Sustainable energy systems in the making: A study on business model adaptation in incumbent utilities

Guillermo Ivan Pereira * [a c], Eva Niesten [b], and Jonatan Pinkse [a]

[a] Manchester Institute of Innovation Research (MIOIR)

Alliance Manchester Business School, The University of Manchester

Booth Street West, Manchester, M15 6PB, United Kingdom

[b] SKEMA Business School – Université Côte d'Azur

Campus Grand Paris - 5, Quai Marcel Dassault

92150, Suresnes, France

[c] Norwich Business School, University of East Anglia

Earlham Road, Norwich NR4 7TJ, United Kingdom

(g.pereira@uea.ac.uk; eva.niesten@skema.edu; jonatan.pinkse@manchester.ac.uk)

* Corresponding author: Guillermo Ivan Pereira, g.pereira@uea.ac.uk, Norwich Business School, University of East Anglia, Earlham Road, Norwich NR4 7TJ, United Kingdom.

Sustainable energy systems in the making: A study on business model adaptation in incumbent utilities

Abstract

Delivering a low-carbon future depends significantly on the decarbonization of the electricity industry. Increasingly, electric utilities have experienced pressure to redefine their business model amid the need to transition to a sustainable energy system. In this study, we focus on how utilities have changed their business model to adapt to the emergence of sustainable energy innovations in the energy system and which value creation drivers they draw on. By framing the business model as an activity system, we capture how utilities expand the boundaries of their business to integrate sustainable energy activities. We analyze 756 boundary-spanning transactions (mergers and acquisitions, joint ventures, and strategic alliances) of 20 European utilities from 1990 to 2019. We find that utilities pursued 20 distinct sustainable energy activities across renewable electricity generation, smart electricity management, emerging technologies, and sustainable mobility. Preference for renewable energy activities, particularly wind generation is observed. The combination of renewable electricity generation and smart electricity management indicates a focus on systems integration. We also find preference for integrating activities through mergers and acquisitions. Utilities focus on acquiring sustainable energy activities leading to a novel bundling of activities contributing to decarbonization while reinforcing the efficiency and lock-in of their traditional business model.

Keywords

Utilities; Sustainable energy systems; Business model adaptation; Activity systems; Boundary-spanning transactions, mergers and acquisitions, joint ventures, strategic alliances; Europe.

1. Introduction

Widespread evidence of climate change's adverse impacts on society has been a driving force behind climate and energy policy that aims for a transition to a low-carbon economy (Goldemberg & Prado, 2010; Sanford, Frumhoff, Luers, & Gulledge, 2014). In the electricity industry, policy guidance and pressure have contributed to the emergence of sustainable energy innovations that support the decarbonization, digitalization, and decentralization of the energy system (Di Silvestre, Favuzza, Riva Sanseverino, & Zizzo, 2018). These innovations include renewable electricity generation technologies, often decentralized; smart grid technologies and electricity management systems that enable demand flexibility; and storage technologies that allow for greater value to be extracted from intermittent renewable energy sources (Erlinghagen & Markard, 2012; International Energy Agency, 2017; Soares et al., 2018). To decarbonize this industry, technological innovations also require a systems transition which creates an enabling environment to invest in infrastructure, develop new markets, and steer behavioral change of consumers (Geels, Sovacool, Schwanen, & Sorrell, 2017; Wainstein & Bumpus, 2016; World Economic Forum, 2012).

Incumbent utilities are central actors in this systems transition. With a traditional utility business model based on vertical integration of centralised fossil-fuel power plants and transmission and distribution networks to supply electricity to customers (Bryant, Straker, & Wrigley, 2018; Frei, Sinsel, Hanafy, & Hoppmann, 2018), they operate at the interface of the traditional electricity infrastructure and sustainable energy innovations which change how electricity is produced, delivered, managed, and used. While utilities can support a low-carbon transition, they also try to keep competition at bay from new entrants specialized in sustainable energy innovations (Schaltegger, Lüdeke-Freund, & Hansen, 2016). Due to technological, operational, and strategic lock-ins and associated path dependencies, utilities tend to have difficulties with the adoption of such innovations (Erlinghagen & Markard, 2012; Richter, 2013; Verbong & Geels, 2010). The growth of solar PV installed at consumer premises has led to speculation of a utility death spiral of declining revenues if consumers become independent for their power needs (Kind, 2013). Because their current business model seems ill-equipped to deliver on a decarbonization agenda, utilities face growing pressure to redefine their position in a changing industry that comprises an increasing number of sustainable energy technologies and actors deploying them. While there is widespread agreement about the need for business model innovation, it is not clear how new business models will allow utilities to decarbonize without a (temporary) decline in revenues.

A growing literature has studied the role of business models to understand how firms navigate the energy transition (Bohnsack, Pinkse, & Kolk, 2014; Pereira, Specht, Silva, & Madlener, 2018; Vernay, Sohns, Schleich, & Haggège, 2019). Studies have analyzed emerging business models for sustainable energy, focusing on electric vehicles (Bohnsack & Pinkse, 2017; Bohnsack et al., 2014), solar PV technology (Vernay, Sohns, Schleich, & Haggège, 2019), smart grids (Niesten & Alkemade, 2016; Shomali & Pinkse, 2016), distributed energy resources (Burger & Luke, 2017), and demand response and energy efficiency (Behrangrad, 2015; Horváth & Szabó, 2018). These studies provide an outline of what sustainable energy business models might look like by identifying how value is created, delivered, and captured. The literature on sustainable business models provides further insight into how utilities can use business model innovation to deliver sustainable energy (Boons & Lüdeke-Freund, 2013; Schaltegger et al., 2016). Bocken, Short, Rana, and Evans (2014) refer to substitution with renewables and moving from product to service provision as sustainable business model archetypes for utilities. This literature also shows how firms can transform their business model to make it more sustainable. Sommer (2012) and Roome and Louche (2016) explain how firms developed new business models for sustainability by opening the black box of organizational transformation. However, they view business model transformation mainly as a process where new business models are designed internally.

As utilities are part of a wider energy system, a focus on internal organizational transformation does not fully capture the business model innovation challenge. Engaging in sustainable energy activities, such as solar photovoltaic (PV) and data-driven customer engagement devices like in-home displays and smart meters, not only involves a transformation of the internal organization but also an adaptation to activities of other actors who also shape the changing energy system. As utilities' competitive position gets disrupted, they need to adapt their business model to keep up with changes in the energy system. Existing value creation drivers will no longer be fit for purpose in a system where new actors and technologies have gained a foothold. In this paper, therefore, we ask the following questions:

- How have utilities changed their business model to adapt to the emergence of sustainable energy innovations in the energy system?
- Which value creation drivers do utilities draw on when adapting their business models to sustainable energy innovations?

To address these questions, we analyze empirically how utilities have adapted their business models by fitting in a wide range of sustainable energy activities. Conceptually, we draw on Zott and Amit's (2010) framing of business models as activity systems. They consider a business model as “a system of interdependent activities that transcends the focal firm and spans its boundaries. The activity system enables the firm, in concert with its partners, to create value and also to appropriate a share of that value” (p. 216). From an activity system perspective, business model innovation involves adding novel activities, linking activities in novel ways, or changing the actors involved in performing any of the activities (Amit & Zott, 2012). Applying it to a systems transition suggests that firms need to continuously make changes to their business model to let it adapt to new activities of other actors because their own activities are interdependent with these. When new entrants introduce sustainable energy activities, for example, they change part of the energy system and push others in the system to reconsider their own boundaries and either integrate these activities or link with them in novel ways. We therefore consider business model adaptation as a process of engaging in boundary-spanning transactions that change the activity system. To analyze business model adaptation, we focus on the boundary-spanning transactions of twenty European utilities using data on mergers and acquisitions (M&As), joint ventures (JVs), and strategic alliances (SAs) over a period of three decades (1990-2019). We investigate which sustainable energy activities utilities invest in (*content*), how activities are linked and sequenced (*structure*), and who performs these activities (*governance*). Building on these insights we identify the main value creation drivers that utilities draw on when adapting the activity system underlying their business models.

2. Literature review

2.1. The disruption of electric utilities

Utilities with an incumbent position in electricity markets need to understand how to navigate the dynamics of the energy transition. Policy pressure to deliver significant emissions reductions and the growing deployment of sustainable energy innovations challenge existing operations and business models. Distributed energy resources represent a significant disruption because they alter the characteristics of electricity supply and demand. On the supply side, rooftop solar and combined heat-and-power plants offer new methods of electricity generation. On the demand side, the uptake of electric vehicles, demand-side management through demand response programs, and the roll-out of behavioral change initiatives alter electricity demand (Athawale & Felder, 2016). Sustainable energy technologies’ growing potential has created uncertainty about what investments to make and what business model to aim for (Tayal, 2016). For utilities, balancing a capital-intensive electricity system in which service reliability is central with the possibilities of new technologies and services that can change patterns of electricity production and consumption poses a significant challenge for how to navigate to a new business model (Richter, 2013).

Due to the regulatory, technological, and societal interdependencies of delivering electricity safely, reliably, and cost-effectively, while supporting the need for deep decarbonization, adapting utilities is a complex endeavor. Utilities find themselves at a crossroads as they need to balance security of supply with the need to decarbonize their activities. Even if governments can provide some financial protection to make this adaptation happen more smoothly (Raskin, 2014), utilities will have to find ways to make deploying sustainable energy technologies financially viable, also without government support (Graffy & Kihm, 2014). A business model perspective reveals how this adaptation occurs. It allows for a systematized analysis of how value is being created, delivered, and captured (Zott, Amit, & Massa, 2011) . Analyzing changes to the business model provides insight into how firms strategically respond to technological and regulatory shocks (Casadesus-Masanell & Ricart, 2010; Shafer, Smith, & Linder, 2005). As disruptive forces unravel the traditional role and position of utilities, the need to improve our understanding of how they adapt their business model has amplified, which has led to a body of knowledge at the intersection of the energy transition, utilities, and sustainable business model literatures.

2.2. Utilities' business models in a changing industry

Previous studies have contributed valuable insights to our understanding of utilities' business models in a changing electricity industry. Richter (2013), for example, studied how German utilities invested in renewable energy, considering consumer-sited renewable energy technology arrangements. Bryant et al. (2018) reviewed business models of European, Australian, and Asian utilities, focusing on their engagement with intermittent renewable energy sources. They identified four new business models: the Green Utility, the Cooperative Utility, the Prosumer Utility, and the Prosumer Facilitator. Hannon, Foxon, and Gale (2013) analyzed the role of energy service companies in the UK and found that technological and institutional change could provide a more favorable environment for energy service companies to contribute to a low-carbon energy system. Helms, Loock, and Bohnsack (2016) studied timing-based business models, focusing on Switzerland, to understand the possibilities for flexibility creation, considering the growing shares of intermittent solar and wind generation. Hall and Roelich (2016) identified business model archetypes for UK local electricity supply, elaborating on value creation and capture, while identifying market barriers. Helms (2016) studied utilities' challenges to transition to service-oriented business models, drawing on cases from Germany and Switzerland. These studies highlight the relevance of analyzing business models when decarbonizing the energy system (Burger & Luke, 2017; Engelken, Römer, Drescher, Welpe, & Picot, 2016). However, they provide a fairly static picture of what business models for sustainable energy look like and provide limited insight into how utilities change their business model to decarbonize business activities.

What is lacking is a more comprehensive understanding of how utilities' business model adaptation to the transition of the energy system unfolds over time. We found only a few studies that provide a more dynamic perspective. For example, Burger and Weinmann (2016) analyzed the adaptation strategies of European utilities and identified two main pathways: internationalization by expanding into growing markets to pursue renewable energy generation opportunities and evolution to service-oriented business models by participating in the management of decentralized assets and information from increased digitalization. Frei et al. (2018) applied a portfolio approach. They considered a broad range of sustainable energy technologies, services, and regions and found an increased focus on decarbonization, decentralization and servitization, as well as system integration and balancing, with decarbonization as main priority.

The sustainable business model literature also provides insight into the dynamics of business model transformation but does not exclusively focus on the energy transition. Sommer (2012) developed a business model transformation framework which presents transformation as an interaction between changes in the business logic and content and individuals' mental models, emotions, and actual behavior. It considers business model transformation as a deliberate process where managers set out a clear vision for how they will change their business model and it focuses on the internal processes of organizational transformation. Roome and Louche (2016) criticized Sommer's model, stating that it only explains business model transformation when the direction of travel is clear from the outset. Based on a study of two firms that tried to create economic value in ways that also contribute to sustainable development, they developed an alternative framework. While their framework stresses the emergent nature of business model transformation – i.e., business models develop in interaction with the different systems in which firms are embedded – it, too, mainly considers changes inside the organization. By contrast, Schaltegger et al. (2016) developed a transformation framework which highlights the interaction between niche pioneers and mass market players in diffusing sustainable business models. In their analysis, they are less interested in how business models of individual firms change, though, but focus instead on the role of sustainable business models in transforming mass markets.

2.3. Activity systems and business model adaptation

To analyze how utilities have changed their business model to adapt to the emergence of sustainable energy innovations in the overarching system, we apply the perspective of business models as activity systems. The activity system encompasses the range of activities associated with a focal firm, including those beyond the boundary of the firm conducted by partners, customers, and vendors. Zott and Amit (2010) conceptualize the business model as a system of interdependent activities resulting from boundary-spanning transactions. This perspective implies that business model adaptation can be seen as a process of engaging in boundary-spanning transactions which change the activity system.

Applying the activity system perspective, value creation results from a combination of business model design elements and drivers. Design elements capture how firms do business and include content, structure, and governance (Zott & Amit, 2010). Content captures the range of activities a firm performs. Structure captures how a firm links and sequences activities. Governance captures who performs the activities. Drivers refer to the firm's dominant sources of value creation. These can result from different configurations of design elements and include novelty, lock-in, complementarity and efficiency. Novelty is related to the adoption of new activities, new ways of linking and sequencing activities, and new roles in performing these activities (Amit & Zott, 2012). Lock-in is related to activities that aim to retain the involvement of existing stakeholders and rely on existing value creation mechanisms. Complementarity focuses on the bundling of activities to increase the potential for value creation. Efficiency is related to the organization of activities to minimize transaction costs for the firm (Zott & Amit, 2010).

The activity system provides a structured framework to study business model adaptation in the context of the energy transition (Hellström, Tsvetkova, Gustafsson, & Wikström, 2015). A limited number of studies have applied the activity system perspective to study the energy transition. Hellström et al. (2015), for example, studied how Finnish firms operating distributed energy services and technologies engage with other firms to collaborate and create value. Bolton and Hannon (2016) investigated the relationship between business models and sociotechnical transitions for UK energy service companies that deployed combined heat and power with district heating infrastructure. The activity system is the conceptual foundation of our study. It provides a set of specific elements (i.e., content, structure, and governance) which are central to our analysis of business model adaptation. To study adaptation, we focus on boundary-spanning transactions in the form of mergers and acquisitions (M&As), joint ventures (JVs), and strategic alliances (SAs). Firms use these transactions to expand their operations, explore new markets, or acquire capabilities (Hagedoorn & Duysters, 2002; Yin & Shanley, 2008). By analyzing the details of these transactions, we capture changes in the activity system and gain a detailed understanding of business model adaptation.

3. Methodology

3.1. Research design and sample

We focus on utilities operating in the European Union (EU). Notwithstanding the country-level idiosyncrasies on energy resource endowments, infrastructure, ownership structures, and policies, during our study period the EU has been implementing policies to deliver an internal energy market. These policies aim to support convergence and integration of market designs and infrastructure interconnection across countries (European Union, 2020). Hence, we analyze utilities that have experienced similar policy shifts which include two main structural reforms. An initial reform focused on achieving a competitive electricity industry through liberalization, gradually implemented since the mid-1990s, followed by an ongoing reform focused on achieving a low-carbon economy through the delivery of a more sustainable electricity industry (Pereira, Silva, & Soule, 2018). To analyze firm-level transactions data (M&As, JVs, and SAs), we operationalize 'sustainable energy activities' as activities resulting from transactions between firms that can be associated with the delivery of a more sustainable energy system by contributing towards decentralization, decarbonization, or digitalization, which are considered the main drivers transforming the electricity industry (Di Silvestre et al., 2018).

The sample aims to be representative of utilities with historical operations based on the traditional utility business model. This traditional business model focused on generating revenue through selling electricity to end-consumers, produced mainly in large-scale, non-renewable power plants. The core service of this business model is the supply of electricity to consumers via a network infrastructure. This traditional business model has a value proposition centered on electricity generation and supply that emphasizes affordability, efficiency, and reliability (Bryant et al., 2018; Frei et al., 2018).

Our sample includes a subset of the largest European utilities. These were selected considering the top utilities listed in European utility-specific investment indices. We also reviewed recent industry reports that focus on analyzing utilities and the power industry. We considered indices as a relevant source given that these are analytical tools and describe a specific market, providing guidance for decision-makers (Lo, 2016). We selected the top 10 utilities in terms of market capitalization on the MSCI Europe utilities index as of May 31st, 2019 (MSCI, 2019), and the top 10 utilities on the STOXX Europe 600 Utilities index as of May 31st, 2019 (STOXX, 2019). We complemented the list of utilities thus obtained with insights from S&P Market Intelligence reports (S&P Global, 2017, 2018a, 2018b). This process resulted in the inclusion of Vattenfall AB, from Sweden, an established utility that did not appear in the selected indices because it is not publicly traded. The combination of sources yielded a sample of 20 utilities from 11 EU countries, representing a range of medium to large utilities in terms of market capitalization based on the S&P Capital IQ database, with medium ranging from $2 to $10 US billion market capitalization, and large including firms above $10 US billion (S&P Capital IQ, 2020b). For validation, we compared our sample with the utilities analyzed in Bryant et al. (2018). We found that 17 of our 20 utilities were also included in their study and classified as traditional utilities while National Grid, Naturgy, and Veolia were not included. We include them in our sample given their traditional utility activities, as confirmed from S&P's Capital IQ Company Intelligence database. Table 1 provides details for the utilities in our sample.

Table 1 Utilities sample, data from S&P Capital IQ (S&P Capital IQ, 2020a), and Refinitiv's SDC Platinum (Refinitiv, 2020)

	Utilities characteristics		**Traditional energy transactions**				**Sustainable energy transactions**			
Utility *(Utility Label)* / Country headquartered in	**Market Cap. M US Dollars 2018**	**Total Revenue M US Dollars 2018**	**M&A *(%)***	**JV *(%)***	**SA *(%)***	**Total**	**M&A *(%)***	**JV *(%)***	**SA *(%)***	**Total**
Centrica plc *(CENTRICA) / United Kingdom*	10,127.50	39,160.50	141 (89.8%)	5 (3.2%)	11 (7.0%)	**157**	29 *(93.5%)*	0 -	2 *(6.5%)*	**31**
CEZ, a. s. *(CEZ) / Czech Republic*	12,580.80	7,986.30	49 (84.5%)	8 (13.8%)	1 (1.7%)	**58**	16 *(100.0%)*	0 -	0 -	**16**
E.ON SE *(EON) / Germany*	20,727.30	33,214.00	470 (86.1%)	56 (10.3%)	20 (3.7%)	**546**	57 *(78.1%)*	9 *(12.3%)*	7 *(9.6%)*	**73**
EDP - Energias de Portugal, S.A. *(EDP) / Portugal*	12,286.50	16,938.00	100 (96.2%)	1 (1.0%)	3 (2.9%)	**104**	35 *(94.6%)*	1 *(2.7%)*	1 *(2.7%)*	**37**
Electricité de France S.A. *(EDF) / France*	46,002.50	76,470.10	222 (74.5%)	48 (16.1%)	28 (9.4%)	**298**	64 *(76.2%)*	10 *(11.9%)*	10 *(11.9%)*	**84**
EnBW Energie Baden-Württemberg AG *(ENBW) / Germany*	8,768.30	22,970.70	86 (89.6%)	6 (6.3%)	4 (4.2%)	**96**	24 *(82.8%)*	3 *(10.3%)*	2 *(6.9%)*	**29**
Enel SpA *(ENEL) / Italy*	56,852.30	81,861.40	272 (89.2%)	15 (4.9%)	18 (5.9%)	**305**	72 *(77.4%)*	3 *(3.2%)*	18 *(19.4%)*	**93**
ENGIE SA *(ENGIE) / France*	33,165.20	67,179.60	215 (88.8%)	20 (8.3%)	7 (2.9%)	**242**	104 *(83.9%)*	10 *(8.1%)*	10 *(8.1%)*	**124**
Fortum Oyj *(FORTUM) / Finland*	18,809.80	5,912.40	93 (91.2%)	6 (5.9%)	3 (2.9%)	**102**	11 *(78.6%)*	2 *(14.3%)*	1 *(7.1%)*	**14**
Iberdrola, S.A. *(IBERDROLA) / Spain*	49,187.60	38,886.80	137 (79.7%)	23 (13.4%)	12 (7.0%)	**172**	48 *(85.7%)*	3 *(5.4%)*	5 *(8.9%)*	**56**
innogy SE *(INNOGY) / Germany*	25,086.20	39,218.40	10 (100.0%)	0 -	0 -	**10**	13 *(86.7%)*	0 -	2 *(13.3%)*	**15**
National Grid plc *(NATIONAL GRID) / United Kingdom*	34,262.20	19,685.80	78 (72.2%)	18 (16.7%)	12 (11.1%)	**108**	3 *(33.3%)*	2 *(22.2%)*	4 *(44.4%)*	**9**
Naturgy Energy Group, S.A. *(NATURGY) / Spain*	24,535.90	26,983.40	120 (87.0%)	4 (2.9%)	14 (10.1%)	**138**	8 *(88.9%)*	0 -	1 *(11.1%)*	**9**
Ørsted A/S *(ORSTED) / Denmark*	27,151.70	11,204.00	26 (96.3%)	1 (3.7%)	0 -	**27**	20 *(83.3%)*	3 *(12.5%)*	1 *(4.2%)*	**24**
RWE Aktiengesellschaft *(RWE) / Germany*	12,913.00	14,892.50	510 (88.9%)	45 (7.8%)	19 (3.3%)	**574**	70 *(87.5%)*	7 *(8.8%)*	3 *(3.8%)*	**80**
SSE plc *(SSE) / United Kingdom*	14,598.20	17,916.20	29 (93.5%)	0 -	2 (6.5%)	**31**	9 *(69.2%)*	2 *(15.4%)*	2 *(15.4%)*	**13**
Uniper SE *(UNIPER) / Germany*	9,169.30	86,757.20	1 (25.0%)	3 (75.0%)	0 -	**4**	0 -	0 -	0 -	**0**
Vattenfall AB *(VATTENFALL) / Sweden*	-[a]	16,289.10	158 (89.3%)	13 (7.3%)	6 (3.4%)	**177**	16 *(72.7%)*	1 *(4.5%)*	5 *(22.7%)*	**22**
Veolia Environnement S.A. *(VEOLIA) / France*	11,006.30	28,726.30	254 (92.0%)	14 (5.1%)	8 (2.9%)	**276**	16 *(84.2%)*	1 *(5.3%)*	2 *(10.5%)*	**19**
VERBUND AG *(VERBUND) / Austria*	14,343.40	3,165.00	25 (83.3%)	5 (16.7%)	0 -	**30**	7 *(87.5%)*	1 *(12.5%)*	- *(0.0%)*	**8**
		Total	**2996 (86.7%)**	**291 (8.4%)**	**168 (4.9%)**	**3455**	**622 *(82.3%)***	**58 *(7.7%)***	**76 *(10.1%)***	**756**

[a] Not publicly traded

3.2. Data collection and analysis

To conduct our analysis, we collected data on M&As, JVs, and SAs from January 1990 to June 2019. We obtained the data from Refinitiv's Securities Data Company (SDC) Platinum database, which provides detailed historical transaction data (Refinitiv, 2020), and we identified 7003 transactions. From the data available for each transaction, we identify the utility, the type of transaction (M&A, JV, or SA), and the year of the transaction. The SDC Platinum did not directly identify the transactions associated with sustainable energy activities. We therefore conducted a pre-analysis for each transaction and classified it according to (1) the activity segment and (2) the activity type.[1] We divided the activity segment in two groups. The ‘traditional business group’, associated with the traditional utility business model, and the ‘sustainable energy group’, associated with transactions for sustainable energy activities. We filtered out non-electricity-industry-related transactions and removed transactions presented as ‘pending’ or ‘intended’ and focused our analysis on those reported as ‘completed’ in the SDC Platinum. Through this process we identified a total of 756 transactions in the ‘sustainable energy group’, which form the data used for our analysis, and 3455 transactions in the ‘traditional energy group’. We then classified each transaction according to its specific activity type to provide more granularity on the activity content and identified 20 individual activity types in the ‘sustainable energy group’ (see Table 2).

We first analyze the utilities’ activity system design elements (i.e., content, structure, and governance) (section 4) and then discuss the utilities’ dominant sources of value creation (section 5). In terms of the design elements, we analyze the activity content and how it evolves over time to identify utility preferences for specific ‘activity types’ and ‘activity themes’ when adapting their business models. The 20 activity types are distributed across four themes. These themes capture the changes sustainable energy innovations bring to how electricity is produced, delivered, managed, and used. The ‘Renewable Electricity Generation (REG)’ theme reflects activities related to electricity production from renewable energy resources, a key aspect of delivering a decarbonized electricity industry. This theme combines activities related to electricity production from renewable energy sources, including wind, solar, and biomass, to name a few (see Table 2). The ‘Smart Electricity Management (SEM)’ theme reflects activities related to how electricity is delivered and managed. This theme combines activities related to demand response/demand side management, and smart grids, meters, homes and cities (see Table 2). The ‘Emerging Technologies (ET)’ theme is cross-cutting and reflects activities in the initial stages of development or deployment across the electric utility supply chain. This theme combines activities related to electricity production from hydrogen as well as electricity delivery and management through storage (see Table 2). The ‘Sustainable Mobility (SM)’ theme reflects a change in how electricity is used resulting from the

[1] The analysis consisted of two steps. The first step considered the summary description of each transaction from Refinitiv’s SDC Platinum data. When the information available was enough to classify the (1) activity segment and the (2) activity type, the process ended. When the description of the transaction obtained was not sufficient, a second step was conducted, in which the firm involved in the M&A was searched on S&P’s Capital IQ Company Intelligence database, or the JV and SA details were searched on publicly available utility communications to confirm the activity’s details.

ongoing uptake of electric vehicles and other forms of electric mobility, which displace internal combustion engines and result in a new electricity use that changes electricity demand.

Building on the activity content information, we analyze activity structures by considering how utilities link and sequence activities over time. To capture activity links, we consider how utilities combine activity types and themes. To capture activity sequence, we consider the order in which utilities select activity types and themes and distinguish *‘within-theme’* from *‘between-theme’* activity structures. We analyze activity governance by focusing on who performs the activities selected, considering the number and type of transactions (M&A, JV or SA).

Table 2 Activity content and structures

		Activity content		
Relates to sustainability transition changes impacting electricity	Production	Delivery and management	Cross-cutting	Use and demand
Activity themes	Renewable electricity generation (REG)	Smart electricity management (SEM)	Emerging technologies (ET)	Sustainable mobility (SM)
Activity types	– Biomass – Biomethane – Distributed combined heat and power – Generation from solar – Generation from waves – Generation from wind – Geothermal – Multi-renewable	– Asset management – Demand response/Demand side management – Energy efficiency – Facilities management – Smart grids, meters, homes, cities	– Carbon capture and storage – Electricity storage – Fuel cells – Heat pump – Hydrogen – Research and development	– Mobility, and electric vehicles
		Activity structure		
‘Between theme’ **Activity Structures**	Renewable electricity generation (REG)	Smart electricity management (SEM)	Emerging technologies (ET)	Sustainable mobility (SM)
1	√	√		
2		√	√	
3			√	√
4	√			√
5		√		√
6	√		√	
7	√	√	√	
8		√	√	√
9	√		√	√
10	√	√		√
11	√	√	√	√

4. Utilities’ activity system design elements

In this section, we present the findings from our analysis of activity content, structure, and governance. The aim is to provide insight into how boundary-spanning transactions related to sustainable energy activities have adapted the business models of utilities.

4.1. Activity content

The analysis of activity content shows how utilities adapt their business model over time through the selection of sustainable energy activities. Analyzing each transaction, we identified 20 sustainable energy activity types, distributed across four themes: renewable electricity generation, smart electricity management, emerging technologies, and sustainable mobility (see Table 3). We analyze the transactions for each theme and for the main activities within each theme.

Table 3 Activity content, transactions per activity theme and type, from 1990 to 2019, 3-year periods

Activity theme	Activity type	Years										Total (%)
		90/92	93/95	96/98	99/01	02/04	05/07	08/10	11/13	14/16	17/19	
Renewable electricity generation	Wind	1		4	6	25	50	73	38	35	55	287 (54%)
	Solar	1	4		2	3	5	23	12	20	37	107 (20%)
	Multi-renewable [a]				8	4	6	20	11	22	19	90 (17%)
	Biomass	1	2				3	10	5	8	8	37 (7%)
	Wave						1	2	2	1	1	7 (1%)
	Geothermal					1	1			1		3 (1%)
	Biomethane			1							1	2 (0.4%)
	Distributed Combined Heat and Power									2		2 (0.4%)
	Total	**3 (30%)**	**6 (46%)**	**5 (71%)**	**16 (80%)**	**33 (85%)**	**66 (90%)**	**128 (83%)**	**68 (77%)**	**89 (65%)**	**121 (57%)**	**535 (71%)**
Smart electricity management	Energy Efficiency	3			1	2	1	9	8	16	18	58 (42%)
	Smart grids, meters, homes, cities					1		2	4	9	21	37 (27%)
	Demand response/Demand Side Management						3	7	2	9	7	28 (20%)
	Facilities management		1		1		3	2		2	4	13 (9%)
	Asset Management									1	2	3 (2%)
	Total	**3 (30%)**	**1 (8%)**		**2 (10%)**	**3 (8%)**	**7 (10%)**	**20 (13%)**	**14 (16%)**	**37 (27%)**	**52 (24%)**	**139 (18%)**
Emerging technologies	Research and development	4	5	1	2					2	4	18 (46%)
	Storage			1				2		3	5	11 (28%)
	Hydrogen					2		1			3	6 (15%)
	Fuel cells							1	1			2 (5%)
	Carbon capture and storage								1			1 (3%)
	Heat pump							1				1 (3%)
	Total	**4 (40%)**	**5 (38%)**	**2 (29%)**	**2 (10%)**	**2 (5%)**		**5 (3%)**	**2 (2%)**	**5 (4%)**	**12 (6%)**	**39 (5%)**
Sustainable mobility	Mobility, and electric vehicles		1			1		2	4	6	29	43 (100%)
	Total		**1 (8%)**			**1 (3%)**		**2 (1%)**	**4 (5%)**	**6 (4%)**	**29 (14%)**	**43 (6%)**
	Total	**10**	**13**	**7**	**20**	**39**	**73**	**155**	**88**	**137**	**214**	**756**

[a] Transactions included in the multi-renewable activity type encompass transactions with a firm operating multiple renewable electricity generation technologies, such as a combination of wind and solar generation assets.

4.1.1. Renewable electricity generation

The renewable electricity generation theme represents the largest proportion of transactions over time. This theme has the largest share of transactions from 1993 to 2019, reaching its maximum in the period 2005-2007 with 90% of the transactions (see Table 3). The transactions in this theme represent 71% of all transactions identified. The prevalence of renewable electricity generation activities emphasizes their importance in the transformation of utilities.

Wind, solar, and multi-renewable activities represent 90% of this theme's transactions. Wind generation is the leading activity with 38% of the total transactions (see Figure 1). This leading role of wind generation was also found in previous studies analyzing renewable energy investments (Eyraud, Clements, & Wane, 2013; Masini & Menichetti, 2013; Mazzucato & Semieniuk, 2018). Masini and Menichetti (2013) discussed the prevalent role of wind generation in clean energy investments between 2004-2008, accounting for 45% of the total. Mazzucato and Semieniuk (2018) found that wind generation represented 56% of the renewable energy investments in 2004-2014, with utilities as leading investors. Wind generation has been the leading sustainable energy activity throughout our period of analysis, with 57% of the transactions in 1996-1999, and from 2002 onwards, 64% in 2002-2004, 68% in 2005-2007, and 26% in 2017-2019 (see Figure 1). The generation of solar and multi-renewable energy is next in terms of utilities' selection of sustainable energy activities.

Wind generation activities contribute to decarbonizing the electricity industry through a low risk (Mazzucato & Semieniuk, 2018), mature technology (Masini & Menichetti, 2013), initially with significant policy support (Eyraud et al., 2013), while allowing utilities to use some of their existing capabilities and experience (Nisar, Ruiz, & Palacios, 2013). Similar to traditional utility activities associated with fossil-fuel-based electricity generation, or transmission and distribution network assets (Goldthau & Sovacool, 2012), wind generation is capital-intensive (Blanco, 2009; Eyraud et al., 2013). Wind farms are often located away from demand and sized to a significant generation capacity. These aspects make undertaking wind generation similar to centralized generation that utilities have traditionally operated (Langniss, 1996), notwithstanding the variability and intermittency associated with wind generation assets.

The transactions of utilities with firms generating multiple types of renewable energy, such as firms operating both wind and solar generation plants, can be associated with the utilities' uncertainty regarding the most adequate type of renewable electricity generation. Selecting transactions that provide access to multiple types of renewable energy generation can reduce the risk of exposure compared to selecting a specific generation technology (Laurikka, 2008; Wüstenhagen & Menichetti, 2012). This approach also allows for experimentation and learning-by-doing with a wider set of generation types, which can inform the selection of sustainable energy activities in the future. This increased potential for learning-by-doing can contribute to proficiency in different generation types and lead to firm-level adaptations to support the diffusion of more diverse types of renewable energy generation (Sagar & van der Zwaan, 2006). For example, we find that the first transaction in the renewable electricity generation theme for EDF, a French utility, was an M&A targeting SIIF – Energies (*Société Internationale d'Investissements Financiers – Énergies*). At the time of the transaction, in 2000, SIIF had operations in wind and solar electricity generation. SIIF was gradually acquired by EDF and became the foundation of what today is EDF Renewables, EDF's renewable generation arm, with operations in onshore and offshore wind, solar photovoltaics, and the development of new types of generation including marine energy, floating wind, tidal, and energy storage (EDF Renewables, 2020; Refinitiv, 2020).

4.1.2. Smart electricity management

The smart electricity management theme has generally been in second place regarding the number of transactions, representing 30% in 1990-1992, 13% in 2008-2010, and 24% in 2017-2019 (see Table 3). The transactions in this theme represent 18% of the total transactions . Within this theme, 90% of the transactions represent service provision and equipment manufacturing for energy efficiency; smart grids, meters, homes, cities; and demand response/demand side management.

Utilities' engagement in energy efficiency activities was initially driven by the oil crises in the 1970s (Waide & Buchner, 2008). Energy efficiency services allowed utilities to go beyond the provision of electricity in terms of customer engagement (York, Kushler, Hayes, Sienkowski, & Bell, 2013). Energy efficiency services include information campaigns, rebate programs for acquiring more efficient appliances, or building energy management services and give utilities insight into consumer preferences and behavior and help identify value-added needs (Sousa, Martins, & Jorge, 2013; York et al., 2013).

Utilities' selection of smart grids, meters, homes, cities activities indicate their interest to engage in the delivery of smart grid services that add digital communication capabilities, sensors and remote-control devices to electricity systems and enable data-driven approaches for electricity services (Farhangi, 2010). Smart meters, often presented as a central component for delivering smart grids, enjoyed significant policy support in Europe, given their potential to facilitate sustainable energy generation. Activities related to smart grids, meters, homes, cities can also contribute to energy efficiency by offering services that improve access to data and control capabilities and more granular approaches to energy management, creating possibilities for value-added services for consumers (Moura, López, Moreno, & De Almeida, 2013). On aggregate, these two activities – energy efficiency and smart grids, meters, homes, cities – represent a shift of the utilities' business model to a provision of services beyond electricity supply, thus reflecting the sustainable business model archetype of moving from product to service provision (Bocken et al., 2014).

Utilities also pursue demand response/demand side management activities. These activities are considered an evolution of the energy efficiency activities provided before smart grid technologies were deployed (Davito, Tai, & Uhlaner, 2010; Faruqui & Fox-Penner, 2011). Demand response and demand side management let utilities manage consumers' electricity demand to optimize resource availability, such as shifting consumption to hours with greater solar and wind generation or curtailing consumption during exceptional circumstances (Farhangi, 2010; Moura et al., 2013). By pursuing demand response/demand side management, utilities indicate a willingness to integrate smart electricity management as a key component complementing their traditional business model and infrastructure. For instance, demand response/demand side management can reduce the need for investments in infrastructure and enable a better allocation of assets and resources (Klaassen, van Gerwen, Frunt, & Slootweg, 2017; Poudineh & Jamasb, 2014).

4.1.3. Emerging technologies

The activity theme on emerging technologies represents 40% of the transactions in 1990-1992, shifting to 3% in 2008-2010, and 6% in 2017-2019 (see Table 3). The transactions in this activity theme represent 5% of the total transactions .

Within this emerging technologies theme, utilities transact with firms that research, develop and manufacture innovative energy technologies such as hydrogen and storage systems. Research and development activities include utilities' exploratory endeavors that may later result in established technologies and services to enable a transition to sustainable energy systems. The following examples illustrate the kind of research and development activities conducted by utilities, extracted from the data collected on SDC Platinum (Refinitiv, 2020). In 1992, IBERDROLA and ENGIE entered into a strategic alliance "to research new product ideas in electricity and utilities" (Refinitiv, 2020). Likewise, in 1994, ENGIE and Hydro-Quebec formed a strategic alliance "to exchange research and technology. The utility companies agreed to pool their resources on energy efficiency, environmental control and technical areas such as high-tension direct-current links and AC-DC converters" (Refinitiv, 2020). In 2001, RWE acquired Electrosynthesis Co Inc., a provider of chemical and electrochemical research services with energy storage applications (EPRI, 2002; Refinitiv, 2020). More recently, ENEL's 2018 strategic alliance with Intesa Sanpaolo Spa. was established "to support innovation in the energy sector, promote the development of the circular economy and open innovation" (Refinitiv, 2020), focusing on supporting small and medium enterprises in the energy sector in Italy and abroad. This strategic alliance has resulted in support for Aton Storage, an Italian manufacturer of photovoltaic and battery integrated systems for the residential sector (ENEL, 2018).

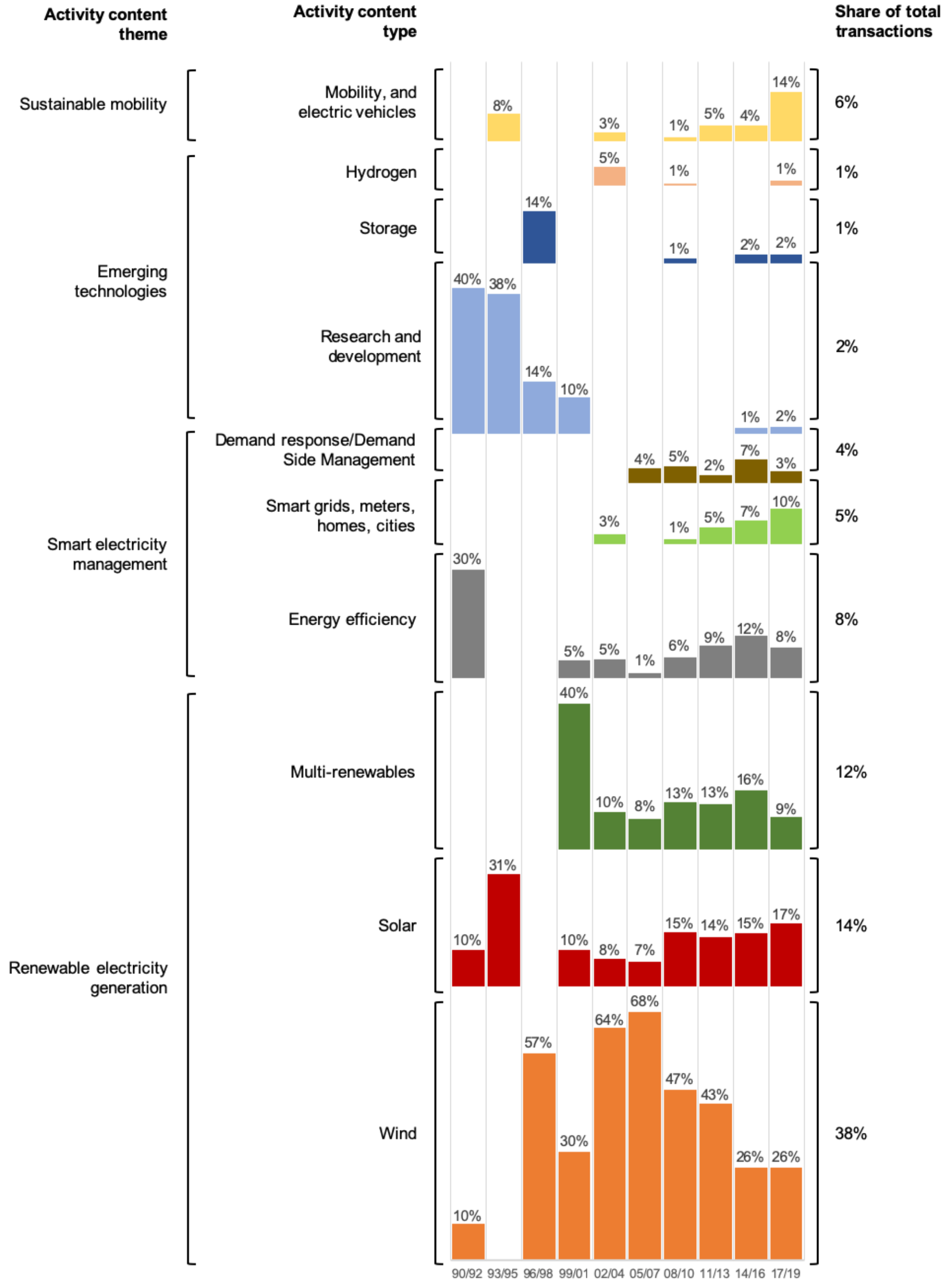
Furthermore, utilities' participation in storage activities can contribute to a greater penetration and more effective use of intermittent renewables, such as wind and solar (Eyraud et al., 2013), which are predominant in utilities. The development of hydrogen activities can contribute to a greater integration of renewables, allowing hydrogen to be produced from renewable electricity and to act as a source of storage, offering a more flexible load to provide, for instance, grid balancing services (IRENA, 2018).

4.1.4. Sustainable mobility

The activity theme on sustainable mobility represents 8% of the transactions in 1993-1995, 1% in 2008-2010, and 14% in 2017-2019 (see Table 3). In total, it represents 6% of the transactions. While this theme focuses on a single activity, mobility and electric vehicles, we present it as a distinct activity theme given the ongoing increase of electric vehicles on the roads (EEA, 2016), and their direct interaction with utilities. This theme includes transactions of utilities with firms that develop and manufacture electric vehicles, charging solutions, and software solutions for vehicle-to-grid or grid-to-vehicle services. Vehicle-to-grid services offer possibilities to use electric vehicle batteries as sources of distributed energy storage (Niesten & Alkemade, 2016), contributing to a better use of renewable energy through the coordination of generation, storage and consumption (Moura et al., 2013). Grid-to-vehicle services focus on the supply of electricity to electric vehicles through the charging infrastructure (Niesten & Alkemade, 2016). Utilities integrating electric vehicles can benefit from lower system operation costs, access to flexible storage, and improved grid stability and management of intermittent renewable generation (Niesten & Alkemade, 2016).

An example of utilities' participation in mobility and electric vehicle activities is DONG Energy (now ORSTED) from Denmark, and its investment and partnership with Better Place in 2008. Better Place, founded in 2007, owned and operated electric vehicle charging infrastructure, batteries, and charging management software in Europe, North America, and Asia (Budde Christensen, Wells, & Cipcigan, 2012; Niesten & Alkemade, 2016). With this investment DONG Energy's CEO aimed "to contribute substantially to reducing CO_2 emissions from Danish cars. At the same time, we will achieve a new way of storing the unstable electricity output from wind turbines, as EVs are typically charged during the night, when the exploitation of power generation is low. This provides optimum exploitation of our resources for the benefit of the environment" (DONG Energy, 2008). However, Better Place went bankrupt in 2013 in the midst of financial difficulties associated with slow electric vehicle market growth and the capital-intensiveness of rolling out a charging infrastructure (Niesten & Alkemade, 2016). In 2014, after the bankruptcy, the interest of utilities in sustainable mobility was observed again with the German utility E.ON acquiring 770 electric vehicle charging stations of Better Place Denmark A/S (Refinitiv, 2020). E.ON's statement at the time indicated the opportunity seen in sustainable mobility activities: "With its climate strategy, the Danish Government has reconfirmed a forward-looking, ambitious objective for the transport sector. There are not many electric cars on the Danish roads yet, but the ambition is there and through close cooperation with decision-makers and companies, I have no doubt that we will see a great development within the electric car area in the years to come" (Copenhagen Capacity, 2014).

Figure 1 Activity content type, main activities, share of transactions, from 1990 to 2019, 3-year periods



4.2. Activity structure

Following Zott and Amit's (2010) definition of activity structure, we analyze how utilities link and sequence sustainable energy activities. Our analysis considers both *'within-theme'* and *'between-theme'* activity structures. The analysis of *'within-theme'* activity structures yields insights into specific activity types linked by the same theme, and the sequence of activity types selected by utilities within each theme. The analysis of *'between-theme'* activity structures reveals how utilities link their participation across activity themes, and the sequence of activity theme combinations. We identified 11 possible *'between-theme'* activity structures, resulting from different combinations of transactions in the four activity themes (see Table 2).

4.2.1. Within-theme activity structure

The analysis of the 'within-theme' activity structure for the renewable electricity generation theme focused on the activities representing 90% of the transactions, as the main activities linked under this theme include wind, solar, and multi-renewable electricity generation. We then analyzed the sequence in which utilities select activities within this theme. Table 4 shows the sequence in which utilities participate in the main activities within renewable electricity generation. This sequence (i.e., 1st activity, 2nd activity, or 3rd activity) indicates the order in which utilities selected the activities. We find that 50% of the utilities select wind generation as their first activity, while 35% make it their second activity. Multi-renewable generation is the first activity for 40% of utilities, while 45% of utilities make it their second or third activity. For 35% of utilities solar generation is their first activity, while it is the second or third activity for 45% of utilities.[2]

Table 5 shows the sequence in which utilities participate in the main activities within the smart electricity management theme. We find that energy efficiency services are the first activity for 50% of the utilities. Activities in the field of smart grids, meters, homes, cities are the first for 30% of the utilities and the second for 20%. For demand response/demand side management we find that 20% of the utilities chose this as their second activity and 10% as their third activity. These findings indicate a gradual development of smart electricity management system capabilities: from building a knowledge base and experience in providing services beyond electricity delivery, through energy efficiency and smart grids, meter, home, city activities to actively managing and integrating demand flexibility in existing electricity systems, through

[2] Summing these % across activities adds up to more than 100% because the same utility can participate in various activities.

demand response/demand side management. This finding is in line with the sequence of activities associated with the deployment of smart grids, where smart meters form the foundation for delivering demand response/demand side management services (Farhangi, 2010).

Table 6**Error! Reference source not found.** shows the sequence in which utilities participate in the main activities in the emerging technologies theme. Within this theme, research and development activities are the first activity for 35% of the utilities. Research and development activities are followed by utilities selecting storage activities, with 20% of utilities selecting them as their first or second activity. The development and production of the innovative technology hydrogen was selected by 20% of the utilities, with no predominant order observed. The sustainable mobility theme is not considered in this section since it contains one activity – mobility and electric vehicles – and therefore no sequence of activity selection can be analyzed.

Table 4 Renewable electricity generation theme, 'within-theme' activities sequence

Activities	Year	Activities sequence		
		1st activity	2nd activity	3rd activity
Wind	90/92	ENGIE		
	93/95			
	96/98	ENEL IBERDROLA	RWE	
	99/01	VATTENFALL		
	02/04	NATURGY	CENTRICA, EDF EON	
	05/07	ORSTED SSE VEOLIA	EDP	
	08/10	ENBW VERBUND		
	11/13			
	14/16		CEZ FORTUM	
	17/19			
		1st activity	2nd activity	3rd activity
Solar	90/92	EON		
	93/95	RWE		
	96/98			
	99/01		IBERDROLA	
	02/04		ENGIE	
	05/07	SSE		EDF ENEL
	08/10	CEZ VERBUND	VATTENFALL VEOLIA	CENTRICA
	11/13	FORTUM		
	14/16	INNOGY	ENBW	
	17/19			ORSTED
		1st activity	2nd activity	3rd activity
Multi-renewable	90/92 … 96/98			
	99/01	CENTRICA EDF EDP VATTENFALL	ENEL	RWE
	02/04			
	05/07	SSE		IBERDROLA EON
	08/10	CEZ ENBW	ORSTED VEOLIA	ENGIE
	11/13			
	14/16		FORTUM NATURGY	

	17/19	NATIONAL GRID

Table 5 Smart electricity management theme, 'within-theme' activities sequence

Activities	**Year**	**Activities sequence**		
		1st activity	**2nd activity**	**3rd activity**
Energy efficiency	**90/92**	EON NATIONAL GRID		
	93/95 **…** **99/01**			
	02/04	CENTRICA VERBUND		
	05/07	VEOLIA		
	08/10	ENGIE VATTENFALL		
	11/13	ENBW		
	14/16	NATURGY RWE	EDF	
	17/19		CEZ	ENEL
		1st activity	**2nd activity**	**3rd activity**
Smart grids, meters, homes, cities	**90/92** **…** **99/01**			
	02/04	ENEL		
	05/07			
	08/10		CENTRICA	
	11/13	EDF	EON	
	14/16	CEZ FORTUM	ENBW	
	17/19	INNOGY ORSTED	ENGIE	RWE VEOLIA
		1st activity	**2nd activity**	**3rd activity**
Demand response/demand side management	**90/92** **…** **02/04**			
	05/07		ENEL	
	08/10		VEOLIA	
	11/13			
	14/16			EON
	17/19		ENGIE NATIONAL GRID	CENTRICA

Table 6 Emerging technologies theme, 'within-theme' activities sequence

Activities	**Year**	**Activities sequence**		
		1st activity	**2nd activity**	**3rd activity**
Research and development	**90/92**	ENGIE IBERDROLA NATIONAL GRID		
	93/95	RWE		
	96/98	VATTENFALL		
	99/01	INNOGY		
	02/04 **…** **14/16**			
	17/19	ENEL		
		1st activity	**2nd activity**	**3rd activity**
Storage	**90/92** **93/95**			
	96/98		ENGIE	
	99/01 **…** **05/07**			
	08/10	ORSTED	RWE	
	11/13 **14/16**			
	17/19	ENEL		
		1st activity	**2nd activity**	**3rd activity**
Hydrogen	**90/92** **…** **99/01**			
	02/04	EON		ENGIE
	05/07			
	08/10		RWE	
	11/13 **14/16**			
	17/19	EDF		

4.2.2. Between-theme activity structure

Building on the insights obtained on the content of the activity themes, we now analyze the *'between-theme'* activity structures. We identify activity links by analyzing how utilities, over time, select and combine transactions across the four activity themes (renewable electricity generation, smart electricity management, emerging technologies, and sustainable mobility). We identify the activity sequence by considering the order in which utilities participate in the different theme combinations. From the 11 possible activity structures (see Table 2), we find that the utilities have transactions in 9 activity structures (see Table 7), which represent 73% of the transactions.[3]

Table 7 'Between-theme' activity structures, transactions per structure, from 1990 to 2019, 3-year periods

Activity structure	Years										
	90/92	93/95	96/98	99/01	02/04	05/07	08/10	11/13	14/16	17/19	Total (%)
1 (REG, SEM)	3	2		2	10	19	42	26	49	3	156 (21%)
2 (SEM, ET)	3										3 (0.5%)
3 (ET, SM)		3									3 (0.5%)
4 (REG, SM)					4			13	5	12	34 (5%)
6 (REG, ET)	2	7		3	10		19	8			49 (7%)
7 (REG, SEM, ET)							11	10			21 (3%)
9 (REG, ET, SM)							25				25 (3%)
10 (REG, SEM, SM)							6	15	35	76	132 (18%)
11 (REG, SEM, ET, SM)									30	100	130 (17%)
Total transactions in 'between-theme' activity structures	**8**	**12**	**0**	**5**	**24**	**19**	**103**	**72**	**119**	**191**	**553 (73%)**
Total transactions in individual themes	**2**	**1**	**7**	**15**	**15**	**54**	**52**	**16**	**18**	**23**	**203 (27%)**
Total	**10**	**13**	**7**	**20**	**39**	**73**	**155**	**88**	**137**	**214**	**756**

Our analysis focuses on a subset of three activity structures as these alone represent 56% of all transactions.

- 1 (REG, SEM), renewable electricity generation, and smart electricity management;
- 10 (REG, SEM, SM), renewable electricity generation, smart electricity management, and sustainable mobility; and
- 11 (REG, SEM, ET, SM). renewable electricity generation, smart electricity management, emerging technologies, and sustainable mobility.

[3] The remainder of the transactions occurred when utilities were active in only one theme: 25% of the transactions when utilities had activities only in the renewable electricity generation theme, 1% in the smart electricity management theme, and 1% in the emerging technologies theme.

First, with 21% of the transactions, is activity structure 1 (REG, SEM) (see Table 7). This activity structure links two important aspects of the energy transition: low-carbon renewable electricity generation and smart electricity management. Communication and control capabilities, central to smart grids and an enabler of smart electricity management, contribute to the effective integration of renewable generation in the electricity system, and increase the possibilities for system optimization through flexibility management via demand response/demand side management (Goldthau & Sovacool, 2012). In terms of sequence, we find that this is the first activity structure for 50% of the utilities. Table 8 shows the sequence in which utilities had transactions falling under the different between-theme activity structures. This sequence (i.e., 1st structure, 2nd structure) indicates the order in which utilities selected to participate across activity structures.

Table 8 'Between-theme' activity structures sequence

Activity structure	Year	Activities structure sequence: 1st structure	Activities structure sequence: 2nd structure
1 (REG, SEM)	90/92	EON	
	93/95 … 99/01		
	02/04	CENTRICA, ENEL	
	05/07	VEOLIA, RWE	
	08/10	ENGIE	
	11/13	ENBW	
	14/16	FORTUM, NATURGY	
	17/19	NATIONAL GRID	
		1st structure	**2nd structure**
10 (REG, SEM, SM)	90/92 … 05/07		
	08/10	VATTENFALL	
	11/13	EDF	
	14/16	CEZ	EON
	17/19	INNOGY, ORSTED	CENTRICA, RWE
		1st structure	**2nd structure**
11 (REG, SEM, ET, SM)	90/92 … 11/13		
	14/16		ENGIE
	17/19		ENEL, EDF

Second, with 18% of the transactions, is activity structure 10 (REG, SEM, SM), linking activities in renewable electricity generation, smart electricity management, and sustainable mobility themes. Linking sustainable mobility with renewable electricity generation and smart electricity management is a strategic step given the ongoing trends for the electrification of mobility (Elebua, 2019). For utilities this includes the possibility to engage in the operation of electric vehicle charging infrastructure, as an extension of distribution grid assets, and to integrate a growing share of electric vehicle loads into the electricity system. Large fleets of electric vehicles may pose challenges for the existing infrastructure, depending on electric vehicle concentration and charging patterns.

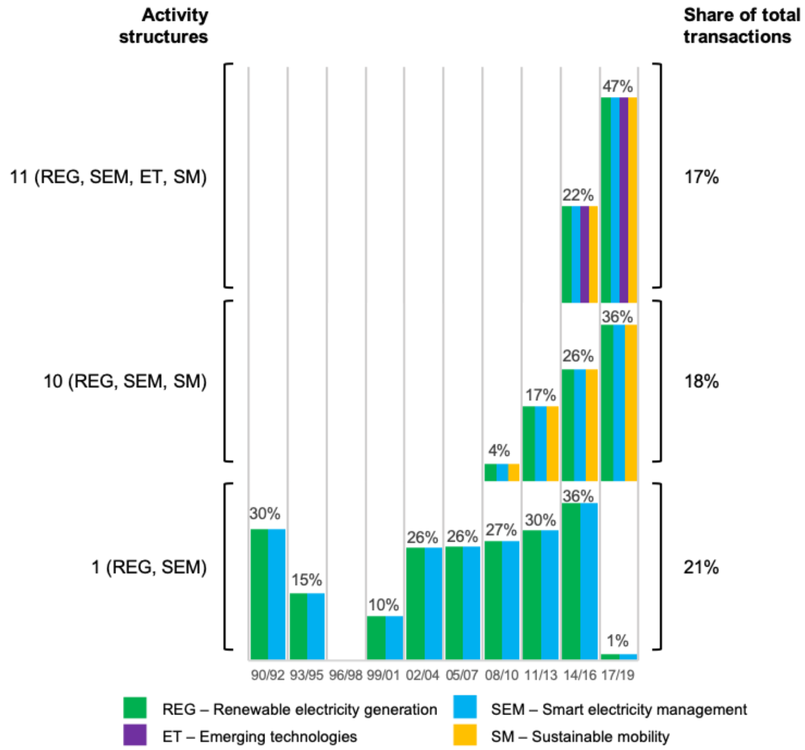
However, increasing numbers of electric vehicles connected to distribution grids also create opportunities to manage the vehicles' batteries as a source of distributed storage capacity and support electric vehicle integration through charging services (Niesten & Alkemade, 2016). This activity structure is observed from 2008 onwards, growing from 4% of the transactions in 2008-2010 to 36% in 2017-2019. In terms of sequence, this is the first activity structure for 25% of the utilities, and the second activity structure for 15% of the utilities (see Table 8).

Third, with 17% of the transactions, is activity structure 11 (REG, SEM, ET, SM) linking all sustainable energy activity themes. Utilities engaged in this activity structure signal their interest in reorienting their traditional business towards a sustainable energy model through a diverse set of activities ranging across the four themes. This activity structure also illustrates a shift to a systems integration approach that encompasses a wide spectrum of sustainable energy activities. For instance, this structure includes renewable electricity generation, a driver of decarbonization which in combination with smart electricity management, allows for an effective integration and management of possible variability through demand response/demand side management actions. In addition, it includes sustainable mobility, indicating the relevance of integrating growing shares of electric vehicles in the utility business model. It also embraces emerging technologies, as a potential source of exploration, experimentation, and learning that will shape the utility business model in the future. Pursuing activities that contribute to systems integration can complement the energy transition, support decarbonization, and increase customer orientation for incumbent utilities (Frei et al., 2018). This activity structure is observed from 2014 onwards, representing 22% of the transactions in 2014-2016, and 47% in 2017-2019 (see Figure 2). Regarding sequence, this activity structure is selected as second for 15% of the utilities (see Table 8).

In addition to our findings on activity sequence, obtained from considering the order in which utilities participated in different structures (see Table 8), we observed growth in the share of transactions under activity structures 10 (REG, SEM SM) and 11 (REG, SEM, ET, SM) from 2008 onwards (see Figure 2). Transactions under activity structures linking fewer activity themes gradually decreased (see Table 7). This trend shows utilities' increasing preference for structures that link three or more themes, from representing 28% of transactions in 2011-2013, to 47% in 2014-2016, reaching 82% in 2017-2019 (see Table 7).

Considering the themes of the main activity structures analyzed, we find that they all include renewable electricity generation and smart electricity generation. Having these common activity themes across structures indicates utilities' efforts towards business model adaptation that delivers decarbonization through renewable electricity generation and digitalization through smart electricity management. Nonetheless, most transactions in any activity structure are in renewable electricity generation (see Supplementary material Figure 1). One reason for this dominance is the degree of availability of sustainable energy technologies over time. While technologies for renewable electricity generation have been around for decades, technologies for smart electricity management and sustainable mobility have only developed over the course of our study as they are the product of developments in information and communication technology.

Figure 2 'Between-theme' activity structures, main structures, share of transactions, from 1990 to 2019, 3-year periods



4.3. Activity governance

From the analysis of activity system governance, we aim to show who performs the activities (Zott & Amit, 2010). Mergers and acquisitions (M&As) integrate different firms into one. Joint ventures (JVs) and strategic alliances (SAs) are inter-firm collaborations established to deliver an activity as part of an agreement (Hagedoorn & Duysters, 2002). While M&As result in the legal and organizational integration of firms (Schaltegger et al., 2016), JVs and SAs are structured using more flexible governance (Hagedoorn & Duysters, 2002). Therefore, utilities opting for M&As indicate a willingness to integrate the sustainable energy activities of other firms into their own business: the utility becomes the one *'who'* performs the activity through integration. Utilities opting for JVs and SAs indicate a preference for more flexibility to deliver sustainable energy activities: the utility and an external firm combine efforts and act together as the ones *'who'* collaboratively perform the activity.

M&As are preferred across our sample of transactions. Overall, M&As account for 82% of the transactions, while JVs account for 8%, and SAs for 10% (see Table 1). The preference for M&As is generally visible across the main activities identified (see Figure 3).[4] Within the renewable energy generation theme, utilities acquire among others wind farms, solar and geothermal plants, solar panel manufacturers, and solar PV installers. Within the smart energy management theme, they acquire providers of energy monitoring, demand response, energy efficiency, and computer programming services, as well as manufacturers of metering devices, broadband power lines, wireless communication equipment and developers of energy intelligence software.

However, a relatively smaller share of M&As is used for mobility and electric vehicle activities, for which JVs account for 7% of the transactions and SAs for 23%. For research and development activities, JVs account for 6% of the transactions and SAs for 61%. Different aspects can be associated with this greater preference for more flexible forms of governance. The utilities' perception of a higher risk of these activities (e.g. regarding their future role in the utility business model) can explain the reduced willingness to integrate them in their business model through M&As, opting for SAs instead. This finding is in line with utilities' preference for low-risk investments (Langniss, 1996; Masini & Menichetti, 2012; Mazzucato & Semieniuk, 2018). For mobility and electric vehicles activities, a higher risk results from the need to adapt operations to serve electric vehicle loads and manage distributed storage and integrate these new system components into the utilities' existing infrastructure. For research and development activities, a higher risk is due to the exploratory nature of the business models being developed.

Firms also prefer SAs over M&As when change requires learning and flexibility (Hagedoorn & Duysters, 2002). SAs allow utilities to join efforts with other firms, learn, and gain a better understanding of new activities through a more flexible collaboration (Hennart & Reddy, 1997; Yin & Shanley, 2008). Mobility, electric vehicles, and research and development are associated with a need for learning to discover potential changes

---

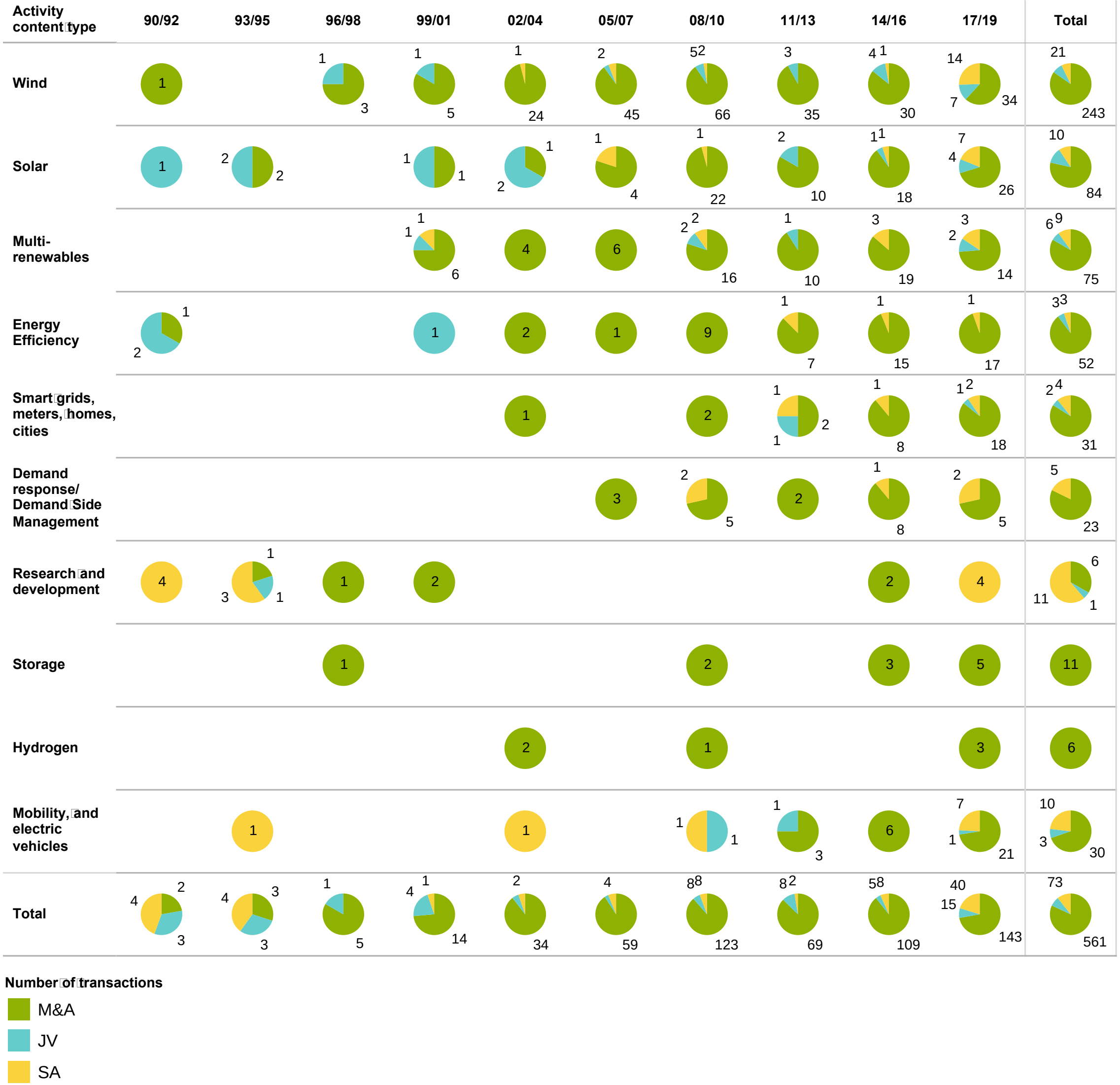
[4] M&As are the preferred transaction type when considering transactions on each activity theme and activity structure. See Supplementary material Figure 2 for data on transaction type per activity theme, and Supplementary material Figure 3 for data per activity structure.

in business models. The utilities in our sample have over time extended the type of partners with whom they transact to facilitate learning. These include firms in the transportation and ICT sectors, such as car manufacturers, automotive repair firms, manufacturers of charging equipment, software developers, and vehicle-to-grid technology firms.

A preference for SAs can also result from a preference for flexible governance to deliver non-core business activities, while using M&As for the core business model (Hagedoorn & Duysters, 2002). The importance of sustainable mobility is increasing, but considering the limited diffusion of electric vehicles and charging infrastructure (EEA, 2016), it can still be seen as a non-core activity. Similarly, research and development activities can be considered a non-core activity as they encompass utilities' exploratory endeavors for which they collaborate with firms also engaged in the development of emerging technologies such as research centers and innovation labs.

From an activity governance perspective, the utilities' preference for M&As indicates their ambition to integrate sustainable energy activities into their business model (Schaltegger et al., 2016). However, Hagedoorn and Duysters (2002) and Yin and Shanley (2008) argue that experience with M&As results in firms' preferring M&As for future boundary-spanning transactions. Therefore, the utilities' preference for M&As can be the result of their M&A experience gained through previous electricity industry restructuring as part of market liberalization, which led to increased M&A activity across the European utilities (Kishimoto, Goto, & Inoue, 2017; Leggio & Lien, 2000).

Figure 3 Activities governance, transaction types, from 1990 to 2019, 3-year periods



5. Utilities' value creation drivers

Our analysis of activity system elements provides a detailed perspective on utilities' business model adaptation. It shows how utilities have navigated the sustainable energy activity space. Considering the characteristics of the activity content, structure, and governance, we now discuss whether the changes utilities made to their activity system using boundary-spanning transactions have led to a reliance on new value creation drivers by considering the role of novelty, lock-in, complementarity, and efficiency (Zott & Amit, 2010). As mentioned, novelty refers to the adoption of new activity content, structure, or governance; lock-in to retaining existing stakeholders and value creation mechanisms; complementarity to bundling activities to increase the potential for value creation; and efficiency to the organization of activities that minimizes transaction costs. The relevance of understanding the dominant value creation drivers is twofold. First, it shows how utilities change their value creation as they adapt their business models to sustainable energy activities that emerged in the transition of the energy system. Second, it reveals how sustainable energy activities interact and relate with the incumbent utility business model and to what extent utilities have moved away from or stayed close to existing value creation drivers. Our findings suggest that all four drivers have played a role as sources of the activity system's value creation. While the traditional utility business model was fully based on efficiency and lock-in as main drivers, novelty and complementarity have become more important over time but did not fully replace efficiency and lock-in.

With their boundary-spanning transactions utilities have tried to tap into *content novelty*. They have not neglected the emergence of sustainable energy activities in the energy system but have repeatedly made investments to integrate these in their activity system. The integration of new activities related to renewable energy generation, smart electricity management, and sustainable mobility, in particular, has led to an adapted business model where service provision is a new key source of value creation. Smart meters, consumer-sited solar PV, and sustainable mobility, for example, create value as they allow utilities to both develop and market new services to their existing customer base and extend their customer base. Hence, the value proposition of utilities is becoming broader. To provide services such as solar PV installation, energy efficiency improvements, and demand-side management, utilities use cross-selling, offering new services to existing customers. By expanding into sustainable mobility, utilities also extend their customer base. Investments in charging infrastructure hardware let utilities sell electricity to consumers with whom they do not have a pre-existing relationship from supplying electricity to their homes. With a further proliferation of electric vehicles, it will become more common for consumers to get electricity from a wider range of different suppliers. However, utilities do not limit sustainable mobility activities to charging infrastructure hardware – which could still be considered a logical extension of current activities –, they also offer software solutions for vehicle-to-grid and grid-to-vehicle services. Expansion into sustainable mobility and smart electricity management show that utilities' activities are adding digital solutions to the more traditional management of physical assets (Niesten & Alkemade, 2016; Shomali & Pinkse, 2016).

The integration of new activities related to research, development, and manufacturing of emerging technologies such as hydrogen, carbon capture and storage, and electricity storage reflects a transformation of utilities becoming more innovative and risk-taking. Instead of relying on turnkey solutions of technology providers, such as Siemens and General Electric, our findings reveal that utilities are increasingly using M&As to conduct their own research and development as well as strategic alliances to conduct it in collaboration with business partners. Transactions related to hydrogen and electricity storage, for example, suggest that utilities invest in emerging technologies because they allow scaling up their renewable electricity generation as they address the intermittency problem. Integrating new activities thus also leads to *structure novelty* as new linkages develop between various old and/or new activities. Most new activities related to service provision, digital management, and research and development are not standalone but closely interact with the existing components of the activity system. Except for renewable energy generation, perhaps, new activities do not replace existing activities but rather complement them. Thus, most utilities are first broadening their value proposition through the integration of new activities before reconfiguring it through the divestment of traditional energy activities.

While novelty has become more important, the traditional value creation drivers of efficiency and lock-in are still important in the emerging activity systems. Sustainable energy activities might be novel, but the findings suggest a prevalence of renewable electricity generation, which accounts for 71% of the transactions (see Table 3), and a focus on wind generation representing 38% of the transactions (see Figure 1). From a business model perspective, renewable energy generation does not lead to novelty per se, because it does not require a radical change of the value proposition. Customers still purchase electricity from the same suppliers. It just happens to have been generated with different technology. On the one hand, the dominance of expanding into renewable energy generation could be seen as a way to keep existing customers locked-in and prevent them from switching to new providers. Since green electricity supply has been the main selling point of new entrants, matching this value proposition through the integration of renewable energy generation keeps such competition at bay. On the other hand, the between-theme activity structures show that renewable energy generation tends to be the first step in a sequence of engaging in multiple sustainable energy activities. Expanding renewable energy generation both compels utilities to engage in smart energy management and electricity storage and allows them to offer new energy efficiency services and sustainable mobility solutions. For example, some utilities in the sample such as Ørsted and Innogy have been able to keep their customers locked-in while reconfiguring their activity system fully around renewable electricity generation and ensuing activities such as energy storage. They have done this not only by expanding into new activities but also by divesting and restructuring activities to dispose of fossil-fuel-based electricity generation.[5] Even if utilities leave their value proposition unchanged to keep customers locked-in, they are adapting their business model by changing the underlying infrastructure to create value for these customers (Schaltegger et al., 2016).

The prevalence of renewable energy compared to other sustainable energy activities indicates a continued reliance on efficiency as value creation driver. Efficiency gains from renewable electricity generation result from cost reductions from identifying, selecting, integrating, and operating renewable generation assets. As utilities repeatedly identify and select renewable generation activities, they gain experience in the evaluation of technological and economic potential of integrating additional renewable assets, leading to lower costs to pursue these activities. By repeatedly integrating and operating renewable generation assets, utilities also accumulate technological knowledge that improves their ability to manage renewable generation in tandem with legacy generation and grid assets, leading to cost reductions for these activities. Moreover, zooming in on the choice of generation technology, utilities show a preference for wind power. Generating electricity from wind contributes to decarbonizing the electricity industry, while sharing similarities with the traditional business model centered on electricity generation and supply (Bryant et al., 2018). These similarities include being capital-intensive and sized to a high capacity. Wind generation can be easily integrated and managed as part of an established network of generation and grid assets (Wüstenhagen & Menichetti, 2012). Utilities thus keep relying on efficiency and lock-in: on the whole,

[5] The restructuring of Ørsted and Innogy explains why these two utilities have a balance between traditional and sustainable energy transactions while the others still have a dominance of traditional energy transactions (see Table 1).

they tend to choose sustainable energy activities that are related to a change in infrastructure rather than a change in value proposition (Schaltegger et al., 2016).

Efficiency and lock-in are also observed from the utilities' governance of activities. Most boundary-spanning transactions are delivered through M&As (82% of transactions, see Table 1). While different options exist through which utilities can expand their business, they focus on full integration of new activities by merging with or acquiring other firms. This finding indicates a consistent preference of utilities to be the one *'who'* performs the sustainable energy activities when adapting their business model to a changing industry. A consistent selection of M&As also leads to efficiency gains due to decreasing costs of repeatedly structuring similar transactions. As utilities continue selecting M&As, they gain experience with the specificities of the transaction structure, including the legal, financial, and technical requirements. Hence, the costs of pursuing M&As decrease over time. While utilities prefer having full control over sustainable energy activities, the nature of the stakeholders involved in the value creation changes, nonetheless. Some renewable energy generation activities such as wind parks build on relationships with existing suppliers, like the technology providers Siemens and General Electric, but the acquisition of solar panel manufacturers and installers requires managing new (global) supply chains. Also, the move towards service provision, digital management, and research and development necessitates different employee skills. The workforce composition is therefore changing. For some new activities such as smart metering services, consumer-sited solar PV, and demand response, utilities need customers to take a more proactive stance towards energy management and therefore require closer customer relationship management. Hence, even if utilities mainly rely on M&As to be in control, they are still adapting their business model by engaging in new forms of exchange with the various stakeholders, i.e., suppliers, customers, and employees, involved in the systems transition. Other collaborative arrangements such as JVs and SAs, which provide more flexibility to deliver activities, were used more sparingly. Utilities seem less keen on JVs and SAs as they would open the door to new entrants taking up potentially pivotal positions in the energy system. Only mobility and electric vehicles and R&D activities saw a greater use of SAs. In these areas, for example, utilities collaborate with car manufacturers and ICT firms which tend to be large firms themselves, making M&As more challenging. In their governance choice, utilities thus try to retain control and limit the potential control of new entrants.

Finally, our data suggest that complementarity has become increasingly important as utilities have started relying more on bundling activities to create new sources of value. Complementarity is observed through our findings on *'between-theme'* activity structures. The main complementarity is between renewable electricity generation and smart electricity management activities. These two activity themes are simultaneously present in four activity structures that represent 58% of the transactions analyzed (i.e., activity structure 1 (REG, SEM), 7 (REG, SEM, ET), 10 (REG, SEM, SM), 11 (REG, SEM, ET, SM), see Table 7). This finding indicates a preference of utilities to follow a systems integration approach which maximizes the benefits of renewable electricity generation and smart electricity management. These two activity themes have a natural fit because the intermittency of renewable energy can be partly addressed through smart electricity management. Moreover, a bundling of these activities has the potential to offer new value to customers, for example in the form of energy management services. '*Between-theme'* complementarity is observed, too, considering the gradual evolution towards activity structures that link more sustainable energy activity themes, as the preference for activity structures linking fewer themes decreases (see Table 7). However, when bundling activities, utilities do not only link new activities to each other, using complementarity to create value for customers but also link these to old activities to further improve efficiency and create value for the energy system (Hiteva & Foxon, 2021). They navigate the sustainable energy space by selecting activities that match existing systems and infrastructure and that they can control themselves. Instead of using the sustainable energy activities to decarbonize and create new (environmental) value for customers, utilities seem to integrate the activities to increase digitalization and reinforce a centralization of the energy system. While complementarity might have become more important, the traditional drivers of efficiency and lock-in remain prominent as well. A consequence of prioritizing lower risk technologies that fit the incumbent utility business model might be lags in the development and diffusion of riskier sustainable energy technologies with a potential to create new types of customer value (Masini & Menichetti, 2013).

6. Conclusion

The need to decarbonize the energy system as part of a transition to a low-carbon future has resulted in increasing pressure for incumbents in the electricity industry to change. Against this backdrop, incumbent utilities have started adapting their business models to a rapidly changing landscape of policies, technologies, and new entrants. We focused on providing a better understanding of the ways in which utilities have made changes to their business model to adapt to the emergence of sustainable energy innovations in the energy system. Building on Zott and Amit's (2010) activity system perspective and using boundary-spanning transaction data from M&As, JVs, and SAs, we explored how utilities adapt their business model explicitly at the boundary of the organization and their interactions with other firms. We analyzed 756 transactions from 20 utilities across 11 countries. This approach led to a granular understanding of the activities utilities selected (content), how these are linked and sequenced (structure), and who performs these activities (governance). In terms of content, we identified 20 activities across four themes. Renewable electricity generation activities, and specifically wind generation, were the most prevalent sustainable energy activities. As for structure, we find evidence of a gradual development of smart electricity management capabilities and a preference for activity structures that combine more activity themes over time, suggesting that utilities pursue complementarities when delivering sustainable energy systems. Regarding governance, utilities prefer integrating sustainable energy activities using M&As, thus becoming the ones 'who' perform the activities.

Furthermore, we investigated the value creation drivers that utilities draw on when adapting their business models to sustainable energy innovations. The analysis of the emerging activity systems not only suggests an increased importance of novelty and complementarity as value drivers but also a strong continued reliance on efficiency and lock-in. During the transition of the energy system, utilities have repeatedly invested in new sustainable energy activities and have adapted to service provision as a novel source of value creation. They have also focused on creating valuable complementarities among the new sustainable energy activities and on integrating these in their existing activity system. While novelty and complementarity have become more important, efficiency and lock-in remain prominent drivers due to the utilities' focus on large-scale, capital-intensive investments in renewable electricity generation, reinforcing the consumption of centrally produced electricity. This emphasis on efficiency and lock-in, resulting from a desire to keep control in the energy system and retain a dominant position, is also evident in the utilities' preference for M&As over more collaborative forms of governance.

Our study has several implications. Firstly, when utilities venture into the sustainable energy space, they not only explore new sources to create value for customers that would substitute for existing sources, but also use sustainable energy activities to reinforce the traditional utility business model which is based on a vertical integration and centralization of electricity generation and supply. A preference for renewable electricity generation activities demonstrates a focus on activities that directly contribute to decarbonization but are complementary to their legacy generation and grid assets. While utilities replace infrastructure and resources to allow for a decarbonization and digitalization of the energy system, for the time being, they tend to uphold their value proposition of supplying reliable and affordable electricity.

Secondly, as evidenced by the large and increasing number of boundary-spanning transactions utilities are engaged in, the utility business model is undergoing fundamental changes. Towards the end of the analyzed period, utilities had rapidly expanded the type of activities they engage in with a focus on service provision, digital solutions, and research and development. However, utilities try to stay relevant not by fully reconfiguring their business model but rather by incrementally adapting it, adding new activities that fit existing ones. Our analysis suggests that utilities are quite capable at absorbing new sustainable energy activities that emerge in the energy system. Similar to findings in the car industry (Jacobides, MacDuffie, & Tae, 2016), incumbents' ownership of capital-intensive assets and transactions to expand these allow them to maintain control on the industry even when it is undergoing change. The sequence of expansion into new activities suggests that utilities first adapt the underlying infrastructure of their activity system (Schaltegger et al., 2016) by changing generation assets, upgrading networks with a digital layer, and developing software solutions, before moving away from the traditional utility business model (Niesten & Alkemade, 2016; Shomali & Pinkse, 2016).

Thirdly, currently business model adaptation is still a process aimed at adding activities that complement rather than substitute for existing activities. While utilities are experimenting with new value propositions, our analysis of transactions data shows that the bulk of sustainable energy transactions is aimed at reinforcing existing generation and grid assets. Moreover, the number of sustainable energy transactions remained modest compared to traditional energy transactions (see Table 1). The preference for M&As shows that utilities try to keep a stronghold on the industry and are not yet considering a more open industry architecture where different actors collaboratively offer products and services. Once utilities have reached a critical stage in changing the underlying infrastructure of their activity system, though, the more digitalized and decarbonized generation and grid assets may allow them to reconfigure their business model more radically by changing their value proposition for existing customers as well as developing value propositions for new customers.

While we provide a comprehensive analysis of utilities' business model adaptation, our study has a few limitations. Firstly, our dataset does not cover the financial value of the transactions. This information was not available for a significant share of the M&As and financial flows are not recorded for inter-firm JVs and SAs. While we analyzed a great number of transactions, we cannot draw conclusions about the financial impact of these transactions for the business model. Secondly, with our focus on boundary-spanning transactions in the form of M&As, JVs, and SAs, we make an assumption that utilities make changes to their business model by sourcing new activities from outside. While utilities are historically not known for their internal R&D activities, this is currently changing. Another limitation of our study, therefore, is that it does not take into account the influence of internally developed sustainable energy activities on the business model. Finally, our research design yielded a sample of mainly publicly traded utilities. Our study provides less insight into how non-traded utilities expand into sustainable energy activities.

Future studies could further dissect the aggregate trends we found regarding business model adaptation. Additional research could explore the relationship between activity content, structure, and governance characteristics, and utility performance. In this study, we use M&A, JV, and SA transactions to assess how utilities pursue sustainable energy activities. Future work can study how such transactions relate to sustainable energy outputs, such as renewables generation capacity, energy savings, or emissions reductions. In this study we analyzed one specific set of boundary-spanning transactions that reflect adaptation at the boundary of the firm and inter-firm relations, through M&As, JVs, and SAs. Future research could explore other forms of collaboration, such as involvement in research, pilot, and demonstration projects, given their possibility to change the boundary of the firm. Also, the motivations and strategic goals of utilities when pursuing different sustainable energy activities deserve further investigation. It is important to understand how firm characteristics, such as size and resources, impact governance choices (M&A, JV, SA), both for utilities and the firms with which they engage for inter-firm collaborations. Finally, it is worthwhile studying how utilities change their activity system by looking into divestments of fossil-fuel-based activities. A systems transition not only unfolds through expanding into sustainable energy activities but also through divesting and decommissioning unsustainable energy activities.

7. Acknowledgments

This work has been funded by the Alliance Manchester Business School Strategic Investment Fund, created following a landmark donation from Lord Alliance of Manchester and his fellow Trustees of the Alliance Family Foundation.

8. References

Amit, R., & Zott, C. (2012). Creating Value Through Business Model Innovation. *MIT Sloan Management Review*, *53*(3), 41–49. https://doi.org/10.2139/ssrn.1701660

Athawale, R., & Felder, F. (2016). Residential Rate Design and Death Spiral for Electric Utilities: Efficiency and Equity Considerations. In *Future of Utilities Utilities of the Future* (pp. 193–209). https://doi.org/10.1016/B978-0-12-804249-6.00010-5

Behrangrad, M. (2015). A review of demand side management business models in the electricity market. *Renewable and Sustainable Energy Reviews*, *47*, 270–283. https://doi.org/10.1016/j.rser.2015.03.033

Blanco, M. I. (2009). The economics of wind energy. *Renewable and Sustainable Energy Reviews*, *13*(6–7), 1372–1382. https://doi.org/10.1016/j.rser.2008.09.004

Bocken, N. M. P., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*, *65*, 42–56. https://doi.org/10.1016/j.jclepro.2013.11.039

Bohnsack, R., & Pinkse, J. (2017). Value Propositions for Disruptive Technologies: Reconfiguration Tactics in the Case of Electric Vehicles. *California Management Review*, *59*(4), 79–96. https://doi.org/10.1177/0008125617717711

Bohnsack, R., Pinkse, J., & Kolk, A. (2014). Business models for sustainable technologies: Exploring business model evolution in the case of electric vehicles. *Research Policy*, *43*(2), 284–300. https://doi.org/10.1016/j.respol.2013.10.014

Bolton, R., & Hannon, M. (2016). Governing sustainability transitions through business model innovation: Towards a systems understanding. *Research Policy*, *45*(9), 1731–1742. https://doi.org/10.1016/j.respol.2016.05.003

Boons, F., & Lüdeke-Freund, F. (2013). Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. *Journal of Cleaner Production*, *45*, 9–19. https://doi.org/10.1016/j.jclepro.2012.07.007

Bryant, S. T., Straker, K., & Wrigley, C. (2018). The typologies of power: Energy utility business models in an increasingly renewable sector. *Journal of Cleaner Production*, *195*, 1032–1046. https://doi.org/10.1016/j.jclepro.2018.05.233

Budde Christensen, T., Wells, P., & Cipcigan, L. (2012). Can innovative business models overcome resistance to electric vehicles? Better Place and battery electric cars in Denmark. *Energy Policy*, *48*, 498–505. https://doi.org/10.1016/j.enpol.2012.05.054

Burger, C., & Weinmann, J. (2016). European Utilities: Strategic Choices and Cultural Prerequisites for the Future. In *Future of Utilities Utilities of the Future* (pp. 303–322). https://doi.org/10.1016/B978-0-12-804249-6.00016-6

Burger, S. P., & Luke, M. (2017). Business models for distributed energy resources: A review and empirical analysis. *Energy Policy*, *109*(July), 230–248. https://doi.org/10.1016/j.enpol.2017.07.007

Casadesus-Masanell, R., & Ricart, J. E. (2010). From strategy to business models and onto tactics. *Long Range Planning*, *43*(2–3), 195–215. https://doi.org/10.1016/j.lrp.2010.01.004

Copenhagen Capacity. (2014). E.ON invests in green transport in Copenhagen. Retrieved from https://www.copcap.com/case/eon-invests-in-green-transport-in-copenhagen

Davito, B., Tai, H., & Uhlaner, R. (2010). The smart grid and the promise of demand-side management. In *McKinsey on Smart Grid*. Retrieved from http://rodanenergy.com/wp-content/uploads/2015/11/MoSG_DSM_VF-1.pdf%0Ahttp://www.calmac.com/documents/MoSG_DSM_VF.pdf

Di Silvestre, M. L., Favuzza, S., Riva Sanseverino, E., & Zizzo, G. (2018). How Decarbonization, Digitalization and Decentralization are changing key power infrastructures. *Renewable and Sustainable Energy Reviews*, *93*(June), 483–498. https://doi.org/10.1016/j.rser.2018.05.068

DONG Energy. (2008). *DONG Energy and California-based Project Better Place to introduce environmentally friendly electric vehicles in Denmark*. Retrieved from https://www.businesswire.com/news/home/20080327005498/en/DONG-Energy-California-based-Project-Place-introduce-environmentally

EDF Renewables. (2020). A world leader. Retrieved from https://www.edf-renouvelables.com/en/edf-renewables/world-leader/

EEA. (2016). *Electric Vehicles in Europe*. https://doi.org/10.2800/100230

Elebua, S. (2019). Accelerating Mobility—The Utility Perspective. *IEEE Engineering Management Review*, *47*(1), 19–21. https://doi.org/10.1109/EMR.2019.2902343

ENEL. (2018). *Enel and Intesa Sanpaolo join forces for innovation in SMEs in support of Aton*. Retrieved from https://www.enel.com/media/explore/search-press-releases/press/2018/06/enel-and-intesa-sanpaolo-join-forces-for-innovation-in-smes-in-support-of-aton

Engelken, M., Römer, B., Drescher, M., Welpe, I. M., & Picot, A. (2016). Comparing drivers, barriers, and opportunities of business models for renewable energies: A review. *Renewable and Sustainable Energy Reviews*, *60*, 795–809. https://doi.org/10.1016/j.rser.2015.12.163

EPRI. (2002). *Handbook of Energy Storage for Transmission & Distribution Applications*. https://doi.org/1001834

Erlinghagen, S., & Markard, J. (2012). Smart grids and the transformation of the electricity sector: ICT firms as potential catalysts for sectoral change. *Energy Policy*, *51*, 895–906. https://doi.org/10.1016/j.enpol.2012.09.045

European Union. (2020). *Internal Energy Market - Fact Sheets on the European Union*. https://doi.org/10.4135/9781412971850.n78

Eyraud, L., Clements, B., & Wane, A. (2013). Green investment: Trends and determinants. *Energy Policy*, *60*, 852–865. https://doi.org/10.1016/j.enpol.2013.04.039

Farhangi, H. (2010). The path of the smart grid. *IEEE Power and Energy Magazine*, *8*(1), 18–28. https://doi.org/10.1109/MPE.2009.934876

Faruqui, A., & Fox-Penner, P. (2011). *Energy Efficiency and Utility Demand-Side Management Programs*.

Frei, F., Sinsel, S. R., Hanafy, A., & Hoppmann, J. (2018). Leaders or laggards? The evolution of electric utilities' business portfolios during the energy transition. *Energy Policy*, *120*(June), 655–665. https://doi.org/10.1016/j.enpol.2018.04.043

Geels, F. W., Sovacool, B. K., Schwanen, T., & Sorrell, S. (2017). Sociotechnical transitions for deep decarbonization. *Science*, *357*(6357), 1242–1244. https://doi.org/10.1126/science.aao3760

Goldemberg, J., & Prado, L. T. (2010). The "decarbonization" of the world's energy matrix. *Energy Policy*, *38*(7), 3274–3276. https://doi.org/10.1016/j.enpol.2010.03.040

Goldthau, A., & Sovacool, B. K. (2012). The uniqueness of the energy security, justice, and governance problem. *Energy Policy*, *41*, 232–240. https://doi.org/10.1016/j.enpol.2011.10.042

Graffy, E., & Kihm, S. (2014). Does disruptive competition mean death spiral for electric utilities. *Energy Law Journal*, *35*(1), 1–44. Retrieved from https://heinonline-org.manchester.idm.oclc.org/HOL/Page?handle=hein.journals/energy35&id=25&collection=journals&index=

Hagedoorn, J., & Duysters, G. (2002). External sources of innovative capabilities: The preference for strategic alliances or mergers and acquisitions. *Journal of Management Studies*, *39*(2), 167–188. https://doi.org/10.1111/1467-6486.00287

Hall, S., & Roelich, K. (2016). Business model innovation in electricity supply markets: The role of complex value in the United Kingdom. *Energy Policy*, *92*, 286–298. https://doi.org/10.1016/j.enpol.2016.02.019

Hannon, M. J., Foxon, T. J., & Gale, W. F. (2013). The co-evolutionary relationship between Energy Service Companies and the UK energy system: Implications for a low-carbon transition. *Energy Policy*, *61*, 1031–1045. https://doi.org/10.1016/j.enpol.2013.06.009

Hellström, M., Tsvetkova, A., Gustafsson, M., & Wikström, K. (2015). Collaboration mechanisms for business models in distributed energy ecosystems. *Journal of Cleaner Production*, *102*, 226–236. https://doi.org/10.1016/j.jclepro.2015.04.128

Helms, T. (2016). Asset transformation and the challenges to servitize a utility business model. *Energy Policy*, *91*, 98–112. https://doi.org/10.1016/j.enpol.2015.12.046

Helms, T., Loock, M., & Bohnsack, R. (2016). Timing-based business models for flexibility creation in the electric power sector. *Energy Policy*, *92*, 348–358. https://doi.org/10.1016/j.enpol.2016.02.036

Hennart, J.-F., & Reddy, S. (1997). THE CHOICE BETWEEN MERGERS/ACQUISITIONS AND JOINT VENTURES: THE CASE OF JAPANESE INVESTORS IN THE UNITED STATES. *Strategic Management Journal*, *18*(1), 1–12. https://doi.org/10.1002/(SICI)1097-0266(199701)18:1<1::AID-SMJ862>3.0.CO;2-R

Hiteva, R., & Foxon, T. J. (2021). Beware the value gap: Creating value for users and for the system through innovation in digital energy services business models. *Technological Forecasting and Social Change*, *166*(October 2020), 120525. https://doi.org/10.1016/j.techfore.2020.120525

Horváth, D., & Szabó, R. Z. (2018). Evolution of photovoltaic business models:

Overcoming the main barriers of distributed energy deployment. *Renewable and Sustainable Energy Reviews*, *90*(November 2017), 623–635. https://doi.org/10.1016/j.rser.2018.03.101

International Energy Agency. (2017). Energy Technology Perspectives 2017. In *International Energy Agency (IEA) Publications*. Retrieved from https://webstore.iea.org/download/summary/237?fileName=English-ETP-2017-ES.pdf

IRENA. (2018). *Hydrogen From Renewable Power: Technology outlook for the energy transition*. Retrieved from www.irena.org

Jacobides, M. G., MacDuffie, J. P., & Tae, C. J. (2016). Agency, structure, and the dominance of OEMs: Change and stability in the automotive sector. *Strategic Management Journal*, *37*(9), 1942–1967. https://doi.org/10.1002/smj.2426

Kind, P. (2013). Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business. In *Edison Electric Institute*.

Kishimoto, J., Goto, M., & Inoue, K. (2017). Do acquisitions by electric utility companies create value? Evidence from deregulated markets. *Energy Policy*, *105*(January), 212–224. https://doi.org/10.1016/j.enpol.2017.02.032

Klaassen, E. A. M., van Gerwen, R. J. F., Frunt, J., & Slootweg, J. G. (2017). A methodology to assess demand response benefits from a system perspective: A Dutch case study. *Utilities Policy*, *44*, 25–37. https://doi.org/10.1016/j.jup.2016.11.001

Langniss, O. (1996). Instruments to foster renewable energy investments in Europe a survey under the financial point of view. *Renewable Energy*, *9*(1–4), 1112–1115. https://doi.org/10.1016/0960-1481(96)88473-4

Laurikka, H. (2008). A case study on risk and return implications of emissions trading in power generation investments. In L. P. Antes R., Hansjürgens B. (Ed.), *Emissions Trading* (pp. 133–147). https://doi.org/10.1007/978-0-387-73653-2_9

Leggio, K. B., & Lien, D. (2000). Mergers in the electric utility industry in a deregulatory environment. *Journal of Regulatory Economics*, *17*(1), 69–85. https://doi.org/10.1023/A:1008153321551

Lo, A. W. (2016). What Is an Index? *The Journal of Portfolio Management*, *42*(2), 21–36. https://doi.org/10.3905/jpm.2016.42.2.021

Masini, A., & Menichetti, E. (2012). The impact of behavioural factors in the renewable energy investment decision making process: Conceptual framework and empirical findings. *Energy Policy*, *40*(1), 28–38. https://doi.org/10.1016/j.enpol.2010.06.062

Masini, A., & Menichetti, E. (2013). Investment decisions in the renewable energy sector: An analysis of non-financial drivers. *Technological Forecasting and Social Change*, *80*(3), 510–524. https://doi.org/10.1016/j.techfore.2012.08.003

Mazzucato, M., & Semieniuk, G. (2018). Financing renewable energy: Who is financing what and why it matters. *Technological Forecasting and Social Change*, *127*(May 2016), 8–22. https://doi.org/10.1016/j.techfore.2017.05.021

Moura, P. S., López, G. L., Moreno, J. I., & De Almeida, A. T. (2013). The role of Smart Grids to foster energy efficiency. *Energy Efficiency*, *6*(4), 621–639. https://doi.org/10.1007/s12053-013-9205-y

MSCI. (2019). *MSCI Europe Utilities Index as of May 31st, 2019*. Retrieved from https://www.msci.com/documents/10199/e5626e0e-a3e2-40da-9b6a-c31906726b3f

Niesten, E., & Alkemade, F. (2016). How is value created and captured in smart grids? A review of the literature and an analysis of pilot projects. *Renewable and Sustainable Energy Reviews*, *53*, 629–638. https://doi.org/10.1016/j.rser.2015.08.069

Nisar, A., Ruiz, F., & Palacios, M. (2013). Organisational learning, strategic rigidity and technology adoption: Implications for electric utilities and renewable energy firms. *Renewable and Sustainable Energy Reviews*, *22*, 438–445. https://doi.org/10.1016/j.rser.2013.01.039

Pereira, G. I., Silva, P. P. da, & Soule, D. (2018). Policy-adaptation for a smarter and more sustainable EU electricity distribution industry: a foresight analysis. *Environment, Development and Sustainability*, *20*(S1), 231–267. https://doi.org/10.1007/s10668-018-0119-x

Pereira, G. I., Specht, J. M., Silva, P. P., & Madlener, R. (2018). Technology, business model, and market design adaptation toward smart electricity distribution: Insights for policy making. *Energy Policy*, *121*, 426–440. https://doi.org/10.1016/j.enpol.2018.06.018

Pinkse, J., Bohnsack, R., & Kolk, A. (2014). The Role of Public and Private Protection in Disruptive Innovation: The Automotive Industry and the Emergence of Low-Emission Vehicles. *Journal of Product Innovation Management*, *31*(1), 43–60. https://doi.org/10.1111/jpim.12079

Poudineh, R., & Jamasb, T. (2014). Distributed generation, storage, demand response and energy efficiency as alternatives to grid capacity enhancement. *Energy Policy*, *67*, 222–231. https://doi.org/10.1016/j.enpol.2013.11.073

Raskin, D. (2014). Getting Distributed Generation Right: a Response To "Does Disruptive Competition Mean a Death Spiral for Electric Utilities?". *Energy Law Journal*, *35*(2), 263–282. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=99252912&site=ehost-live

Refinitiv. (2020). *Securities Data Company (SDC) Platinum*. Retrieved from https://www.refinitiv.com/en/products/sdc-platinum-financial-securities/?utm_content=Refinitiv Brand Product-UKI-EMEA-G-EN-BMM&utm_medium=cpc&utm_source=google&utm_campaign=68832_RefinitivBAUPaidSearch&elqCampaignId=5917&utm_term= +refinitiv +sdc +platinu

Richter, M. (2013). Business model innovation for sustainable energy: German utilities and renewable energy. *Energy Policy*, *62*, 1226–1237. https://doi.org/10.1016/j.enpol.2013.05.038

Roome, N., & Louche, C. (2016). Journeying Toward Business Models for Sustainability. *Organization & Environment*, *29*(1), 11–35. https://doi.org/10.1177/1086026615595084

S&P Capital IQ. (2020a). *Company Comparable Analysis, European Utilities*.

S&P Capital IQ. (2020b). *Market overview, European Emerging Markets, European Developed Markets, Electric Utilities, Multi Utilities*.

S&P Global. (2017). *European Integrated Utilities In 2017: Rebenchmarking The Sector*. Retrieved from https://www.spratings.com/documents/20184/1481001/European+Integrated+Utilit ies+In+2017/a5a59071-259b-4566-a0e2-abfd1652d9fb

S&P Global. (2018a). *Industry Top Trends 2019 Utilities – EMEA Regulated*. Retrieved from https://www.spratings.com/documents/20184/1818036/Industry+Top+Trends+2018+Utilities+EMEA+Regulated/827d380f-c3b6-47f8-b537-0f82b8a9f49a

S&P Global. (2018b). *Industry Top Trends 2019 Utilities – EMEA Unegulated*. Retrieved from https://www.spratings.com/documents/20184/1818036/Industry+Top+Trends+2018+Utilities+EMEA+Unregulated/8d6f9582-6e3b-4425-b9cc-ce03115f84ab

Sagar, A. D., & van der Zwaan, B. (2006). Technological innovation in the energy sector: R&D, deployment, and learning-by-doing. *Energy Policy*, *34*(17), 2601–2608. https://doi.org/10.1016/j.enpol.2005.04.012

Sanford, T., Frumhoff, P. C., Luers, A., & Gulledge, J. (2014). The climate policy narrative for a dangerously warming world. *Nature Climate Change*, *4*(3), 164–166. https://doi.org/10.1038/nclimate2148

Schaltegger, S., Lüdeke-Freund, F., & Hansen, E. G. (2016). Business Models for Sustainability: A Co-Evolutionary Analysis of Sustainable Entrepreneurship, Innovation, and Transformation. *Organization and Environment*, *29*(3), 264–289. https://doi.org/10.1177/1086026616633272

Shafer, S. M., Smith, H. J., & Linder, J. C. (2005). The power of business models. *Business Horizons*, *48*(3), 199–207. https://doi.org/10.1016/j.bushor.2004.10.014

Shomali, A., & Pinkse, J. (2016). The consequences of smart grids for the business model of electricity firms. *Journal of Cleaner Production*, *112*, 3830–3841. https://doi.org/10.1016/j.jclepro.2015.07.078

Soares, N., Martins, A. G., Carvalho, A. L., Caldeira, C., Du, C., Castanheira, É., … Garcia, R. (2018). The challenging paradigm of interrelated energy systems towards a more sustainable future. *Renewable and Sustainable Energy Reviews*, *95*, 171–193. https://doi.org/10.1016/j.rser.2018.07.023

Sommer, A. (2012). Managing Green Business Model Transformations. In *Springer*. https://doi.org/10.1007/978-3-642-28848-7

Sousa, J. L., Martins, A. G., & Jorge, H. (2013). Dealing with the paradox of energy efficiency promotion by electric utilities. *Energy*, *57*, 251–258. https://doi.org/10.1016/j.energy.2013.02.040

STOXX. (2019). *STOXX Europe 600 Utiltiies Index as of mAY 31*. Retrieved from https://www.stoxx.com/index-details?symbol=SXXP

Tayal, D. (2016). Disruptive forces on the electricity industry: A changing landscape for utilities. *The Electricity Journal*, *29*(7), 13–17. https://doi.org/10.1016/j.tej.2016.08.004

Verbong, G. P. J., & Geels, F. W. (2010). Exploring sustainability transitions in the electricity sector with socio-technical pathways. *Technological Forecasting and Social Change*, *77*(8), 1214–1221. https://doi.org/10.1016/j.techfore.2010.04.008

Vernay, A.-L., Sohns, M., Schleich, J., & Haggège, M. (2019). Commercializing Sustainable Technologies by Developing Attractive Value Propositions: The Case of Photovoltaic Panels. *Organization & Environment*, 108602661985379. https://doi.org/10.1177/1086026619853797

Waide, P., & Buchner, B. (2008). Utility energy efficiency schemes: savings obligations and trading. *Energy Efficiency*, *1*(4), 297–311. https://doi.org/10.1007/s12053-008-9024-8

Wainstein, M. E., & Bumpus, A. G. (2016). Business models as drivers of the low carbon power system transition: a multi-level perspective. *Journal of Cleaner Production*, *126*, 572–585. https://doi.org/10.1016/j.jclepro.2016.02.095

World Economic Forum. (2012). New Energy Architecture Enabling an effective transition. *World Economic Forum*.

Wüstenhagen, R., & Menichetti, E. (2012). Strategic choices for renewable energy investment: Conceptual framework and opportunities for further research. *Energy Policy*, *40*(1), 1–10. https://doi.org/10.1016/j.enpol.2011.06.050

Yin, X., & Shanley, M. (2008). Industry determinants of the “merger versus alliance” decision. *Academy of Management Review*, *33*(2), 473–491. https://doi.org/10.5465/AMR.2008.31193515

York, D., Kushler, M., Hayes, S., Sienkowski, S., & Bell, C. (2013). *Making the Business Case for Energy Efficiency: Utility Performance with Supportive Regulation*. Washington, DC.

Zott, C., & Amit, R. (2010). Business Model Design: An Activity System Perspective. *Long Range Planning*, *43*(2–3), 216–226. https://doi.org/10.1016/j.lrp.2009.07.004

Zott, C., Amit, R., & Massa, L. (2011). The Business Model: Recent Developments and Future Research. *Journal of Management*, *37*(4), 1019–1042. https://doi.org/10.1177/0149206311406265