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Energy Supply Security in Southern Europe and Ireland

Konstantinos J. Chalvatzis[a,b,*], Alexis Ioannidis[a]

[a]*Norwich Business School, University of East Anglia, Earlhm rd, Norwich NR4 7TJ, UK*
[b]*Tyndall Centre for Climate Change Research, University of East Anglia, Earlham rd, Norwich NR4 7TJ, UK*

Abstract

Energy supply security is of paramount importance to all countries, however, not all countries present the same capacity to respond to energy security threats. Financial wealth is one of the means that can support access to energy resources and as such countries that have been hit the hardest by the 2008 financial crisis present energy supply vulnerabilities. We focus on Ireland, Portugal, Spain, Italy and Greece and find that they have continuously improved their energy supply diversity. At the same time, we argue that during, and as a result of the financial crisis our focus countries reduced their exposure to expensive imported resources predominantly in the transport sector and increased the role of renewables. Overall, we find improved supply security which could be strengthened further if financial resources were directed towards innovation for renewable energy sources.

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Keywords: energy security; sovereign debt; South Europe;

1. Introduction

Access to energy is one of the most important aspects for the well-being and sustainable development of modern societies [1]. The majority of the most important commodities cannot be used, produced or delivered to the market without the use of energy. In that context the role of energy is directly linked to the economic, social and environmental development of a country [2].

The global energy system faces a number of distinct governance and policy challenges. World energy demand is expected to expand by 45% between now and 2030, and by more than 300% by the end of the century, necessitating a tripling in the amount of needed investment in infrastructure [3]. These figures illustrate the significant growth on energy demand globally and particularly to the existing problematic European energy market. The depletion of fossil fuel reserves and the increasing demand for clean, affordable and secure energy are important concerns for all countries [4].

The scope of energy supply security can be challenging to define [5]. The definition given by Grubb et al (2006) [6] and the formal definition of the International Energy Agency [7] could be

* Corresponding author. Tel.: +44 (0)1603 59 7241
E-mail address: k.chalvatzis@uea.ac.uk

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summarized as "*affordable price that does not disrupt the economy is a presupposition for a secure energy supply"*. The term has evolved from the old-fashion simplified approach which was based just on resource availability [8,9] to a new paradigm that takes into account international trade and competitive markets. In the case of less developed countries energy security is defined as the access to modern energy services [10].

Challenges such as energy resources scarcity, global warming and commodity price fluctuations set the agenda for what is known as the "Energy Trilemma" [11,12]. The EU, a global leader in emissions reduction, suffers from a chronic lack of energy resources which results in higher energy prices and an anaemic recovery from the 2008 financial crisis. At the same time, technological innovations with the potential to disrupt the energy supply and consumption landscape emerge with electric mobility [13], energy storage [14,15], and demand-side management joining large scale deployment of renewable energy sources [16,17].

We argue that these issues are particularly important for the Southern European countries [18,19] and Ireland which have gone through a period of extensive financial vulnerability throughout the financial crisis. All aforementioned EU States signed bailout programmes, which although significantly different, are characterized by welfare and investment cuts. Greece's and Portugal's crises could more rightly be named as sovereign debt crises, Ireland's and Cyprus' as a mixture of sovereign and banking crises, while Spain's a banking crisis. Portugal, Ireland and Cyprus have managed to exit their bailout programmes, however, Greece is still troubled by the remnants of their loans' strict conditionalities. Spain is an exception, since it has only received a bank recapitalization fund. Significantly, the crisis has had a major political impact in Europe, as ten out of the nineteen Eurozone countries have witnessed power shifts.

In this regard we perform a security evaluation of their energy supply and discuss the results alongside their capacity to innovate and respond to vulnerability effectively. We closely focus on the potential role of technological innovation as an enabler for more secure pathways [20].

2. Methodology

Diversity and dependence present two different aspects of security of energy supply and two different paradigms [21] and alongside other propositions [22,23,24] present a straight-forward approach to resource security evaluation. It can be argued that dependence has given way to diversity as the dominant security paradigm and that the latter is indeed more fitting for an increasingly interconnected world [9]. A country's import portfolio is mainly evaluated on the basis of the variety of suppliers and balance in the volume of the commodities imported from each supplier and in respect to the country's fuel mix. For the purpose of this research the two most widely used indices Shannon-Wiener [25,26,27] and Herfindahl-Hirschmann [6,28] are selected along with import dependence metrics. The adopted approach is straight-forward and novel. It is straight- forward because we use the most established concepts to assess supply security; dependence and diversity. Both are estimated with straight- forward indices that were used before in the energy security literature. The novelty of our approach is that never before was the combination of these indices used to analyse how the energy security of indebted countries was affected from the 2008 financial crisis.

Shannon–Wiener Index:

SWI=-$\sum_{i=1}^{n} S_i \times ln\, S_i$

Where S_i is the share of fuel option i available in the total energy mix.

Herfindahl–Hirschman Index:

HHI=-$\sum_{i=1}^{n} S_i^2$

S_i the proportion of option i expressed as a percentage.

Each fuel represents an option for HHI and SWI. There is no absolute guidance over the appropriate

fuel mix diversity (as measured by SWI) and concentration (as measured by HHI). However, a suggestion from the US Department of Justice sets the benchmark of 1500 for a competitive marketplace and 2500 for a highly concentrated one. This has been previously identified as a general weakness of diversity indices [29] which are beyond doubt useful for comparative purposes.

3. Results and Discussion

3.1 Energy Dependence

Energy imports to crisis-hit countries (Figure 1) could not be the exception from the rest of EU as the Union imported more than half of its fossil fuels the last half century and more than 50% of its current energy mix in based on crude oil and coal [19]. Referring to the examined countries more than 1/3 of their energy mix is based on crude oil which in all cases is depended on at least 80% on imports.

It is noteworthy that in all five countries import dependence appears to be reduced from 2009 onwards (with the exception of 2012). This is explained by a shrinkage of energy consumption linked to reduced economic activity. This in turn led to the abandonment of expensive imported energy resources. At the same time growth of renewable energy production facilitated use of indigenous resources and reduced imports further. Specifically, renewables grew by 90% (with a very large and volatile hydro power sector) in Portugal and led with a corresponding import dependence reduction of 8%. The lowest increase in renewables production is observed in Ireland with 28% and a similar 7% decrease in the country's import dependence. Ireland is the most import depended country exceeding 80% consistently during the last 40 years.

Alongside the similar trends presented by all examined countries it is essential to notice the significant gap between their primary energy dependence ratio. Greece presents the lower degree of dependence while Ireland is the most import dependent country. One more issue that becomes apparent is that Italy and Portugal have always had an almost stable degree of dependence and only during the financial crisis started reducing that dependence. However, Greece, Spain and even more Ireland have experienced a strong growth of import dependence between 1995 and 2005.

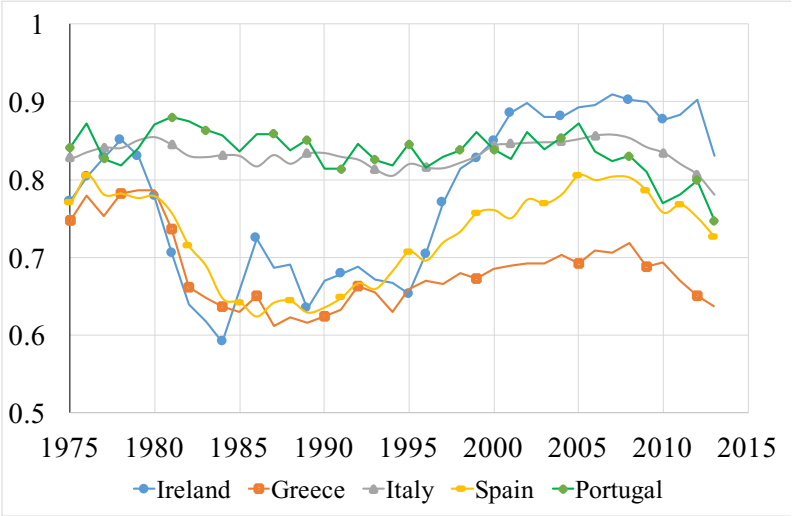

Fig. 1. Primary energy import dependence in selected countries, 1975-2013. Data Source: IEA, 2016

3.2 Energy Supply Diversity

Import dependence is only one aspect of energy supply security. In order to develop pathways to a sustainable, decarbonized energy future, diversity of energy resources is, at least, equally important.

In fact, the EU has adopted a long-term strategic approach on this issue in an attempt to reduce its reliance on expensive and environmentally damaging fossil fuels [30]. Two indices are being used to assess diversity and concentration respectively, SWI (Figures 2a and 2b) and HHI (Figures 3a and 3b).

They both are sensitive to the total number of options used in the fuel mix; therefore, they tend to show a disproportionately large diversity increase even when an option with negligible contribution is introduced to the fuel mix [28]. This is particularly the case for SWI and for this reason using both SWI and HHI provides a complimentary picture. Moreover, we present them with all energy options taken into account (Figures 2a and 3a) and when only options that contribute more than 3% are considered (Figures 2b and 3b). Despite the aforementioned sensitivity issues both indices show similar trends. It is reminded that HHI is a measure of concentration which is opposite to diversity and for this reason the two indices appear to mirror each other.

Overall it is clear that diversity is following a growing trend which does not appear to have been impacted during the financial crisis. Looking closely into the fuel mix of the examined countries we can see that the main drivers for diversity growth have been a reduction in transport fuel use and an increase in renewable energy sources. These two trends help balance the total fuel mix and increase the diversity measures. Throughout our analysis Ireland comes out as the country having the least diverse fuel mix and Spain together with Portugal come out having the most diverse fuel mix.

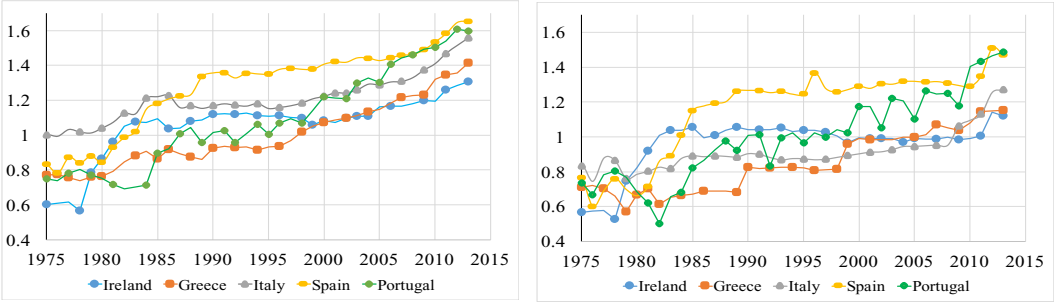

Fig. 2a and 2b. Primary energy supply diversity measured with Shannon Wiener Index (SWI) for selected countries between 1975-2013 with all fuel mix options (2a) and with only those that contribute more than 3% (2b). Data Source: IEA

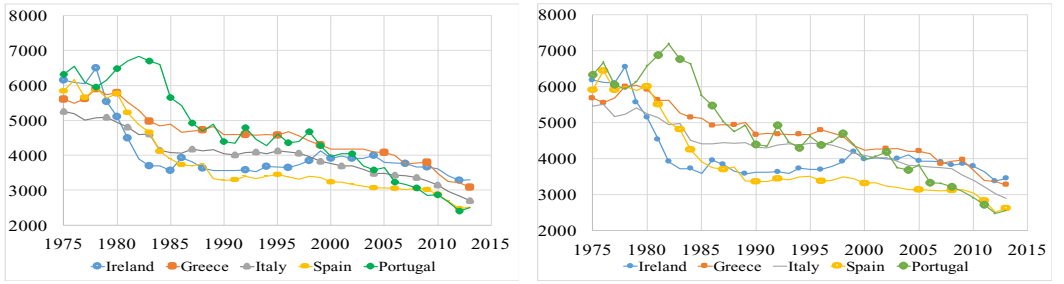

Fig. 3a and 3b. Primary energy supply concentration measured with Herfindahl-Hirschmann (HHI) for selected countries between 1975-2013 with all fuel mix options (3a) and with only those that contribute more than 3% (3b). Data Source: IEA

3.3 Imports Diversity

A relatively underexplored issues in the energy security literature is that of import diversity. Here, acknowledging the fact that the countries in this research have significant part of their energy imported we examine the diversity of those imports. To achieve this, we model the total imported energy supply (in energy units) and calculate the SWI and HHI. The focus in our approach is on import diversity per country of origin; thus, controlling for any one of our selected country's exposure to potential disruptions owning to energy exporters (Figures 4a, 4b, 5a, 5b). Before discussing the specific results, it is important to mention that while countries use a variety of energy resources to

meet their needs, the vast majority of their imported energy is oil and gas. When countries rely heavily on coal that is because they can meet most of their demand with indigenous coal. Likewise, for our selected countries oil has been the main imported resource, followed by gas.

It becomes immediately clear that Ireland is set apart from all other examined countries for its substantially lower import diversity. This is undoubtedly a source of substantial vulnerability. Moreover, the time trajectory of import diversity provides useful insights in relation to the recent economic crisis. Specifically, it appears that energy import diversity for the examined countries peaked at the height of the financial crisis in 2009-2010, and followed a reduced trend in the subsequent years. Ireland has followed the exactly opposite trajectory but it has to be highlighted that Ireland's import mix consists of just about 5-7 countries whereas the other examined countries import energy from a pool of approximately 15-18 countries. Therefore, Ireland's large distance from oil and gas exporting countries in the MENA region and its proximity to the UK meant that its import mix present peculiarities in relation to that of its South European counterparts.

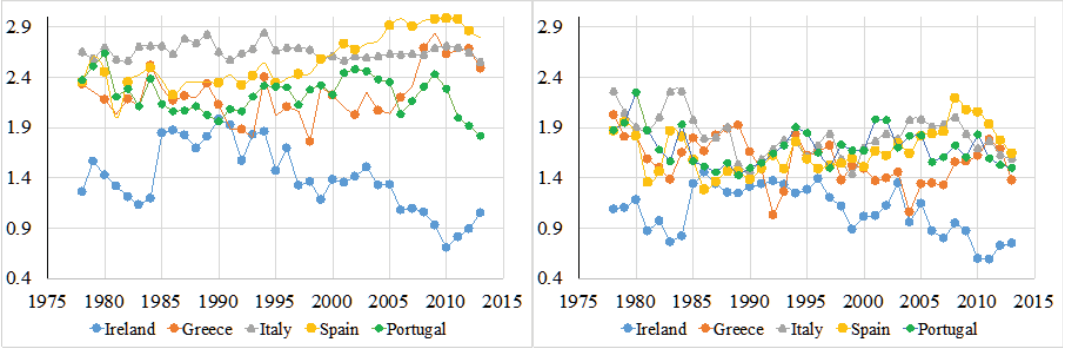

Fig. 4a and 4b. Primary energy imports diversity measured with Shannon Wiener Index (SWI) for selected countries between 1975-2013 with all fuel mix options (4a) and with only those that contribute more than 3% (4b). Data Source: IEA

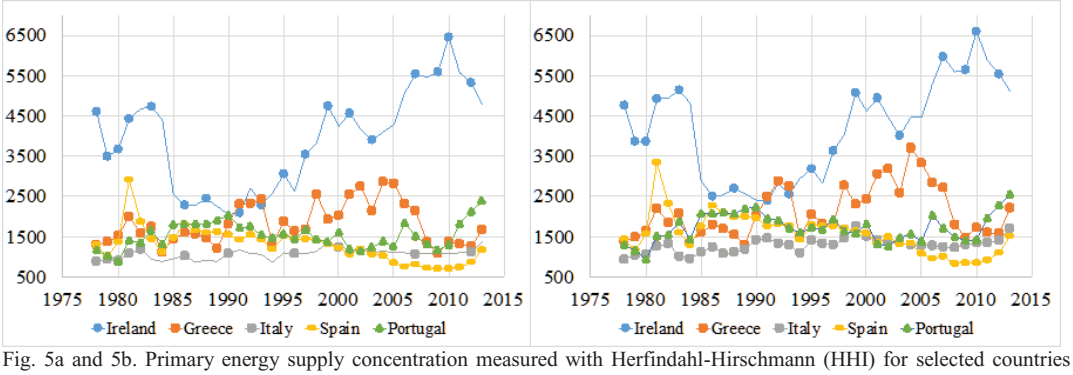

Fig. 5a and 5b. Primary energy supply concentration measured with Herfindahl-Hirschmann (HHI) for selected countries between 1975-2013 with all fuel mix options (5a) and with only those that contribute more than 3% (5b). Data Source: IEA

4. Conclusion

Energy security is important for all countries and substantially more for countries that are simultaneously exposed to further vulnerabilities. As such, countries of the European South and Ireland present a distinct case study since they have suffered from the 2008 financial crisis and their capacity to strategically secure their energy supply may have been weakened.

We have identified that Ireland presents both the highest import dependence and the lower fuel mix diversity putting it at a particularly negative light with regards to supply security. Moreover, Ireland is particularly vulnerable because of its low import diversity. On the contrary Greece presents the lowest import dependence of all examined countries and Spain and Portugal have the most diverse

fuel mix. In all cases renewable energy sources play a significant role in reducing import dependence and at the same time contributing to diversifying the fuel mix. Therefore, our recommendation is for all countries to secure investment budgets to encourage renewable energy installations. Clearly, this will have additional benefits in controlling air pollution which is significant in fossil fuel intensive countries [31]. Within this context it is also import to highlight our finding that a sequence of events occurs that starts with the crisis hit countries reducing their energy consumption; then reduced demand leads to reduced imports and reduced imports lead to a reduction of energy supplying countries which is a source of vulnerability.

Within this study we highlight the inherent link between the energy sector and the broader economy. Specifically, as it is shown growth in renewable energy sources benefits directly energy supply diversity and energy independence improving the overall energy security outlook. However, in certain cases renewable energy sources may have negative effects on job creation as it has been previously highlighted for Spain [32]. Moreover, renewable energy has been linked to increased retail power prices in the EU which can be counterproductive for financially vulnerable countries which need to improve their competitiveness [33].

In concluding, it is essential to assess the role of energy and energy security in the broader context of the examined countries. Potential negative impacts on employment or power prices can be countered within a strategy that makes use of improve energy supply security and encourages investment in innovation. This approach should include investment in energy storage facilities which can play a bundle of roles at small, facility scale [34], and equally, at larger regional scale [35]. Certainly, one size does not fit all and each one of the examined countries should focus on the types of resources that offer a competitive advantage (for example Portugal has enormous hydro power potential which can provide energy storage services). Acknowledging the role of strategic coordination in energy investment and planning, the EU Commission may have to provide leadership. This should fit alongside the EU's agenda for leadership for the abatement of climate change and the burden sharing for emissions reduction between the EU States [36].

Acknowledgements

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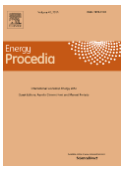
References

[1] Chalvatzis KJ. Electricity generation development of Eastern Europe: A carbon technology management case study for Poland. *Renew Sustain Energy Rev* 2009;**13**:1606–12.
[2] Martchamadol J, Kumar S. Thailand's energy security indicators. *Renew Sustain Energy Rev* 2012;**16**:6103-22.
[3] Brown M, Sovacool B. Climate change and global energy security: technology and policy options. *J Policy Anal Manag* 2013;**32**:910-2.
[4] Augutis J, Martišauskas L, Krikštolaitis R, Augutien E. Impact of the renewable energy sources on the energy security. *Energy Procedia* 2014;**61**:945-8.
[5] Kanchana K, Unesaki H. ASEAN energy security: An indicator-based assessment. *Energy Procedia* 2014;**56(C)**:163-71.
[6] Grubb M, Butler, L, Twomey, P. Diversity and security in UK electricity generation: The influence of low-carbon objectives. *Energ Policy* 2006;**34**:4050-62.
[7] Internantional Energy Agency. Energy security. Available at: http://www.iea.org/topics/energysecurity/ [Accessed 25 Jul. 2016].
[8]International Energy Agency. Energy Security and Climate Policy. Available at: https://www.iea.org/publications/freepublications/publication/energy_security_climate_policy.pdf [Accessed 25 Jul. 2016].
[9] Chalvatzis KJ, Hooper E. Energy security vs. climate change: theoretical framework development and experience in selected EU electricity markets, *Renew Sustain Energy Rev* 2009 **13**:2703-9.
[10] Brahim SP. Renewable energy and energy security in the Philippines. *Energy Procedia* 2014;**52**:480-6.
[11] Heffron R, McCauley D, Sovacool B. Resolving society's energy trilemma through the Energy Justice Metric. *Energ Policy* 2015; **87**:168-76.
[12] Bishop, J, Amaratunga G, Rodriguez, C. Using strong sustainability to optimize electricity generation fuel mixes. *Energ Policy* 2008; **36**:971-80.
[13] Hofmann J, Guan, D, Chalvatzis KJ, Huo H, Assessment of electrical vehicles as a successful driver for reducing CO2 emissions in China, *Appl Energ* 2016; [In Press].

[14] Zafirakis D, Chalvatzis KJ, Baiocchi G, Daskalakis G. The value of arbitrage for energy storage: Evidence from European electricity markets. *Appl Energy* 2016;[In Press].
[15] Zafirakis D, Chalvatzis, KJ, Baiocchi G, Daskalakis G, Modeling of financial incentives for investments in energy storage systems that promote the large-scale integration of wind energy,*Appl Energ 2013 ;* **105**:138-54.
[16] Cherp A, Adenikinju A, Goldthau A, Hernandez F, Hughes L, Jewell J, etal. Energy and security. Global Energy Assessment: Toward a Sustainable Future 2016; 325-83.
[17] Zafirakis D, Chalvatzis, KJ, Kaldellis JK,"Socially just" support mechanisms for the promotion of renewable energy sources in Greece, *Renew Sustain Energy Rev* 2013;**21**:478-93.
[18] Costantini, V, Gracceva F, Markandya A, Vicini G. Security of energy supply: Comparing scenarios from a European perspective. *Energ Policy 2007*, **35**:210-26.
[19] European Comission. (2016). Energy Security Strategy - Energy - European Commission. [online] Available at: https://ec.europa.eu/energy/en/topics/energy-strategy/energy-security-strategy [Accessed 29 Jul. 2016].
[20] Chalvatzis KJ, Rubel K. Electricity portfolio innovation for energy security: The case of carbon constrained China. *Technol Forecast Soc Change* 2015;**100**:267–76.
[21] Nuttall WJ, Manz DL. A new energy security paradigm for the twenty-first century, *Technol Forecast Soc Change 2008;* **75**:1247-59.
[22] Jun E, Kim W,Chang, S. The analysis of security cost for different energy sources. *Appl Energ* 2009;**86**:1894-901.
[23] Sovacool B, Mukherjee I, Drupady I, D'Agostino A. Evaluating energy security performance from 1990 to 2010 for eighteen countries. *Energy* 2011; **36**:5846-53.
[24] Kruyt B,Van Vuuren D, De Vries H, Groenenber H. Indicators for energy security. *Energ Policy*; 2009; **37**:2166-81.
[25] Stirling A. Diversity and ignorance in electricity supply investment. Addressing the solution rather than the problem. *Energ Policy* 1995;**22**:195-216.
[26] Stirling A. Diversity in electricity supply: a response to the reply of Lucas et al. *Energ policy* 1995;**23**:8-11.
[27] Stirling A. The Dynamics of Security: stability, durability, resilience, robustness. Presentation to workshop on 'Energy Security in a Multipolar World', London: *Royal Society*; 2009.
[28] Hickey EA, Lon Carlson J, Loomis D. Issues in the determination of the optimal portfolio of electricity supply options. *Energ Policy* 2010; **38**:2198-207.
[29] Ferreira HL, Costescu A, L'Abbate A, Minnebo P, Fulli G. Distributed generation and distribution market diversity in Europe. *Energ Policy* 2011;**39**:5561-71.
[30] Forbes.(2016).ForbesWelcome.[online]Available at: http://www.forbes.com/sites/mikescott/2014/05/29/europe-must-reduce-reliance-on-all-fossil-fuels-not-just-russias/#c4a30ae59fc0 [Accessed 29 Jul. 2016].
[31] Kaldellis JK, Spyropoulos G, Chalvatzis KJ. The impact of Greek electricity generation sector on the national air pollution problem. *Fresen Environ Bull* 2004;**13**(7):647-56.
[32] Gea Y, Zhi Q. Literature Review: The Green Economy, Clean Energy Policy and Employment. *Energy Procedia* 2016;**88**:257-64.
[33] Sisodiaa GY, Soaresb I, Ferreirac P, Banerjid S, den Poele DV, Kumarf M. Does the use of Solar and Wind Energy Increase Retail Prices in Europe? Evidence from EU-27. *Energy Procedia* 2015;**79**:506-12.
[34] Zafirakis D, Elmasides C, Sauer DU, Leuthold M, Merei G, Kaldellis JK et al. The multiple role of energy storage in the industrial sector: Evidence from a Greek industrial facility. *Energy Procedia* 2014;**46**:178-85.
[35] Zafirakis D, Chalvatzis KJ. Wind energy and natural gas-based energy storage to promote energy security and lower emissions in island regions. *Fuel* 2014;**115**:203-19.
[36] Zafirakis D, Chalvatzis KJ, Baiocchi G. Embodied CO_2 emissions and cross-border electricity trade in Europe: Rebalancing burden sharing with energy storage. *Appl Energy* 2015;**143**:283-300.



Biography

Konstantinos J. Chalvatzis is a Senior Lecturer in Business and Climate Change at Norwich Business School and the Tyndall Centre for Climate Change Research. His research is focused on the role of energy innovation in improving energy services and energy supply security.