous growth theory leaves little room for policy interventions as convergence and technology leapfrogging are more or less automatic, so long as savings are adequate and population growth low enough. Endogenous growth theory, on the other hand opens up the possibility for greater state intervention to correct market failures, many of which relate to technology adoption. Nevertheless, intervention is only justified to the extent that market failures exist, as the 'melorative' trend in the operation of economies will otherwise ensure optimal outcomes.

Kong (2007) identifies this shift in the emphasis of economists from the notion of accumulation of physical capital, human capital and the knowledge used in production as the proximate causes of economic growth, to a focus on incentives, which are seen as more fundamental. A focus on incentives is a critical step, if we need to ask about people's incentives, we can no longer model economic agents independent of the context in which they find themselves. Even if we accept an individual rationality postulate, actions will only be rational with respect to the incentive structure agents face, this is no longer a *given* but determined by idiosyncratic institutional and political arrangements that frame their actions (Adam & Dercon 2009). Incentives are dependent upon context and structure becomes important. This points towards a need to understand how institutions create incentives for actions with economic (and technological) implications. And - from a perspective of long-term economic growth and development – how particular institutional forms develop. It is not clear how this can be incorporated into some

[295] Of course, the problem is that economics is not the science it thinks it is, it is not falsifiable as it is protected by the *ceteris paribus* clause. In fact, it is a little bemusing that Friedman's appeal to Popperian epistemological tenants, took on what it needed (i.e. instrumentalism) but has not really embraced the second essential part of this theory, falsificationism.

generalizable growth model. Indeed, North (2005) echoing comments by Nelson and Arthur (Chapter 2) contends that neo-classical theory is unsuited to these tasks:

"The economic paradigm – neo-classical theory – *was not created to explain the process of economic change*. We live in an uncertain and ever changing world that is continually evolving in new and novel ways. Standard theories are of little help in this context. Attempting to understand economic, political, and social change (and one cannot grasp change in only one without the others) requires a fundamental recasting of the way we think. Can we develop a dynamic theory of change comparable in elegance to general equilibrium theory? The answer is probably not. But if we can achieve an understanding of the underlying process of change then we can develop somewhat more limited hypotheses about change that can enormously improve the usefulness of social science theory in confronting human problems." [emphasis added] (North 2005: vii)

We look at the 'institutional turn' in development economics in section 3.3 in greater detail with a view to developing an analytical framework for a positive institutional and political economy analysis. In the following section we look at alternative approaches to conceptualizing the process of economic growth and technological change, which are in accord with the evolutionary micro-foundations expounded in Chapter 2.

A3.1.2 A heterodox approach to development: National Innovation Systems

Broadly neo-classical accounts of economic growth and technological change (or the lack-of it), turn on market failures in a particular economic system. This is essentially a scaled-up, macro-level account of the induced innovation accounts we addressed in the previous chapter. The notion of market failures that the orthodox account ends up relying on so heavily, turns out not to be a particularly good explanation. The 'market failures' emerge only relative to some theoretical optimum, which not only does not exist, but with the existence of *systematic* failures, *cannot* exist. Meaning there is actually no theoretical optimum against which market failures can be identified (Nelson 2008). Developing this idea, in his influential analysis of latecomer catch-up in the East Asian Newly Industrializing Countries (NICs), Lall writes:

"It is misleading to think of market failure as something that can, or should, be remedied in order that the economy can be brought back to a desired (static) optimum. In developing countries, where technological learning is essential to industrial development, externalities are rife, and markets highly imperfect – indeed, when new markets, agents or endowments are being created – it is difficult to describe policy as remedying market failure in the neo-classical sense. Where economies of scale exist in intermediate products, leading to multiple equilibria, government policy should aim to move from low to high productivity/technology paths." (Lall 2000: 23)

Lall's account rests upon the observation that markets are not able to generate the knowledge 'externalities' that are necessary for technological catch-up. A whole other set of institutional arrangements is necessary, and the state has an important role to play in the provision of these institutions. The set of these institutional arrangements and the state's capability to realize them fall largely under what Abramovitz (1986) described as social capability, or in Lall's account, 'National technological capability':

"National technological capability is the complex of skills, experience, and effort that enables a country's enterprises to efficiently buy, use, adapt, improve, and create technologies." (Lall 2000: 14)

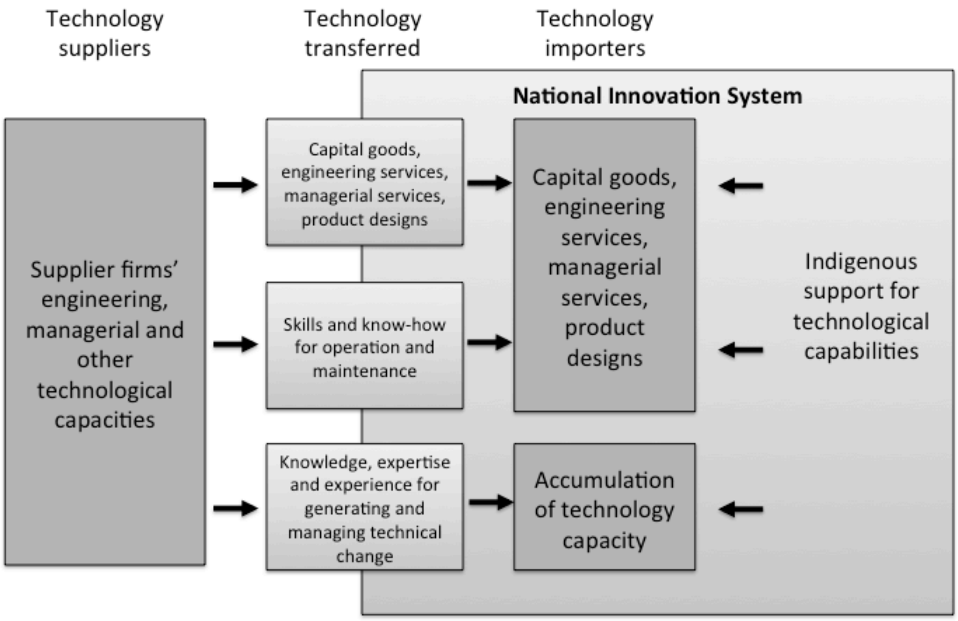
In common with Abramovitz (1986), Lall (2000) maintains that, even in an era of international flows of technology and capital critical to technological catch-up, national capabilities are critical in determining the extent to which countries are able to utilize these resources. National differences in the availability of these non-transferable, institutional assets are important, national boundaries delineate the boundaries of a common set of institutions which determine incentives, factor markets, attitudes and business systems, which condition and enable learning at the level of the firm.

This account has a lot in common with the work on National Innovation Systems (NIS) developed by writers such as Nelson (1993), Dosi (1988c), Lundvall (1992) and Freeman (2002). The NIS account draws on the characterisation of technological change central to evolutionary theory to analyse the process of technological catch-up in developing countries. Although some technological knowledge is codifiable in operations manuals and blueprints, or embodied in capital stock, a large portion is not, and the gradual accumulation of tacit knowledge generated by actually learning to use and adapt technologies is often essential (Dosi 1988; Freeman 1995). A large portion of the knowledge associated with the assimilation and effective use of new technologies is related to the organisation of the production processes themselves, indeed processes by which knowledge itself is acquired (Lall 2000; Teece 2000; Lipsey 2009)(Figure A3.1).[296] The notion of capabilities also extends outside the firm to the web of non-market inter-

[296] As Lall (2000) puts it 'learning itself has to be learned.'

firm networks, methods of doing business and other institutions, including consumer markets and state institutions (Lall 2000; Soete 2007; Cimoli et al 2009).

Figure A3.1: Technology transfer in National Innovation Systems



Source: Adapted from Bell 1990; Watson et al 2011

In contrast to the picture suggested by the 'leapfrog' characterisation of technological change where technological advance is largely a result of capital accumulation, from the NIS perspective, technological catch-up is neither cost nor risk free, but is time consuming, uncertain and costly. The description given by Kim (1997) of the efforts expended by Hyundai in developing car manufacture offers a powerful illustration of the processes involved in technological learning:

"Despite the training and consulting services of experts, Hyundai engineers repeated trials and errors for fourteen months before creating the first prototype. But the engine block broke into pieces at its first test. New prototype engines appeared almost every week, only to break in testing. No one on the team could figure out why the prototypes kept breaking down, casting serious doubts even among Hyundai management, on its capability to develop a competitive engine. The team had to scrap eleven more broken prototypes before one survived the test. There were 2,888 engine design changes ... Ninety-seven test engines were made before Hyundai refined its natural aspiration and turbocharger engines.... In addition, more than 200 transmissions and 150 test vehicles were created before Hyundai perfected them in 1992." (Kim 1997: 122 cited in Nelson and Pack 1999)

Four points salient to our argument emerge out of the NIS account. Firstly, a rejection of the notion that countries can costlessly access new technologies and the production arrangements these imply. Technological upgrading, to paraphrase Hobday (1995), is cumulative and painstaking, better characterised as a 'hard-slog' rather than 'leapfrog.' In this context, competiveness and comparative advantage are created rather than discovered. Secondly, institutional arrangements matter. These include both market and non-market institutions. Thirdly, the nation state is important in enabling the development of advanced technological capabilities (Cimoli et al 2009; Yoon & Hyun 2009). Finally, given the importance of state intervention to enable technological catch-up, the capability of the state itself to intervene effectively in this way is also of fundamental importance. This is not just a matter of the technical ability to govern effectively, but it is dependant upon the state having the *political power* to effectively intervene to enable technological change (Chang 1996; Evans 1998; Khan & Blankenburg 2009; Robinson 2011). This final point is extremely important, and one to which is addressed in section 3.3.

An extensive empirical evidence supporting this account is found in studies of the structure of innovation systems in a number of industrial sectors in a few OECD countries in the 1970s and 1980s, and in evolutionary approaches to economics described in the previous chapter (e.g. Nelson & Winter 1982; Dosi 1988; Lundvall 1992; Nelson 1993; Lundvall et al 2002; Balzat 2004). It is closely related to the large body of empirical case studies conducted of catch-up industrialization, particularly in the East Asian NICs (e.g. Johnson 1982; Amsden 1992; Chang 1993; Wade 2004). It has also proved useful in developing historical case studies of technological catch-up (e.g. Freeman 1995). In some cases it has also proven a useful analytic for describing relative weakness in processes of catch-up (e.g. Intarakumnerd et al 2002). Recent studies on sectoral innovation systems (Marerba & Nelson 2010) and innovation systems, and MNE development (Cantwell et al 2010) also serve to stress the importance of national institutional arrangements in international technology transfer. As does a recent review of the evidence on technological upgrading the latecomers by Fu et al (2011), they find that the proactive development of domestic technological capabilities is an essential part of the process of technological catch-up:

"The evidence suggests that, despite the potential offered by globalization and a liberal trade regime, the benefits of international technology diffusion can only be delivered with parallel indigenous innovation efforts and the presence of modern institutional and governance structures and a conducive innovation system…[…]…Without proactive indigenous innovation efforts, foreign technology remains only static technology embedded in imported machines which will never turn into real indigenous technological capability." (Fu et al 2011: 1210)[297]

As we have pointed out this literature has an important implication for the role of government in economic catch-up. Specifically in the development institutional arrangements that can act to foster economic growth (Yoon & Hyun 2009).

A3.1.3 What does all this tell us about technological catch-up?

Returning to the considerations mentioned at the start of this section relating to understanding the process of technological catch-up, and the extent to which it is best characterised as a process of 'leapfrog,' or as in Hobday's (1995) characterisation as a 'hard-slog'. Experiences of increasingly rapid technological catch-up point to a realisation of the Gerschenkronian 'advantages of backwardness', which may suggest that the process is simply one of factor accumulation and of moving along a global production function (Szirmai 2011). But such an account would be silent on the causal processes by which this happens, or why in many cases this fails to happen, the process itself would remain something of a black-box.

In exogenous growth theory and the empirical growth accounting work that it inspired, the black-box lays in a, more or less, undifferentiated and nebulous residual. The achievement of endogenous growth theory, lies in not so much opening the box to gain an understanding of the *actual* causal processes by which factor accumulation and growth occurs, as in replacing it, with the generation of a multitude of models that, given particular market failures, allow a demonstration of how factor accumulation and economic growth could occur within a neo-classical mathematical model. Either way, as with our discussion of induced innovation (Chapter 2), we are left with not so much an explanation, but with a series of aggregate inputs mediated by fictitious market-based allocation, and the unexplained emergence of a series of aggregate outputs.

What emerges from the empirical work conducted within the broadly neo-classical growth tradition is that determinate causal processes have been very difficult to pin down using growth accounting, cross-country accounting or cross-country regression analysis. As we have argued, more fundamental issues belie familiar problems related to the use of

[297] This mirrors findings from Verdolini and Galeotti 2011, cited in Chapter 2, which suggests that countries are only able to respond to changes in energy prices if they possess the domestic institutional apparatus to allow them to do so.

proxy indicators, data quality, endogeneity and model specification. In line with the arguments we presented in Chapter 2 and Annex A2, we contend that the contingent causation, feedbacks and path-dependency that characterise the process of economic growth and technological catch-up are likely to preclude the discovery of non-trivial universally valid generalisations.

The alternative account suggests that the process of factor accumulation, and technological catch-up is difficult to achieve and impossible to understand from any perspective that seeks to obscure the uncertain, contingent and path-dependant nature of economic change. If technological catch-up is difficult to achieve, and is not an automatic economic response to factor accumulation, then it becomes important to understand how this process has been realised. NIS accounts, in contrast to neo-classical theory, present a perspective that traces the means by which nation states effected factor accumulation and developed absorptive capabilities. They present a cogent picture in which the activity of the public and private sectors working together within a national institutional context were able to create conditions for rapid economic growth and catch-up. Importantly for our argument, they present a picture where *non- market institutions and the state* play a central role in creating the conditions for economic growth.

What emerges out of the consideration of both the cross-country empirical literature and the NIS country case studies is that the role of domestic institutions is critical in the process of technological catch-up. Once the assumption of perfectly functioning markets is relaxed, there is nothing in their functioning that can guarantee an optimal outcome. This constitutes a *prima facie* argument for extra-market interventions. Whether or not interventions are justified in order to promote catch-up *in fact* depends upon the ability of the state to intervene effectively. The question of whether the state is able to intervene effectively is a question relating to its institutional, and crucially its political capabilities. This leaves us in a position, along with an increasing number of influential writers, from both neo-classical and heterodox economic traditions, where the political economy is deemed the crucial variable in determining the success or otherwise of national development policy and by implication of the process of technological change (Acemoglu et al 2005; Khan & Blankenburg 2009; Khan 2010; Levy & Fukuyama 2010; Robinson 2011):

> "To promote industrialization in a society, we need a positive theory of policy. I use the term "political equilibrium" to refer to the concatenation of political forces that determines this policy outcome. It is the political equilibrium of a society that leads to particular policy choices. To give policy advice that would foster industry, one has to understand this political equilibrium and either attempt to change it or work within the environment it generates." (Robinson 2011: 134)

Thus our investigation of the process of technological catch-up is leads us towards the same conclusions we reached in Chapter 2, that the political economy is likely to be crucial to an understanding of the process of technological change, and therefore the process of environmental technological change.

A4 Annexes to Chapter 4

Table A4.1. Foreign ownership of electric utilities for selected countries: percent of a country's capacity, output or assets of electric utilities owned and controlled by foreign firms 1913 - 1972

	1913-1914	1928-1932	1947-1950	1970-1972
Europe				
Austria	60-90	20	0	0
Belgium	10	10	0	0
Denmark	0	0	0	0
Finland	22	9	0	0
France	15-25	10-15	0	0
Germany	10	<10	0	0
Great Britain	1-2	5-10	0	0
Italy	30	0	0	0
Netherlands	0	0	0	0
Norway	5	2	0	0
Poland	<45	74	0	0
Russia/USSR	90	0	0	0
Spain	29/33	27	0	0
Switzerland	10	0	0	0
Australasia				
Australia	15	4	0	0
New Zealand	18	0	0	0
Africa				
Egypt	90+	90+	90+	0
Ethiopia	x	100	80 - 100	0
Kenya	100	100	100	0
Nigeria	0	10	10	10
South Africa	78	65	0	0
Asia				
China	<10	51/62/65	0	0
Hong Kong	17	0	0	58
India	80	31	0	0
Indonesia	100	100	0	0
Japan	0	0	0	0
Korea	100	100	0	0
Malaysia	0	46	46	13-20
Philippines	100	97	70	0
Taiwan	100	100	0	0
Thailand	50	50	0	0
Latin America				
Argentina	85 - 95	90+	70 - 80	9
Brazil	67 - 82	67/80	67/82	34
Chile	95	88	80	0
Colombia	0	10	5	0
Mexico	90	90	60	0
Venezuela	1515	15	15	<10
North America				
Canada	13	34	24	5
United States	<1	0	0	0
Middle East				
Israel (Palestine)	x	100	0	0
Turkey	80	20	0	0

Source: Hausman et al 2008: 31 – 33. Note: 'x' is indicative of negligible electrification; - indicates no value given. Where more than one figure given as in the case of China 1928 – 1932 (i.e. 51/62/65) these indicate different indicators, in this case capacity, output and investment.

Table A4.2. Developing countries by ESI structure in 2006

Structure	Countries
Vertically integrated monopolist (79 countries, 53% of sample)	Angola, Antigua and Barbuda, Azerbaijan, Barbados, Belarus, Benin, Bhutan, Botswana, Burundi, Cape Verde, Central African Republic, Chad, Comoros, the Democratic Republic of Congo, the Republic of Congo, Djibouti, Dominica, Equatorial Guinea, Eritrea, Ethiopia, Fiji, Gabon, the Gambia, Grenada, Guinea, Guinea-Bissau, Guyana, Haiti, Islamic Republic of Iran, Iraq, Kiribati, Democratic People's Republic of Korea, the Kyrgyz Republic, Lebanon, Lesotho, Liberia, Libya, Madagascar, Malawi, Maldives, Mali, Marshall Islands, Mauritania, Micronesia Fed. Sts., Mongolia, Mozambique, Myanmar, Namibia, Nicaragua, Niger, Paraguay, Rwanda, Samoa, São Tomé and Principe, Saudi Arabia, Seychelles, Sierra Leone, Solomon Islands, Somalia, South Africa, St. Kitts and Nevis, St. Lucia, St. Vincent and Grenada, Sudan, Suriname, Swaziland, Syrian Arab Republic, Tajikistan, Timor-Leste, Togo, Tonga, Turkmenistan, Uruguay, Uzbekistan, Vanuatu, Venezuela, the Republic of Yemen, Zambia, Zimbabwe
Vertically integrated monopolist + IPPs (36 countries, 24% of sample)	Bangladesh, Belize, Burkina Faso, Cambodia, Cameroon, China (most provinces), Costa Rica, Côte d'Ivoire, Croatia, Cuba, the Czech Republic, the Dominican Republic, the Arab Republic of Egypt, Ghana, Honduras, India (most states), Indonesia, Jamaica, Lao People's Democratic Republic, Malaysia, Mauritius, Mexico, Morocco, Nepal, Nigeria, Oman, Pakistan, Papua New Guinea, Senegal, Sri Lanka, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Vietnam, West Bank and Gaza
Single buyer as a national genco, transco or disco, or a combined national genco-transco or transco-disco+ IPPs (16 countries, 11% of sample)	Albania, Algeria, Armenia, Bosnia and Herzegovina, Estonia, Georgia, India (Andhra Pradesh, Karnataka, New Delhi, Orissa, Rajasthan, Uttar Pradesh), Jordan, Kenya, Latvia, Lithuania, the former Yugoslav Republic of Macedonia, the Philippines, Serbia and Montenegro, the Slovak Republic, Uganda
Many discos and gencos, including IPPs, transco as single buyer with third party access (6 countries, 4% of sample)	Bulgaria, Ecuador, Hungary, Moldova, Poland, Russian Federation
Power market of gencos, discos and large users, transco and ISO (13 countries, 9% of sample)	Argentina, Bolivia, Brazil, Chile, Colombia, El Salvador, Guatemala, Kazakhstan, Panama, Peru, Romania, Turkey, Ukraine

Note: Sample of 150 developing countries. genco – generation company; transco – transmission company; disco – distribution company; IPP – independent power provider.
Source: Besant-Jones 2006: 22

Table A4.3. ESI corporations in the top 100 TNCs by foreign assets 1997, 2003 and 2011

Top 100 TNC Rank	Corporation (main activity)	Home country	Assets: Foreign (billion US$)	Assets: Total (billion US$)	Proportion of foreign assets (%)
		1997			
1	General Electric Co (e)	USA	97.4	304.0	32
14	ABB Ltd. (e)	Switzerland	-	29.8	-
19	Siemens AG (e)	Germany	25.6	67.1	38
26	Alcatel Alsthom Cie (e)	France	20.3	31.8	64
		2003			
1	General Electric Co (e)	USA	258.9	647.5	40
11	GDF Suez (u)	France	74.1	88.3	84
12	EDF SA (u)	France	67.1	185.5	36
13	E.ON AG (u)	Germany	64.0	141.5	45
15	RWE AG (u)	Germany	60.3	98.6	61
17	Siemens AG (e)	Germany	58.5	98.0	60
53	Endesa (u)	Spain	25.5	58.2	44
77	Duke Energy (u)	USA	15.4	56.2	27
87	Scottish Power (u)	UK	13.0	24.7	53
		2011			
1	General Electric Co (e)	USA	502.6	717.2	70
7	GDF Suez (u)	France	194.4	296.6	66
9	Enel SpA (u)	Italy	153.7	236.0	65
12	E.ON AG (u)	Germany	133.0	212.5	63
17	Siemens AG (e)	Germany	112.4	141.8	79
23	EDF SA (u)	France	95.0	322.1	29
25	Iberdrola SA (u)	Spain	88.0	134.7	65
41	RWE AG (u)	Germany	66.4	128.8	52
54	Veolia Environment SA (u)	France	52.7	70.1	75
56	BG Group PLC(u)	UK	52.6	61.4	86
58	Vattenfall AB (u)	Sweden	51.9	78.2	66
64	Schneider Electric SA (u)	France	45.6	49.9	91
92	ABB Ltd. (e)	Switzerland	32.1	39.6	81
93	National Grid PLC (u)	UK	31.8	63.1	50
98	Alstom S.A. (e)	France	30.7	41.4	74
99	AES Corporation (u)	USA	30.4	45.3	67

Source: UNCTAD World Investment Report 2012, 2005, 2000

Note: main activity has been designated e – engineering services and electrical equipment; and, u – utilities. Although most of these companies tend to be involved in both. Other large companies that have significant involvement in electricity generation include the large oil companies that have interests in natural gas exploitation and electricity generation projects (such as Exxon, BP, Royal Dutch Shell and Cheveron), a number of Japanese conglomerates are also active in both the supply of equipment and plant to the ESI and investment in utilities, these have not been included as their main activities outside the ESI predominate.

A4.1 Emerging political imperatives, emerging energy imperatives?

It is beyond the scope of this research to go into detail about the future direction of the ESI. Nevertheless, in completing this review of the interactions between the political economy and the development of the ESI it is worthwhile considering current pressures facing the ESI, and how they might effect the techno-economic paradigm and broader institutional and political economy considerations. As we have noted, the wave of liberalisation reforms that were implemented in the sector from the 1990s have not resulted in the emergence of a stable set of institutional arrangements. Indeed, Thomas (2006) argues that very little is actually left of the substance of market reforms even in the economies that lead it. In the industrialised world, tightly regulated oligopolistic ESIs have emerged with few firms, and limited competition:

> "….mergers and alliances between European utilities have been accelerated. As a consequence it is expected that strong business concentrations will emerge in the electricity sector and may even lead to the creation of private monopolies." (Meyer 2003: 676)

Perhaps the most significant change has been with the way the system is run. In the past considerations of reliability and IRS dominated an engineering oriented approach, but reforms served to place cost and financial management considerations to the fore. Or as Verbong & Geels (2010) put it, the ESI has moved from an institutional system dominated by engineers to a "market based system ruled by managers"(1215). This is a point echoed by Kessides (2005) who acknowledges the shortcomings of ESI reforms but suggests that reforms have served to put considerations of financial sustainability and cost at the heart of electricity provision.

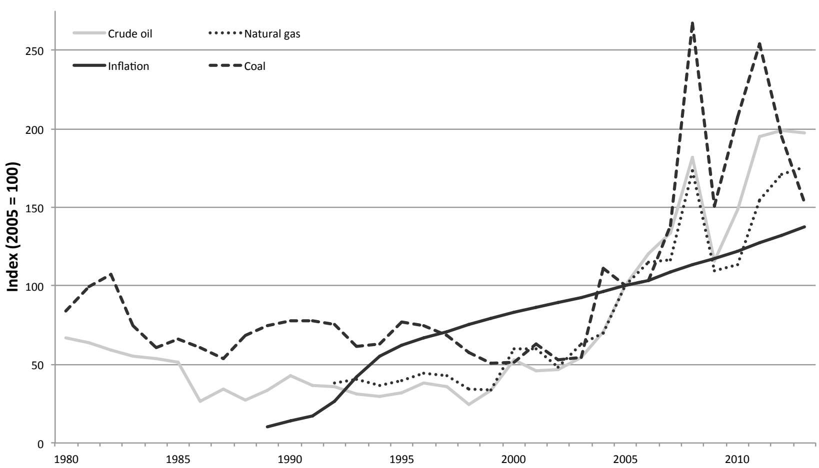
In developing countries, as we have seen, in most cases the reforms relative to the 'standard model' have been limited. Where reforms have taken place they have answered the voracious appetite for capital that characterises the ESI. But here too the emergence of large utilities companies, whether state owned or private is a common feature as a number of writers have noted (Williams & Ghanadan 2006; Victor & Heller 2007; Hausman et al 2008). These systems are dominated by the need to increase supply, and the costs of which tend to dominate investment decisions. In developing countries, the weakness of regulatory institutions and the central role the state maintains in ESIs means that frequently they remain dominated by the need to allocate resources to strategically important sectors and groups.

In many ways, the pressures facing the ESI have not changed much since the beginning post war period. Concerns about energy security and price, in developing countries ensuring universal access, and above all the need for capital investment dominate sector considerations. If anything, these concerns are now more acute than they were 60 years ago. In addition, there is the overriding concern relating to the long-term environmental impacts of the ESI, and in particular climate change. These in turn point to a range of other issues within the ESI, securing a reliable fuel supply, keeping tariffs at manageable levels, technology choice, and securing adequate investment in the sector.

Firstly, security of energy supply has been a concern in Western Europe since the 1950s, and globally since the 1970s (e.g. see Deese 1979). Since the 1970s, Asian, European and many developing countries have become increasingly reliant upon energy imports (Toichi 2003; Correljé, & van der Linde 2006; ASIF, & MUNEER 2007; Gnansounou 2008). The world is still relies heavily upon fossil fuel resources concentrated in what are regarded as potentially politically volatile regions, such as Russia and the Persian Gulf, fuel transit through pipelines and shipping lanes also have to pass through potentially volatile regions such as central Asia and the trans-Caucasus region (Yergin 2006). It is currently unclear what the implications of the development of shale gas will have for energy security in the long to medium term. Ensuring energy supply remains a key strategic and political issue, and one that bears on technology choice in the ESI.

Secondly, closely related to this is the issue of energy price, a key cost of fossil fuel thermal electricity generation is the cost of the fuel itself. Recent years have seen increasingly volatile prices for fossil fuels. The rapid increase in demand from China, India and other emerging economies has been an important factor in driving these price-rises. This has been characterised not only by fuel price increases well above the rate of inflation, but also increased volatility in fuel prices (Figure A4.1). Price volatility can be hedged through long term contracts and futures markets, although this does little to mitigate longer-term cost increases. In countries with domestic fuel reserves it may be the case that, at the opportunity cost of foregoing higher export prices, fuels can be made available to the ESIs at subsidised prices. Price controls on electricity tariffs are also frequently used to supress electricity prices, putting government finances and the solvency of electricity generators under pressure (IEA et al 2011; Commander 2012; IEA 2012b; IMF 2013). In general, industrialized countries where electricity costs tend to represent a smaller proportion of consumption expenditure it has been easier for governments to pass these costs on to consumers than in developing countries (Commander 2012).

Figure A4.1. Global energy and consumer price indices 1980 - 2013



Source: IMF 2013

Thirdly, the need for capital in the ESI remains extremely large. Globally, given current policy commitments between 2012 and 2035 the IEA estimates that the sector will need over US$ 16.8 trillion in investment, or around US$ 766 billion a year. Of this around US$ 10 trillion is needed in rapidly growing non-OECD countries (IEA 2012d). Based upon Krishnaswamy's (2007) estimates, that optimistically ESIs in non-OECD countries are able to meet 30% of these costs through self-financed investment, 12% through private sector and 5% through IFI funding, this still leaves a funding gap of around US$ 5.5 trillion. While these figures may prove to be off the mark, they make the point that capital needs in the sector are likely to be extremely large. They also point to the continuing political importance of this pressure.

Finally, considerations of climate change. The detail of this is covered elsewhere here we should note its importance in guiding policy decisions related to the ESI. Unlike considerations of energy security, price or ESI investment needs, the avoidance of climate change itself does not necessarily lead to a good in the short-term, indeed acting to mitigate climate change is likely to be costly in the short term. Many authors take the political commitment to climate change in ESI policy making for granted (e.g. see Geels 2011; Negro et al 2012), but because of the short-term costs involved it would pay to be sceptical about ostensive political commitments. It is beyond the scope of this research to investigate the question of commitment further, it is enough to note that in some countries at least, and for whatever reason, the commitment seems serious and has resulted in significant investment in climate mitigation technologies.[298]

These four broad considerations are of differing importance in different countries depending upon their level of development, economic structure, growth of demand, institutional arrangements, resource endowment and disposition of political power amongst other things. But almost everywhere they are influential to a greater or lesser extent in guiding policy in the ESI. Although these are portrayed as separate issues there are important linkages between all four. As a number of authors have pointed out there are significant relationships between energy security and energy price and climate change mitigation in the ESI (e.g. Asif & Muneer 2007; Bazilian et al 2011). Renewables energy technologies tend to use indigenous energy resources (wind, sunshine, waves, falling water), thus mitigating energy security concerns somewhat for import dependant countries. On the other hand, countries with large indigenous fossil fuel reserves such as South Africa, India and China, climate considerations trade-off energy security and price considerations (Bazilian et al 2011). As relates to costs, climate change mitigation is likely to increase costs in the short to medium term at least. With the exception of hydropower, most renewables technologies tend to be more expensive than fossil fuel alternatives even with recent fossil fuel price increases. What is more, climate mitigation technologies imply proportionately greater up-front capital costs than fossil fuel technologies and higher technology and policy risk potentially compounding financing issues (PB Power 2004; Murray 2009; Hayward et al 2011; Joskow 2011; BREE 2012; REN21 2012; Schmidt et al 2012; NREL & DOE 2013).

If all these challenges are to be met, it is likely to imply significant changes to the technological and economic characteristics of the sector, which will in turn imply institutional change. Some technological changes may not be particularly disruptive of the ESI, such as moderate expansion of renewables and distributed generation (such as

[298] For an index measuring climate change policy commitments see Steves et al (2011).

CHP), nuclear, end-of-pipe technologies such as CCS and the greater pursuit of demand side management. All of which could reasonably be achieved within the dominant system design (Unruh & Carrillo-Hermosilla 2006). More significant changes such as the much higher penetration of renewables technologies, the development of micro-grids and increased reliance on distributed generation, the wide scale introduction of smart grid technologies and the development of trans-national grids for the international transport of renewables resources (Abusharkh et al 2006; Hofman & Elzen 2010; Verbong & Geels 2010; Schleicher-Tappeser 2012).

Characteristics of renewable technologies including high capital costs relative to operational costs, small-scale modular nature of the some renewables technologies (PV cells in particular) technology and the intermittent availability may imply significant change to the structure of the ESI. In particular, the intermittency of electricity production from many renewables sources (wind, solar, ocean and wave) means that electricity generation is unpredictable and adequate back-up supply needs to be operated to ensure the reliability of the grid. For small amounts of renewables this back-up need can be met through existing reserve margins using conventional technologies (although not without additional operational costs for these generators). For higher levels of variable renewables penetration additional measures are likely to be needed. Suggestions have included, i) additional installation of conventional back-up capacity;[299] ii) the interconnection of geographically dispersed renewables energy resources, acting to smooth renewables intermittency; iii) reactive demand side management and smart metering; and, iv) transmission scale electricity storage, amongst mother things (Hofman & Elzen 2010; Verbong & Geels 2010; Kubik et al 2012; House of Lords 2012).

Recent papers by Hofman & Elzen (2010), Verbong & Geels (2010) and Schleicher-Tappeser (2012) investigate the possibilities for different types of ESI structure that may emerge in response to these technological changes. They suggest two fundamentally different sectoral structures that could emerge, i) a continuation of large-scale grid structures linking geographically dispersed utility-scale renewables sources (possibly across international boundaries as with the European super-grid (Higgins 2008)) and

[299] Where available hydropower would be favored as it can rapidly alter generation output, CCGTs may also provide relatively quick response.

increased nuclear power generation with HVDC transmission lines;[300] ii) a move towards wide scale distributed generation, with either independent or national grid connected micro-grids. This would incorporate smaller scale renewables, CHP and smart grid technologies, and imply a significant change to the grid structure. At the current time, while distributed generation technologies have made significant inroads, through CHP, and renewables technologies in a range of different technological niches, it remains unclear how these changes are likely to unfold (Künneke et al 2010).

Whatever the eventual structure of the ESI, it will have significant implications for the institutional organisation of the ESI. Indeed there are an increasing number of doubts expressed as to the ability of a liberalized power sector to secure a long-term transition to more environmentally benign technologies (Meyer 2003; Finger & Künneke 2006; Mitchell 2010; Chick 2011; Kessides 2012b; Finon 2013):

"There is widespread agreement that liberalized, unbundled electricity markets are poorly designed to encourage large-scale investment in, and deployment of, renewable and other low-carbon generating technologies. The transition to a renewable energy will give rise to new regulatory and market design issues. It will also generate important financing challenges because of the cost characteristics of these technologies." (Kessides 2012b: 87)[301]

In general, the large-scale incorporation of intermittent renewables implies is much more complex from an operational perspective than a grid based upon dispatchable fossil fuels (Finon 2013). It also requires a level of coordination of long-term investments and research, and, in terms of system operations, is likely to imply mechanisms that are unlikely to be realized without greater government intervention (Mitchell 2010; Mayer 2003). In this regard it is worthwhile quoting Chick (2011) in his deft identification of the problem:

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[300] Indeed, the search for cheap power is motivation the search for cross-broader power sales. Such as from Nepal to India, DRC to South Africa, Lao PDR to Thailand, China and Vietnam, Myanmar to China and Thailand to name a few.

[301] It may be that Kessides has nuclear in mind when he is thinking about the potential efficacy of markets in this regard, as Thomas suggest: "Without the approval and underwriting from governments, even if sometimes tacit, for waste disposal, materials security, insurance, siting and decommissioning, nuclear power cannot survive…[…]…signals from the market should not be ignored; but it would be foolish dogma to dismiss an energy source of the potential of nuclear power simply because it did not fit into a particular way of organizing electricity supply." (Thomas, & Berkhout 1992:594)

"The liberalisation of markets in which large sunk investments were required simply increased uncertainty and risk, and made those investments less likely to occur. Increased competition could make the existing assets work harder, but the increased uncertainty about future returns and relative prices pushed time-related discount rates higher thereby reducing investment in new large sunk assets. This might not matter, except that in industries like energy, governments express concern about the security implications, be they environmental, economic or military, of a failure to solicit sufficient long-term sunk investment. While issues of national security are a legitimate area for government activity, most of those concerns, be they with global warming or electricity capacity shortages, currently work backwards to the present from a future projection of danger. Government appears to have shifted its area of responsibilities forward in time, while working with present markets which accommodate time inadequately. It might be better for government to accept responsibility for the present precisely by acting to reduce current uncertainty about the future." (Chick 2011: 759)

Much of this comment focuses on ESIs in European and other industrialized countries, these are essentially technological concerns which relate to both the type of technology and the economic attributes emerging from these technological characteristics, and to that extent these questions are also of relevance to developing countries. Developing countries however face tighter investment constraints, lower tolerance for upwards pressure on end-user tariffs and lower levels of regulatory, planning and technological capability which will be needed for the successful implementation of these technologies, and their future institutional arrangements.

What is clear in both the case of industrialized and developing countries is that the challenges facing the ESI and the proposed technological solutions, if such change were to go ahead, would be disruptive of incumbent vested interests. Despite the dramatic change wrought by the development of the power sector, it has not been disruptive of important vested interests in fossil fuel extraction. But the transitions envisaged here could well be. This may especially be a problem in developing countries where the economic and political power of these interests is large relative to other groups. Down-stream impacts may also feature large if end-user tariffs increase or smart metering has unpopular impacts on use patterns. Finally, resistance may come from inside the sector, if the established interests of utilities are threatened. The particular context and generation mix will determine how the political economy is elaborated and how considerations of technological change interact with other pressures facing the ESI.

A5 Annexes to Chapter 5

A5.1 Case study methodology

The case study approach to developing accounts of important causal processes are common in the literature on technological change (Mokyr 1998; Geels 2009; Raven & Geels 2010; Berkers & Geels 2011), economic catch-up (Johnson 1982; Amsden 1992; Kim & Nelson 2000; Wade 2004, 2007), political economy (Khan & Jomo 2000; Meadowcroft 2011) and the ESI (Victor & Heller 2007; Kahrl et al 2012; Turnheim & Geels 2012). There are four main reasons for adopting a case study approach to the subject matter. Firstly, case studies are deemed appropriate for just these sort of causally complex processes. These dynamic and interlinked processes develop overtime and involve important idiosyncratic and contingent factors, which are not amenable to other forms of analysis. Secondly, a case study approach allows the incorporation of varied data sources. When considering political economy processes for which there is limited evidence the ability to incorporate eclectic sources of data is particularly important. Thirdly, in the case of political economy research where the subject of study (i.e. the political economy process) is more often than not inferred rather than directly available to the researcher, complex and multi-layered information can be used to establish an adequately robust empirical basis for the research. A sufficiently robust causal narrative can be constructed through the use of multiple data sources and seeking independent verification of key findings from informants. While the standard of proof implied by this process is lower than that applied in quantitative analysis, for example, we contend that the causal narrative developed offers for our purposes a better description of the reality of the political economy process than would be possible using other approaches. Finally, from the theoretical standpoint adopted here of evolutionary economics, which highlights uncertainty, contingency and the role of complex dynamic causal processes, case studies are the preferred method through which to explore these processes.

The main disadvantage of this single country case study approach is that the implications which can be drawn from this for other countries. The objective of almost all academic research in the social sciences is the identification of causal patterns in the world and the development of theory from which generalizations can be drawn. Reliance on a case study will result in findings being only narrowly applicable, and are likely to yield weaker generalizations than other approaches that seek to incorporate larger samples. To address this concern the case study is described as an instance of the wider general argument we have developed in Chapters 2, 3 and 4. The argumentation in Chapters 6 and 7 has sought to draw on a wide body of evidence to support it.

A5.2 Sources of empirical evidence

To enable the development of a robust case study information sources that have been drawn on have been as broad as possible. These include a range of available information from sources including official documentation, grey literature, secondary quantitative data and key informant interviews.

First, official documentation understanding state policy and plans is central to understanding the political economy. These include sectoral planning documents, legislation and administrative documents. Firstly, as a means of to developing an overview of how policy in the key areas related to the ESI in Vietnam. Secondly, while policy and planning may only be indirectly indicative of the political economy they nevertheless represents ostensive state intentions. Thirdly, an understanding of the gap between stated (*de jure*) policy intentions and actual (*de facto*) policy outcomes can be indicative of how political economy power in a country is articulated.

Second, the grey literature relating to the broad topic of this research is significant. In the absence of other sources the grey literature has been of particular importance in building the case study. Both foreign language and Vietnamese sources have been extensively utilised. These sources include Vietnamese language press, English language press, foreign media, donor reports and project documentation, consultancy reports and other technical materials. The extensive use of grey literature may be seen to pose epistemic problems, as these sources lack the supposed veracity of peer reviewed academic literature. Nevertheless, as the standpoints of the author institutions are usually clear it is not a difficult task to discern bias in their reporting. Moreover, they can often be an important source of policy information or factual evidence which is not subject to bias to the same extent as the analysis or opinion of the source. Finally, given their particular institutional perspective they can be a useful source on the views of key interest groups in approaching these policies.

Third, secondary quantitative data, this study has not sought to collect primary quantitative data on the ESI as it is either difficult to obtain, generally not available or in some cases (such as accounting information on SOEs) is a closely guarded secret. However, a range of secondary data is available including that gathered by the government, IFIs and other organizations as a key source of evidence. In particular, energy and electricity usage and demand projections, information on investment flows to different sectors, and general macroeconomic data, which have all been important basis for the development of the argument. The quality of this data is a concern. It is a well-know, if not widely acknowledged amongst researchers that some datasets are of poor quality. However, this is less of a problem in the ESI where much of the data has been externally verified, comes form reliable sources or is of a non-controversial nature. Nevertheless, caution has still been required in the use of data. For example, information on transmission and distribution losses is reputedly unreliable (see Chapter 6), and much of the information on the financial performance of EVN and other energy parastatals has been open to question. Where these questions of data reliability emerge, caveats have been added in the text.

Fourth, key informant interviews have been an important source of information, essential in developing a convincing picture of sectoral development in Vietnam, and especially in developing an accurate picture of the political economy. Annex A6.6 includes a list of interviewees questioned during the course of this research. Due to the nature of this research a substantial proportion of these interviews have been conducted on an informal basis. Unstructured interviews were used to obtain an overall picture of the sector, to find out about specific events, which were illustrative of the political economy of the sector and to verify the findings of the research. Frequently, interviews and other communications (phone and e-mail) were conducted on an iterative basis the picture of the development of the sector was built up.

The relatively closed and opaque nature of the Vietnamese polity and the sensitive nature of the research means that it has been important to maintain the anonymity of all informants. Government officials were not available for interview, although in some cases where they were employed as consultants or work in affiliated institutes they have been questioned, staff from international organisations have also been an important source of information (e.g. World Bank, IFC, ADB, JICA etc.). Other groups interviewed include private sector developers, businesses, lawyers, financiers, and private individuals and companies working in international development and infrastructure provision have also been an important source of information.

A5.3 Vietnam's economic context and the prelude to reform

A5.3.1 Recent economic performance and perceptions of future prospects

In the two decades between 1990 and 2010, Vietnam saw an average annual real GDP growth of 7.4%, coupled with relatively modest population growth, this lead to dramatic increases in per capita GDP and declines in the poverty rates (Table 5.1) (Rama 2008; GSO 2013; World Bank 2013). Growth in the industrial and service sectors has been, and continues to be, largely responsible for the rapid economic growth.[302] Poverty rates declined both as a consequence of improvements in agricultural productivity and job creation in manufacturing industry (Van Arkadie & Mallon 2003; Das & Shrestha 2009).[303]

All ownership sectors were important in realising this rapid economy growth, including domestically owned private enterprises and foreign invested enterprises, but the lion's share of growth during the 1990s was accounted for by the state owned sector, while the sector continues to play an important part in the economy, since around the turn of the century private sector investment has been of more importance in driving growth (Beresford 2008; Ffrode 2007; Van Arakadie & Mallon 2003; Perkins 2010). In particular and in common with other East Asian industrialising economies, trade and inward investment in the shape of FDI have been important contributing factors (Luong 2007; Thoburn 2009). Export earnings have increased rapidly, both in absolute terms and in relation to GDP - increasing from 36.0% of GDP in 1990 to 77.5% of GDP by 2010 (Table 5.1). The export of commodities and primary products has played an important role in this growth accounting for around 35% of export value in 2010 (GSO 2013).[304] However, since 2002 commodity exports have been exceeded by exports of

[302] Although the solid performance in agricultural sector, creating conditions in which secondary and tertiary sector growth could take off should not be overlooked.

[303] As observed in Chapter 3 and Annex A3 see also Szirmai (2011).

[304] Of which the largest was seafood and crude oil both accounting for around 6.9% of exports, wood and wooden products accounted fro 4.8% of exports, rice 4.5%, rubber 3.3%, coffee 2.5% and coal 2.2%. Volatility in commodity prices suggests we should be cautious in interpreting the implications of this, but a review of export revenue between 1995 and 2010 shows a secular decline in the share of commodities in exports from around 67% in 1995, to around 50% in 2002, to the current figure of 35% (GSO 2013). We return to look in greater detail at the importance of exports of fossil fuels in section 5.2.1.

manufactured goods, which accounted for most of the remaining export value in 2010.[305] FDI flows have also been an important element of Vietnam's growth story, at its peak net inflows of FDI reached 11.9% of GDP in 1994 and 10.9% in 2009 (Tran 2009; World Bank 2010a; World Bank 2013).[306] By 2010, the effects of the FDI boom were immediately apparent in the macro-economic indicators, FDI accounted for 25% of investment, and foreign invested enterprises accounted for 42% of industrial output and 54% of exports (GSO 2013).

Rapid economic growth and structural change in the economy has brought with it significant social change. Employment in manufacturing, industry and services has growth significantly, and the share of employment in agriculture, forestry and fisheries has in recent years declined.[307] Employment creation in and around urban areas has lead to rapid urban population growth. Conservative government figures put urban population growth at 3.6% per year between 1990 and 2010, although this is probably a considerable underestimation.[308] This compares to national annual population growth of around 1.3% over the same period, and implies large-scale rural-urban migration (Sharpe et al 2006; GSO 2013).

Given the importance of *perceptions* about future growth prospects in determining future energy and electricity demand, and the role these expectations are playing in the development of the ESI, it is important to say a word about future growth prospects in Vietnam. In recent years doubts have been raised about Vietnam's development prospects relating to macro-economic imbalances,[309] corruption and cronyism, ineffective reforms to large state owned companies and a bank-lending fuel boom-and-bust in the real estate sector (Rama 2008; Dapice 2008; Le 2008; Pincus & Vu 2008; Pincus 2009; Daiss 2012; Fforde 2012; Fforde 2013).

[305] Light manufacturing, such as textiles and garments (16%), and footwear (7%) account for approximately 35% of manufacturing exports in 2010 with the remainder made up engineering and materials exports (machinery, iron and steel, chemicals etc).

[306] The average for the period was 6.2% of GDP (World Bank 2013).

[307] According to official figures agricultural employment peaked in 2009 at 24.6 million, and declined slowly in 2009-2010. It still accounted for approximately 50% of employment in 2010. Domestic economic woes are probably reflected in the uptick in agricultural employment in 2011 – although its relative share of employment continues to decline whereas manufacturing only accounted for around 14% of employment (GSO 2013).

[308] In large urban areas such as HCMC and Hanoi officials privately admit that actual populations exceed official figures by between 15 – 30%.

[309] In particular, emerging as a result of the government's response to the Global Financial Crisis.

While it is clear Vietnam faces substantial challenges in maintaining rapid economic growth, the perception remains that in the medium to long term Vietnam has relatively good growth prospects. A number of influential investment reviews have noted Vietnam's long term growth prospects, for example, Goldman-Sachs identified Vietnam as one of the 'Next Eleven' emerging economies after Brazil, India, Russia and China, and forecasted a growth rates exceeding 6% to 2030 and above 4% to 2050 (Wilson & Stupnytska 2007). Similar growth prospects are envisaged in official planning documents, for example the current power development plan foresees a growth rate exceeding 7.5% between 2010 and 2030 (MOIT 2011). Suffice to say that despite current economic turbulence the general perception is that Vietnam's long-term economic growth prospects remain strong. Such perceptions are critical in determining investment in and policy towards the energy sector (IMF 2012; Oxford Economics 2012).

A5.3.2 The context for economic reform

Vietnam's much vaunted economic success seems all the more remarkable considering its particularly traumatic recent history. Three decades of armed conflict preceded the unification of North and South Vietnam under Communist Party (CP) rule in 1976, following the end of the Vietnam War in 1975.[310] The CP inherited a physically shattered and politically divided country. From an economic perspective, immediately following the end of the conflict managing the aftermath of the war was the main priority. The CP faced with large numbers of internally displaced persons, the wholesale destruction of infrastructure and the integration of two independent and very different economic systems. Nevertheless, from 1976 economic policy and planning focussed on the development of a centralised command economy along Soviet lines with state ownership over the means of production.[311] In principle, the allocation of resources (financial, material and labour) was determined by a centralised planning process, enterprises were required to meet production targets set by the state planners, marketing and distribution of goods, price, salaries and the use of investment funds were all determined by the plan. More substantively, this implied a concentration of resources on heavy industry (including the energy sector) and 'production of the means of production', with light manufacturing and agricultural sectors receiving relatively little state investment – and this despite agricultural development being a priority of stated policy (Probert & Young

[310] Official reunification took place in 1976 with the formation of the Socialist Republic of Vietnam.

[311] At this time the influence of Soviet planners and economic experts was important in developing economy policy.

1995; Van Arkadie & Mallon 2003).[312] Efforts to promote a socialist transformation of the country gathered pace in 1978, with campaigns to nationalise private enterprises and collectivise agriculture in the south (Van Arkadie & Mallon 2003).

Efforts to realise national industrialisation and renewal through central planning were largely unsuccessful. And through the late 1970s and early 1980s the country lurched from economic crisis to economic crisis, with falling production in industrial and agricultural sectors, food shortages, high levels of inflation and declining balance of trade (Luong 2003).[313] Reforms in the 1979 - 1982 restored some production incentives and lead to increasing agricultural and industrial output. This offered only temporary reprieve, reforms had failed to tackle issues relating to pricing, incentives facing bureaucrats or financial management (Probert & Young 1995; Van Arkadie & Mallon 2003). By the mid 1980s inflationary pressures and falling growth lead the government to increase state wages, expand the money supply and reform prices. However, this lead to a loss of faith in the value of the Dong and a damaging inflationary spiral, falling economic growth and by 1986 annual inflation was running in excess of 700 % (Luong 2003).

Geopolitical factors also featured large in Vietnam's economic woes. The aftermath of the war left Vietnam subject to a US embargo and isolated internationally, as a result aid flows that were expected in the aftermath of the war did not emerge. While both China and the USSR had been important supporters of the communist north during the war, peace brought escalating tensions with China following the Sino-Soviet split and rising Chinese suspicions of Soviet influence in Vietnam. Vietnam was pulled closer into the Soviet orbit through membership of the Council for Mutual Economic Assistance (CEMA) in 1978 (Probert & Young 1995; Luong 2003). Relations with China soured further in 1978 with the Vietnamese invasion of Cambodia and an 'anti-capitalist' campaign, which targeted small businesses in the south of the country which were largely owned by ethnic Chinese. Chinese economic assistance was cancelled at this time. This culminated in a short border war with China in 1979 and intermittent low-level conflict on the border, which rumbled through the 1980s. Finally, the occupation of Cambodia,

[312] New plans promoting central planning were adopted in 1976 (1976 – 1980), and interim three year plan to address the failing of the previous plan in 1978 (1978 – 1980) and in 1980 (1981 – 1985) (Van Arkadie, & Mallon 2003).

[313] Van Arkadie and Mallon (2003) cite an report of the Asian Development Bank, suggesting that "By the late 1970s, Viet Nam was facing a 'major economic crisis, with acute shortages of food, basic consumer goods, and inputs to agriculture and industry, and growing external debt." (47)

which continued until 1989 also made considerable demands on Vietnam's limited economic resources (Horn 1987; Luong 2003;Van Arkadie & Malllon 2003).

In the face of a gathering economic crisis and growing popular discontent, a change in the strategic direction of economic policy was formally announced at the sixth Communist Party Congress (CPC) in 1986 in the shape of '*Doi Moi*'. *Doi Moi* heralded a significant change in direction for government economic policy, with an emphasis on the development of a 'market oriented' economy and a shift away from a centralised command economy. While a number of key reforms were adopted in the years immediately following the announcement of *Doi Moi* – such as wide-reaching agricultural reforms in 1986 and 1988, the abolition of the two price system for most goods in 1989, and the official sanctioning of private and joint venture enterprises in 1990 – it was not until after the seventh CPC in 1991 that reforms started to bear fruit economic growth started to take off, and economic indicators started to show significant (and somewhat unexpected) improvement (Fforde & De Vylder 1996; Luong 2003; Van Arkadie & Mallon 2003; Beresford 2008).

Most diagnoses of the immediate internal causes of Vietnam's poor economic performance during this period centre on the failure of central planning to offer appropriate incentives for improved productivity, the overemphasis on heavy industry, the passive resistance to the operation of central planning (particularly at the level of agricultural collectives) and the state's inability to effectively implement policy. External factors including the end of preferential CEMA trade agreements and Soviet aid with the collapse of communist governments in Eastern Europe and the USSR also dealt a severe blow to the industrial rump of Vietnam's economy which relied heavily upon this support (Probert & Young 1995; Van Arkadie & Mallon 2003; Kerkvliet 2005; Perkins & Vu 2010).[314]

The broad contours of the impetus for reform and of economic performance in the reform period are generally agreed upon. As are important endogenous factors including

[314] Comicon, or the Council for Mutual Economic Assistance (CEMA) was an economic organization for trade and multilateral aid composed of mainly eastern European but also other communist countries lead by the USSR.

the generation of the first oil revenues from the Bach Ho field in 1989,[315] the withdrawal of troops from Cambodia allowing the normalisation of international relations, and a policy of international integration culminating in accession to the WTO in late 2006.[316] The meat of the debate focuses upon an understanding of the role and efficacy of the state and polices adopted in the *Doi Moi* era. This goes the heart of our concerns in understanding the political economy of Vietnam, discussed in section 5.2.1.

A5.4 Vietnam's energy resources and prospects

A5.4.1 Energy sector development

As might be expected the composition and quantity of Vietnam's energy supply and use has evolved rapidly with economic growth and structural change. There are three things to note as regards this development. First, as a consequence of economic growth energy supply (and demand) has grown rapidly, on average 6.2% a year between 1990 and 2010, over the period total energy demand has more than doubled. Per capita energy consumption has similarly increased rapidly, an energy supply growth rate below levels of GDP growth suggests that the energy intensity of the economy is falling.[317] Second, while energy supply from all sources has grown, the energy supply mix has shifted with traditional use of biomass (biofuels and waste) declining relative to modern commercial energy sources (Baruya 2010; Do 2011). Coal, natural gas and hydropower in particular have grown rapidly, much of which is used in electricity generation (Figure A6.1 below).

Thirdly, increases in energy use in the industrial, transportation, and residential and commercial sectors have driven consumption growth. Industry accounted for about 40% of the growth in energy consumption between 1990 and 2010, whereas the other two sectors accounted for about 25% each. Finally, there has been a distinct shift in final energy consumption away from more traditional energy sources such as biomass, to modern commercial energy sources (Figure A6.2). According to IEA (2013) figures,

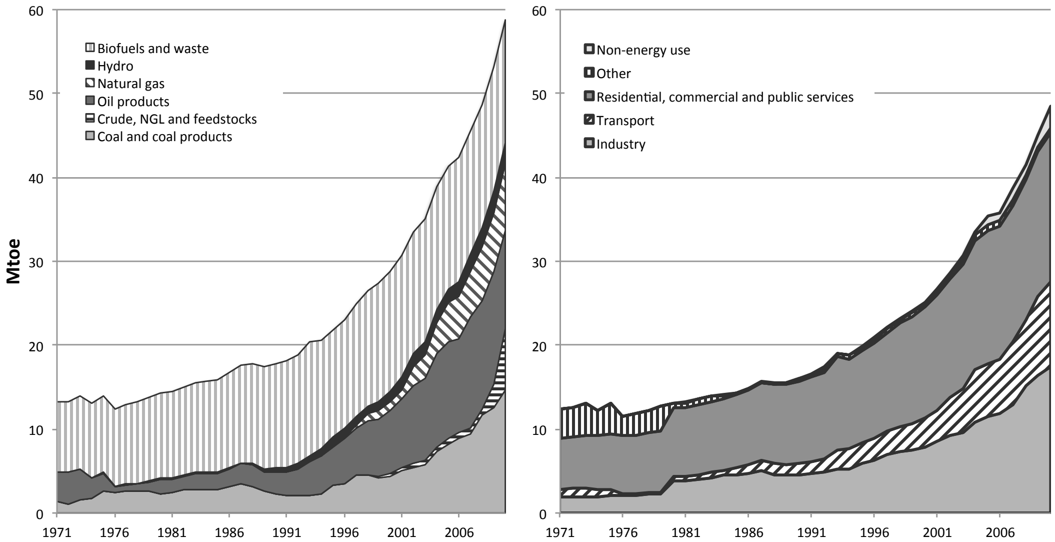
[315] Oil exploration had been carried out during the 1980s by a joint venture between the USSR and Vietnam, largely bankrolled by the Soviets. Oil revenues played an important part in plugging the current account deficit in the early 1990s and continue to be an important source of foreign exchange earnings.

[316] Relations were normalised with China ASEAN and most Western European countries in 1991, and the USA in 1994. Shortly afterwards Vietnam joined the World Bank, IMF and the Asian Development Bank, and in 1995 joined Asia-Pacific Economic Cooperation (APEC) and the Association of South East Asian Nations (ASEAN). The Bilateral Trade Agreement with the US finalised in 2001, which paved the way for Vietnam's accession to the WTO in late 2006.

[317] The reasons for declines in energy intensity likely reflect more efficient use of energy in some cases, but also reflect structural changes in the economy as less energy intensive industries account for larger shares of GDP.

between 1990 and 2010 electricity consumption grew by about 14.1% per year, coal and coal products by 10.5%, and oil products by 10.3%.

Figure A5.1. Vietnam total primary energy supply (left)[a] and total final energy consumption (right) 1971 – 2010 (Mtoe)[318][319]



Source: IEA 2013 Note: a – approximately 398 Ktoe (0.7% of total primary energy supply) is electricity imported from China, to simplify the diagram this has been left out of the left-hand figure.

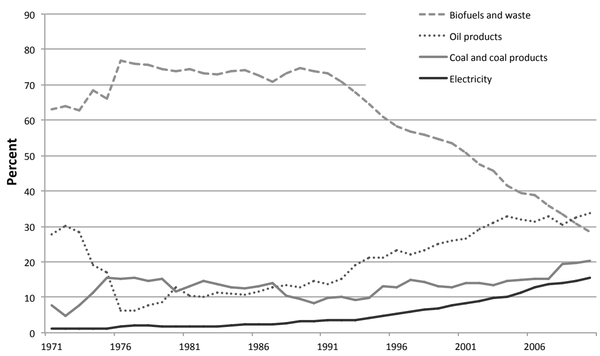
Finally, Figure A5.3 illustrates how the relationship between energy use, and economic growth and structural change in Vietnam compares to that in other countries in the region. These figures serve to emphasise, i) Vietnam's very low level of energy consumption per capita, a little over a third of the world average in 2010; ii) its rapidly rising energy consumption relative to other countries, rapidly declining energy intensity of GDP - which reflects not just the efficiency of technologies in use but also the structure of the economy - Vietnam has seen rapidly declining energy intensity, in common with other centrally planned economies, much of the decline in energy intensity

[318] Total primary energy supply (TPES) is defined as production plus imports, minus exports, plus or minus stock changes (i.e. in energy inventories). Total final consumption is defined as the total of consumption in the end use sectors.

[319] National statistics from the World Bank, IMF and IEA are generally based upon official sources. In the case of Vietnam this is the General Statistical Office (GSO) under the Ministry of Planning and Investment (MPI), and in the case of energy related figures the Institute of Energy (IE) a nominally independent body under the Ministry of Industry and Trade (MOIT). While the general trends presented by these statistics are probably reliable, the detail is not. Data collection and monitoring capacity is generally weak and some statistics are politicized and yet others are openly acknowledged to be unreliable, for example emissions estimates published in the Second Communication to the IPCC were thought to have a margin of error of plus or minus 20% (MoNRE 2010). Another example are the figures on energy supply from biomass and waste, 2000 figures differ between sources

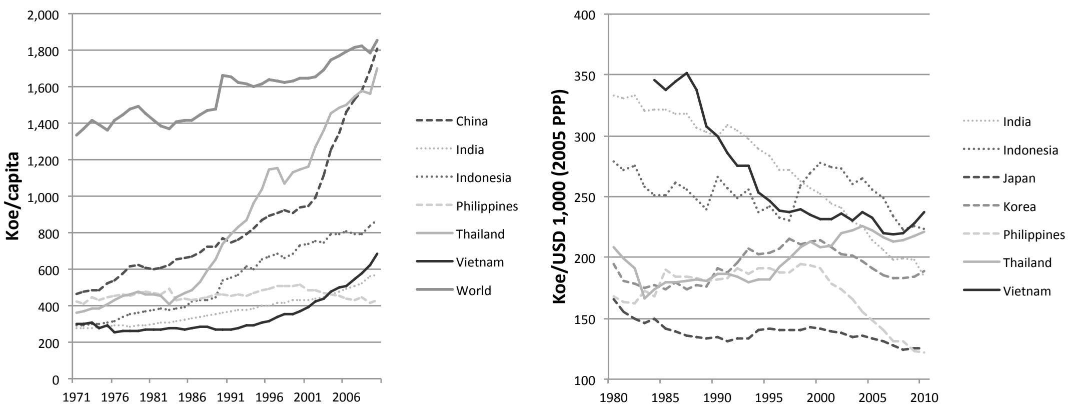
is structural and related to a relative shift away from an inefficient allocation of resources to energy intensive sectors;[320] iii) With the obvious caveat that there are likely to be structural differences in economies, Vietnam has a long way to go to catch-up to the technological leaders (here represented by Japan and Korea) in terms of energy efficiency.

Figure A5.2. Vietnam share of final energy consumption by fuel 1971 - 2010



Source: IEA 2013

Figure A5.3. Vietnam's energy intensity in comparison with selected countries, per capita 1971 – 2010 (left) and per unit value added 1980 – 2010 (right)



Source: World Bank 2013

A5.4.2 Energy resources

Vietnam has significant fossil fuel reserves, hydropower and renewable energy generation potential (Table A5.1). The presence of ample domestic hydropower and coal resources

320 Although in recent years energy intensity has seen something of an upsurge, it is not clear yet whether this represents a long-term trend.

has been an important factor in determining technology choice in the ESI since the early days of the sector. These resources have also been extremely important in realising Vietnam's rapid economic growth, enabling the supply of relatively cheap energy (either directly or through transformation to electrical power).

Driven by growing demand and investment in the sector Vietnam's energy sector has been through a rapid transformation since the middle of the 1980s. This is expressed in terms of exponentially increasing energy production and demand, a shift towards modern commercial energy sources (such as oil products and electricity) and away from non-commercial biomass, and increased energy efficiency – if not from the deployment of more energy efficient technologies or practices then from a structural shift in the relative composition of industrial production (Do & Sharma 2011).[321]

Table A5.1. Vietnam's energy resources

Energy source	**Proven reserves**	**Annual Exploitability**	**Expected life (years)**
Coal	6 billion tons	60 – 80 million tons	85
Oil	1.6 billion tons	10 – 15 million tons	10 -15
Natural Gas	6.8 trillion m^3	15 – 20 billion m^3	25
Hydropower	20 GW	80 TWh	
Renewables			
Small hydropower	4 GW	2,500 MW	
Solar	44 billion TOE $year^{-1}$	3.25 MW	
Wind	22.4 GW	500 MW	
Biomass	45 million TOE $year^{-1}$	400 MW	
Geothermal	0.24 GW	240 MW	
Uranium	RAR: 113 tons		
	EAR-I: 16,563 tons		

Note: the estimation of energy resources is complex and uncertain, reserves are a function of geological certainty and techno-economic feasibility both of which are subject to changes due to geological discoveries, changing energy extraction technologies and changing economic conditions. Thus different estimation exercises result in widely differing assessments of reserves. These estimates should be regarded as indicative.

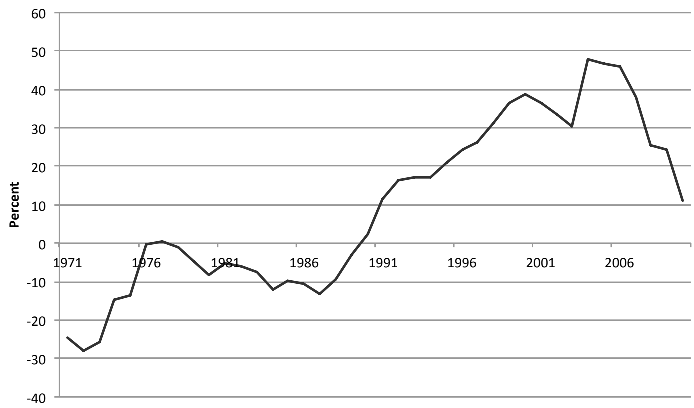
Source: IE 2007 cited in Do & Sharma 2011; Pham et al 2011

321 Writers such as Minh Do & Sharma (2011) are critical of Vietnam's poor energy efficiency performance, while compared to the technological leaders it is poor. But his may be an unrealistic comparison, when compared to countries at similar levels of development, Vietnam does not perform too badly. We should also reiterate that structural differences in economies make thee kinds of comparison problematic.

There are a few points salient to our analysis here. Firstly, the availability of domestic energy resources have been an important factor in determining technology choices in the ESI, with access to hydropower and coal resources extremely important in the sectors development, and since around 1995 the growing importance of natural gas resources.

Secondly, Vietnam has been a net energy exporter since around 1990 (Figure A6.4). Revenues from energy exports have continued to be an important source of state revenues and foreign exchange earnings (e.g. see Van Arkadie and Mallon 2003). For example, with increasing production and increased global price levels, earnings from both crude oil and coal exports increased from US$ 0.2 billion and US$ 3.8 billion in 2003 respectively to a peak of US$ 10.3 billion and US$ 1.3 billion in 2008 (World Bank 2010b).[322] International prices and as a consequence export revenues have since fallen, but on average revenues between 2003 and 2009 were US$ 7.2 billion for crude oil and US$ 0.8 billion for coal.

Figure A5.4. Vietnam's net energy exports (proportion of total energy use) 1971 - 2010



Source: IEA 2013

[322] It should also be noted, however, that until 2009, when Dung Quat refinery was opened in Quang Ngai province, Viet Nam had no domestic refining capacity. Dung Quat is currently processing 140,000 bbl of oil per day, supplying around a third of current domestic demand for refined products, and plans to increase capacity to 215,000 bbl/day by 2016. There are also plans for two other refineries. Construction started in 2011on the Nghi Son refinery with a planned 200,800 bbl/day capacity. A third refinery, Long Son, is planned with a 240,000 bbl/day capacity. With a total refining capacity in place of 655,000 bbl/day (about 30 million tons), Viet Nam would be able to meet about three quarters of expected domestic demand for refined products in 2025.

Table A5.2. Projected overall energy balance for Vietnam 2005 - 2030[323]

Fuel (physical unit)	2005		2010		2020		2030	
	Physical	Ktoe	Physical	Ktoe	Physical	Ktoe	Physical	Ktoe
Primary energy demand		43,832		59,440		135,317		234,205
Domestic energy resources:		61,145		77,063		107,100		129,384
Coal (million tons)	32.6	18,271	50	28,000	75	42,000	100	56,000
Crude oil (million tons)	17.8	18,120	19.86	20,217	20.7	21,073	22	22,396
Gas (billion m^3)	6.89	6,205	7.82	7,046	14.85	13,368	18	16,200
Hydro (TWh)	17.49	3,762	30.03	6,458	59.6	12,814	69.7	14,993
Small hydro (TWh)			1.99	428	9.79	2,105	15.9	3,423
Renewable energy	44.8	14,788	45.2	14,914	47.7	15,740	49.6	16,372
Surplus (+) deficit (-)		17,313		17,623		-28,217		-104,820

Source: Based on Pham et al 2011

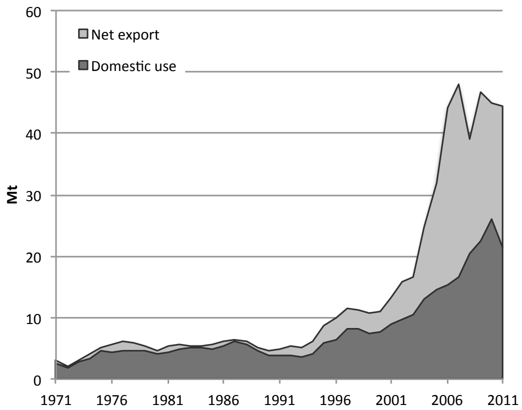
Thirdly, domestic consumption of energy resources is starting to outstrip domestic production. Vietnam is expected to become a net energy importer by 2015 as reduction in coal exports and increased domestic demand from the power sector and the consumption of oil products exceeds production (Reuters 2011; Energy Tribune 2013). While future projections of energy demand differ in their details, they all foresee consumption growth continuing to outstrip domestic supply capacity and a large increase in energy imports (MOIT 2011; Do, 2011; Nguyen 2011; Pham et al 2011). The figures in Table A5.2 imply that imports will be needed to meet around 45% of primary energy demand by 2030. This in turn implies a loss of energy independence and security. It also means that the state's ability to effectively control energy input prices will be greatly reduced as Vietnam increasingly relies on international markets for energy inputs. This also implies a growing headache for the country as it is forced to improve the productivity of energy use and allow end user prices to rise.

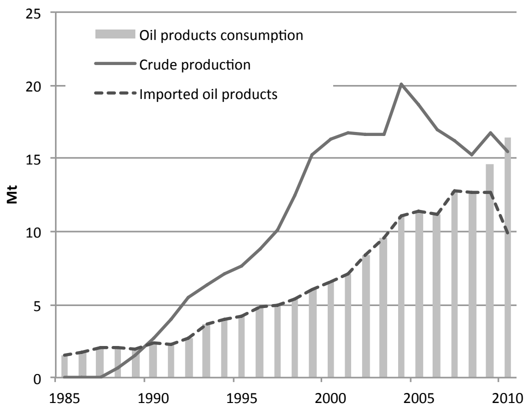
Driven by growing demand and investment Vietnam's energy sector has been through a rapid transformation since the middle of the 1980s. Expressed in terms of exponentially increasing energy demand and per capita energy consumption, a shift towards modern commercial energy sources (such as oil products and electricity), and increased energy

[323] These energy balance figures are reported from the VIth Power Development Plan (PDP) 2006 – 2010, published in 2006 developed by the Institute of Energy (IE), they have now been superseded by PDP VII figures.

efficiency – if not from the deployment of more energy efficient technologies or practices then from a structural shift in the relative composition of industrial production.[324]

Figure A5.5. Vietnam's main fossil fuel trade in coal 1971 – 2011 (left), and crude oil and oil products 1985 - 2010(right)





Source: IEA 2013

Vietnam's energy sector has not only been an important resource that has provided direct inputs to its rapid economic growth but has also been an important sector for the generation of revenue for government and for its contribution to exports the generation of foreign currency earnings. Vietnam is still currently a net exporter of energy, in 2010 exporting an equivalent of around 11% of its total energy production although this has declined from its peak of around 48% of domestic use in 2004 (IEA 2013). Apart from small cross-boarder exports of electricity through interconnections with Cambodia and Laos, most of these exports are coal and oil (Figure A5.5). There are two salient points to note about Vietnam's energy trade. First, it has been important source of foreign exchange earnings and budget revenues. With increased production and increased global price levels, earnings from both crude oil and coal exports increased from USD 0.2 billion and USD 3.8 billion in 2003 respectively to a peak of USD 10.3 billion and USD 1.3 billion in 2008 (World Bank 2010b).[325] International prices and as a consequence

[324] Writers such as Minh Do & Sharma (2011) are critical of Vietnam's poor energy efficiency performance, while compared to the technological leaders it is poor. But his may be an unrealistic comparison, when compared to countries at similar levels of development, Vietnam does not perform too badly. We should also reiterate that structural differences in economies make thee kinds of comparison problematic.

[325] It should also be noted, however, that until 2009, when Dung Quat refinery was opened in Quang Ngai province, Viet Nam had no domestic refining capacity. Dung Quat is currently processing 140,000 bbl of oil per day, supplying around a third of current domestic demand for refined products, and plans to increase capacity to 215,000 bbl/day by

export revenues have since fallen, but on average revenues between 2003 and 2009 were USD 7.2 billion for crude oil and US$ 0.8 billion for coal. Oil revenues have been of particular importance making up, on average, about 23% (US$ 3.5 billion) of budget revenues between 2000 and 2010, with a peak of 30% (US$ 5.2 billion) of revenues in 2006. Although a significant proportion these revenues have been used to subsidise domestic energy consumption, IEA subsidy estimates suggest that energy consumption subsidies were equivalent to around 78% of oil revenues in 2010 (IEA 2012b; IMF 2011, 2012; GSO 2013).[326]

Secondly, domestic consumption of energy resources is starting to outstrip domestic production. Vietnam is expected to become a net energy importer by 2015 as reduction in coal exports and increased domestic demand from the power sector and the consumption of oil products exceeds production (Reuters 2011; Energy Tribune 2013). While future projections of energy demand differ in their details, they all foresee consumption growth continuing to outstrip domestic supply capacity and a large increase in energy imports (MOIT 2011; Do, 2011; Nguyen 2011; Pham et al 2011). For example, the figures in Table A5.2 imply that imports will be needed to meet around 45% of primary energy demand by 2030.

2016. There are also plans for two other refineries. Construction started in 2011on the Nghi Son refinery with a planned 200,800 bbl/day capacity. A third refinery, Long Son, is planned with a 240,000 bbl/day capacity. With a total refining capacity in place of 655,000 bbl/day (about 30 million tons), Viet Nam would be able to meet about three quarters of expected domestic demand for refined products in 2025.

[326] Estimation of fossil fuel subsidies is a fraught exercise, as fossil fuels frequently enjoy a range of explicit and implicit subsidies all through the value chain. The IEA estimates cited here are for consumption subsidies and are calculated using a 'price gap' approach, for more information on this method see IEA (2012b). It should be noted the price gap approach may over-estimate the actual level of fiscal transfers as in the case of Vietnam, much of the subsidy actually represents the opportunity cost of domestic consumption.

A6 Annexes to Chapter 6

A6.1 Early development of the ESI in Vietnam 1892 - 1975

Electrification spread rapidly to cities round the world, only 10 years after the Pearl Street Station opened in New York, in December 1892 a 500 kW generator was installed near Hoan Khiem lake in the centre of Hanoi by the Lake Side Lamp Company. Saigon followed soon afterwards with the construction of Cho Quan power plant in 1896.[327] Vietnam's electrification followed a similar pattern to that of other European colonies. Privately owned commercial power utilities operated in Hanoi, Saigon and other large population centres such as Hai Phong. Large industrial users owned off-grid isolated generation units. Although small gird networks were developed in the first decades of the twentieth century, such as that linking larger population centres on the Red River Delta, in general the electricity systems that existed were small and fragmented (EVN HCMC 2012; EVN Hanoi 2012). Information on the ownership and institutional arrangements surrounding the ESI in these early days is not available. It is probable that, as elsewhere, a variety of ownership patterns developed. References to power plants in the large cities imply private companies owned them. Other plants were developed by the colonial authorities. For example, An Kroet hydropower plant in Lam Dong province was originally commissioned in 1945 by the Indochina Department of Public Works to supply Da Lat city (EVN 2012; EVN Hanoi 2012).

In terms of the overall size of the sector, disaggregated figures have not been available for the three French protectorates of Tonkin, Annam and Chochinchina that now make up Vietnam. Nevertheless, figures of the whole of Indochina[328] are available and give some indication of the limited extent of electricity provision in the colonial period, with only an estimated 63 GWh of electricity production in 1929 which had expanded to 182 GWh by 1950 (UN 1952), suggesting a relatively modest growth rate during the war-disrupted period between 1929 and 1950 of 5.2%.[329]

[327] Both Hanoi and Saigon had electric trams, those in Hanoi only ceased operation in 1991.
[328] Mostly what is now Cambodia, Lao PDR and Vietnam.
[329] It should be noted that figures on Vietnamese electricity production and consumption and estimates of T&D losses and own use differ between sources (For example there are considerable differences between figures reported by the World Bank (1999) and figures included in the World Development Database maintained by the World Bank (2013)). It is not clear from the available data, which are the most reliable. However, in general the detail is not important to illustrate the general trends of the case, where these are not in agreement this is noted and care is taken to justify the path taken.

In 1954, upon achieving independence from the French, the new Communist government of the Democratic Republic of Vietnam nationalised the ESI in the north. At this time Northern Vietnam had around 31.5 MW of installed capacity, producing around 53 GWh annually, by 1958 capacity had approximately doubled to over 60 MW, with new plants in Vinh, Thanh Hoa and Lao Cai. Transmission and distribution infrastructure were being upgraded with the introduction of higher voltage lines (35kV by 1958 and 110kV by 1962). Despite the war capacity was expanded gradually, wit h an emphasis on supply of electricity to industries essential for the war effort. Overseas aid from China and particularly the Soviet Union was important. Major investments in a 48 MW coal fired thermal power plant at Uong Bi in Quang Ninh province in operation from 1963 and the first large hydropower plant in the north (120 MW) at Thac Ba, Yen Bai province 180 Km north of Hanoi commissioned in 1972 were all sponsored by Soviet aid (EVN 2009a). The north also saw considerable expansion of small hydropower plants[330] from the 1960s, using equipment imported from China and Eastern Europe using public funds for civil works. These plants typically supplied small or mini-grids in remote and mountainous areas close to the hydropower facilities (Meier 2013).

Little information is available on the installed capacity in the Republic of South Vietnam in 1954, although Krishnaswamy & Suggins' (2007) estimate of a 100 MW in the whole of Vietnam, implies an installed capacity of around 70 MW. Capacity expanded relatively rapidly in the south during the war years. Larger plants built during this period included the 160 MW Da Nhim hydropower plant in Ninh Thuan province finished in 1963, built with funds from Japanese war reparations and the 18 MW oil fired plant in Da Nhim in Dong Nai province. Although total installed capacity had grown to over 800 MW during the war years, of that only 481 MW were in working order in 1975 (EVN 2009a). As with the north the conflict made serious expansion of transmission and distribution infrastructure difficult, with most production serving loads in Saigon-Cho Lon and Bien Hoa which accounted for around 77% of electricity consumption in 1960.

The central region of Vietnam had a particularly underdeveloped power system by 1975. Estimates suggest that the region had around 16 diesel powered generation units with a cumulative capacity of around 74 MW. These served small command areas in and around

[330] The official Vietnamese classification of a small hydropower plant is any hydropower plant with an installed capacity of less than 30 MW, we adopt this definition here.

population centres such as Da Nang, Hue and Quy Nhon, there was no overall grid in the region (EVN 2009a).

In sum, between the end of the nineteenth century and the last quarter of the twentieth century Vietnams ESI had developed in a manner familiar from the historical review of ESI development in Chapter 4. However, in Vietnam's case development of a national grid and large centralised power generation facilities had not been developed in part due to the conflict, and in part due to the related geographical and political distinctions that characterised the country. Upon reunification Vietnam had two separate and limited distribution systems in the densely populated deltaic areas of the north and south, and in the rest of the country a series of smaller grids. Institutionally, private ownership had been replaced swiftly by state ownership following independence. But the development of a vertically integrated state utility and a integrated national grid remained a long way off.

A6.2 Images of electrification in state propaganda

Figure A6.1. Propaganda posters illustrating ideological the importance of the ESI

Note: Clockwise from top-left – 1. Date unknown, the socialist iconography of science and technology show a young woman in the foreground clasping a science text book which bears the stylised atom in its top left corner, the centre of the image is dominated by an electricity transmission tower, and in the background to the left water flows from large hydropower dam. The caption reads "*Science. Technology. We have the strength to develop the homeland*"; 2. A poster dating from 2004 commemorating 50 years of Vietnamese independence following victory of the French at the Dein Bien Phu. In the background of the left hand side of the picture, the familiar silhouettes of factories and transmission lines; 3. Dating from 1982 this image links the typical socialist iconography of the red ground with the yellow star of Vietnam in the left and the hammer and sickle of the Communist Party on the right with an image of Ho Chi Minh in the middle, in the middle ground are the tropes of modernisation, tower blocks and a hydropower dam to the left and modern industrial factories to the right, including what resembles a cooling tower and an electricity transmission tower. The caption reads " *For the socialist fatherland, for the ideals of Uncle Ho, for the happiness of the people*"; 4. Date unknown, this poster shows the terraced rice field and hydropower production in the mountainous area of Dien Bien. In the foreground a hydropower engineer stands beside a woman dressed in a traditional costume resembling the Red Dao minority group, a school child stands in from of them.

The caption reads, "*Promoting the traditional hero of Dien Bien. Let's be determined in making the fatherland rich and powerful*" alluding to the victory over the French at Dien Bien Phu in 1954; 5. Date unknown probably dates from before 1975, showing a farmer maintaining an irrigation pump, sporting an olive green shirt and pith helmet reminiscent of a soldier's uniform. Note the electricity transmission lines and dam in the background and the implied link to the electrical irrigation pump. The caption draws parallels between productive and military activities reading "*Brave fighter. Exemplary in production*"

Source: Heather 2009

Figure A6.2. Reverse side of 5,000 Dong note in circulation since 1993

Note: The hydropower plant continues to be a familiar and very much socialist ideological trope. The reverse side of the 5,000 VND note still in circulation shows the hydropower plant at Tri Anh in the Dong Nai river basin, in Dong Nai province in South-Eastern Vietnam. The plant was constructed with Soviet assistance between 1986 and 1988. The installed capacity of the dam is 400 MW and has produced on average 1.76 TWh per year since commissioning in 1988. The plant is now wholly owned by a subsidiary of EVN.

A6.3 Additional data

Table A6.1. Emergence of the parastatals: State corporations formed under Decision 91 in 1994

State corporation	Member enterprises	JV enterprises	Legal capital (Billion VND)
Electricity corporation of Vietnam (EVN)	**34**	**-**	**19,332**
Vietnam post and telecommunication Corporation	88	6	4,740
Vietnam rubber corporation	32	2	2,700
Cement corporation of Vietnam	14	4	2,235
Vietnam National Shipping Lines (Vinalines)	24	12	2,145
Vietnam steel corporation	17	4	1,336
Vietnam textile and garment corporation	53	2	1,186
Vietnam Airline Corporation	20	6	1,043
Vietnam paper corporation	18	-	1,028
Coal corporation of Vietnam (VINACOAL)	**47**	**4**	**824**
Vietnam Petroleum Corporation (PETROVIETNAM)	**17**	**4**	**761**
Southern food Corporation - VINAFOOD 2	33	3	568
Vietnam tobacco corporation	12	-	550
Vietnam coffee corporation	68	-	276
Vietnam Ship Building Corporation (Vinashin)	22	2	204
Northern food Corporation - VINAFOOD 1	30	2	194
Vietnam National Gem and Gold Corporation	12	-	12
Vietnam Chemical Corporation	50	14	…

Note: Energy parastatals in **bold.**
Source: Van Arkadie & Mallon 2003: 132

Table A6.2. Small hydropower IPPs reaching financial closure between 2005 and 2012

Name	Year of Financial closure	Installed Capacity (MW)	Investor
Dasiat Hydropower Plant	2005	13.5	Southern Hydropower JSC (100% / Vietnam)
Za Hung Hydropower plant	2005	30	N/K
Daksrong 3B Hydropower Plant	2007	19.5	Hoang Anh Gia Lai Group (100% / Vietnam)
Xiaozhong River Hydropower Station	2007	22	China Southern Power Grid Corporation (.. / Cl
La La Hydropower Plant	2008	3	Mai Linh Energy JSC (100% / Vietnam)
Daksrong 2 & 2A Hydropower Plants	2009	18	Ho Chi Minh City Infrastructure Investment Joi
Suoi Lum 1 Hydropower Plant	2009	20	Nam Lum Hydroelectric JSC (.. / Vietnam)
Ea Drang 2 Hydropower Plant	2010	6.4	Dak Lak Power JSC (.. / Vietnam)
Dakrong 3 Hydropower Plant	2010	8	Truong Son JSC (.. / Vietnam)
Song Mien 5 Hydropower Plant	2010	20	Song Mien Hydropower JSC (.. / Vietnam)
Thac Xang Hydropower Plant	2010	20	Song Da General Construction Company (.. / V
Dak Rong 4 Hydropower Plant	2010	21	Thuong Hai JSC (100% / Vietnam)
Bao Loc Hydropower Plant	2010	24.5	Bao Loc VRG JSC (.. / Vietnam)
Song Bung 6 Hydropower Plant	2010	30	Song Bung JSC (100% / Vietnam)
Ta Co Hydropower Plant	2010	30	Bac Minh Development Investment JSC (.. / Vie
Vinh Son 3 Hydropower Plant	2010	30	Vinh Son Song Hinh JSC
Dakrosa II SHPP	2011	2.4	Dakrosa Hydropower JSC (100% / Vietnam) (2(60%)
SMA DakGlun SHPP	2011	18	Sai Gon Machinery Spare Parts JSC (SMA) (100(
Thien Nam I-III HPPs	2011	19.6	Thien Nam JSC (100% / Vietnam)
Nam Can II HPP	2011	20	Nam Can Hydro Electric JSC (100% / Vietnam)
Nam Luc Hydropower Plant	2011	24	ESACO Corporation (100% / Vietnam)
Lang Bang SHPP	2012	3.6	Van Yen Exploitation Production and Construct
Nam Cat SHPP	2012	5	North Trade Cement Corporation (100% / Viet
Cavico Tan My SHPP	2012	6	Cavico Corporation (100% / Vietnam)
INTRACOM Ta Loi 2 SHPP	2012	10.5	Infrastructure Investment and Transportations C (INTRACOM) (100% / Vietnam)
Nam Xay Noi II SHPP	2012	12	Song Da General Construction Company (100%
Dak Nong II SHPP	2012	14.6	Viet Nguyen Construction Works (100% / Vietr
Nam Si Luong 4 Hydropower Plant	2012	15.6	Cavico Corporation (.. / Vietnam)
Song Chay V SHPP	2012	16	Song Da General Construction Company (100%
Song La III HPP	2012	18	Song Lo 3 Hydropower JSC (100% / Vietnam)
Sovico Son Tay HPP	2012	18	SOVICO Holdings (100% / Vietnam)
Ban Ve Nam Non HPP	2012	20	Ban Ve Hydropower JSC (100% / Vietnam)
Minh Luong SHPP	2012	22.5	Minh Luong Hydro Power JSC (100% / Vietnan
VRG Dak Sin I SHPP	2012	27	Vietnam Rubber Group (VRG) (100% / Vietnar

Source: Wolrd Bank 2013, newspaper reports

Table A6.3. Actual commercial operations date v's planned PDP VI

Planned COD	Project	Type	Capacity (MW)	Actual COD
2006	Se San 3	Hydro	260	2006
	Se San 3A	Hydro	54	2006
	Srok Phumienng	Hydro	51	2006
2007	Cao Ngan	Coal	100	2006
	Unong Bi 1 extension	Coal	300	2007
	Se San 3A-2	Hydro	54	2007
	Quang Tri	Hydro	64	2007
	Ca Mau 1	Gas	750	2008
	Tuyen Quang 1	Hydro	114	2008
	Dai Ninh	Hydro	300	2008
2008	Ca Mau 2	Gas	750	2008
	Nhon Trac 1	Gas	450	2008
	Tuyen Quang 2, 3	Hydro	228	2008
	A Vuong	Hydro	210	2008
	Son Dong	Coal	220	2009
	Pleikrong 1	Hydro	50	2009
	Song Ba Ha	Hydro	220	2009
	Buon Kuop	Hydro	280	2009
	Hai Phong 1-1	Coal	330	2010
	Pleikrong 2	Hydro	50	2010
	Ban Ve 1	Hydro	150	2010
2009	O Mon 1-1	Gas	300	2009
	Buon Tua Sah	Hydro	86	2009
	Se San 4 - 1	Hydro	120	2009
	Cam Pha 1	Coal	300	2010
	Quang Ninh 1-1,2	Coal	600	2010
	Ban Ve 2	Hydro	150	2010
	Cua Dat	Hydro	97	2010
	Dong Nai 3-1,2	Hydro	180	2010
	Song Con 2	Hydro	63	2010
	Hai Phong 1-2	Coal	300	2011
	An Khe Kanak	Hydro	173	2011
	Mao Khe 1	Coal	220	2012
	Nong Son	Coal	30	2012
	Hai Phong 2-1	Coal	300	2013
2010	Srepok 3	Hydro	220	2010
	Se San 4-2,3	Hydro	240	2010
	Son La 1	Hydro	400	2010
	Quang Ninh 2-1	Coal	300	2011
	Cam Pha 2	Coal	300	2011
	Nhon Trach 2	Gas	750	2011

Song Tranh 2	Hydro	190	2011
Na Le	Hydro	90	2011
Dak Rtih	Hydro	141	2011
Se San 4A	Hydro	63	2011
Dong Nai 4	Hydro	340	2011
Se Kaman 3	Hydro	248	2011
Vung Anh 1-1	Coal	600	2013
Mao Khe 2	Coal	220	2013
Hai Phong 2-2	Coal	300	2014
O Mon 1-2	Gas	200	2014
Thac Mo extension	Hydro	75	2015

Source: JETRO 2010, newspaper reports, interviews. Note: records in shaded cells denote delayed projects.

A6.4 Additional information

Table A6.6. List of other sources**

Source	Date	Location	Form of communication	Interviewee*
1	10 June 2010	Hanoi	Personal interview	A
2	11 June 2010	Hanoi	Personal interview	B
3	11 June 2010	Hanoi	Personal interview	C
4	22 July 2010	Hanoi	Personal interview	D
5	23 July 2010	HCMC	Phone interview	E
6	23 July 2010	HCMC	Phone interview	F
7	8 August 2010	N/A	Personal communication	E
8	11 October 2010	Hanoi	Personal interview	D
9	14 October 2010	Hanoi	Personal interview	C
10	25 October 2010	Hanoi	Personal interview	G
11	28 October 2010	Hanoi	Personal interview	H
12	28 October 2010	Hanoi	Personal interview	I
13	11 November 2010	N/A	Personal communication	G
14	13 November 2010	N/A	Personal communication	J
15	20 December 2010	N/A	Personal communication	K
16	9 January 2011	N/A	Personal communication	L
17	11 July 2011	Hanoi	Personal interview	M
18	11 July 2011	Hanoi	Personal interview	N
19	12 July 2011	Hanoi	Personal interview	C
20	12 July 2011	Hanoi	Personal interview	O
21	19 July 2011	N/A	Personal communication	M
22	23 July 2011	N/A	Personal communication	P
23	1 August 2011	N/A	Personal communication	Q
24	8 August 2011	N/A	Personal communication	M
25	27 February 2013	Siem Reap	Personal interview	R
26	28 February 2013	Siem Reap	Personal interview	S
27	1 March 2013	Siem Reap	Personal interview	T
28	12 June 2013	N/A	Personal communication	C
29	16 August 2013	N/A	Personal communication	R
30	18 August 2013	N/A	Personal communication	R

* Interviews, phone conversations and personal communications were held with a range of key informants between 2010 and 2013 relating to the political economy of the ESI in Vietnam. Informants consisted i) Vietnamese policy advisors and technical staff from government agencies these interviews; ii) Vietnamese consultants and technical experts; iii) Vietnamese academics; iv) International technical experts; v) Donor agency staff; and, vi) International finance and PPP specialists. Given the sensitive nature of the topic and the political environment in Vietnam the anonymity of all informants has been protected.
** Note, these are referenced in the text in footnotes referring to this table and the interview number.