Energy Security in a Quintuple Helix Innovation Ecosystem

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Abstract

For the past decade, nation states have been collaborating to global carbon emissions for the pursuit of global environmental sustainability. In 2015, the Heads of State and Government and High Representatives of the United Nations unanimously adopted the 2030 Agenda for Sustainable Development, with an urgent call for investments into 17 Sustainable Development Goals (SDG). Despite these efforts, the World Economic Forum has nominated climate change as the highest impact and highest likelihood global threats for 2019. This chapter focuses on the creation of new businesses within the context of SDG7 (ensure access to affordable, reliable, sustainable and modern energy for all). We look at energy transformations from the lenses of the Quintuple Helix Innovation model and propose that the natural environments of society and economy do not only apply to ensuring sustainable energy security (SDG7), but to ensuring energy security as a whole. Both nation states and international organizations have fallen short of adopting this point of view, as revealed by their failure to adopt both top-down (industry, government, and academia) and bottom-up (civil-society and entrepreneurship-empowered) approaches.

Key Words: Climate Change, Quintuple Helix Innovation Ecosystem, Sustainable Development Goals, Energy Security

Introduction

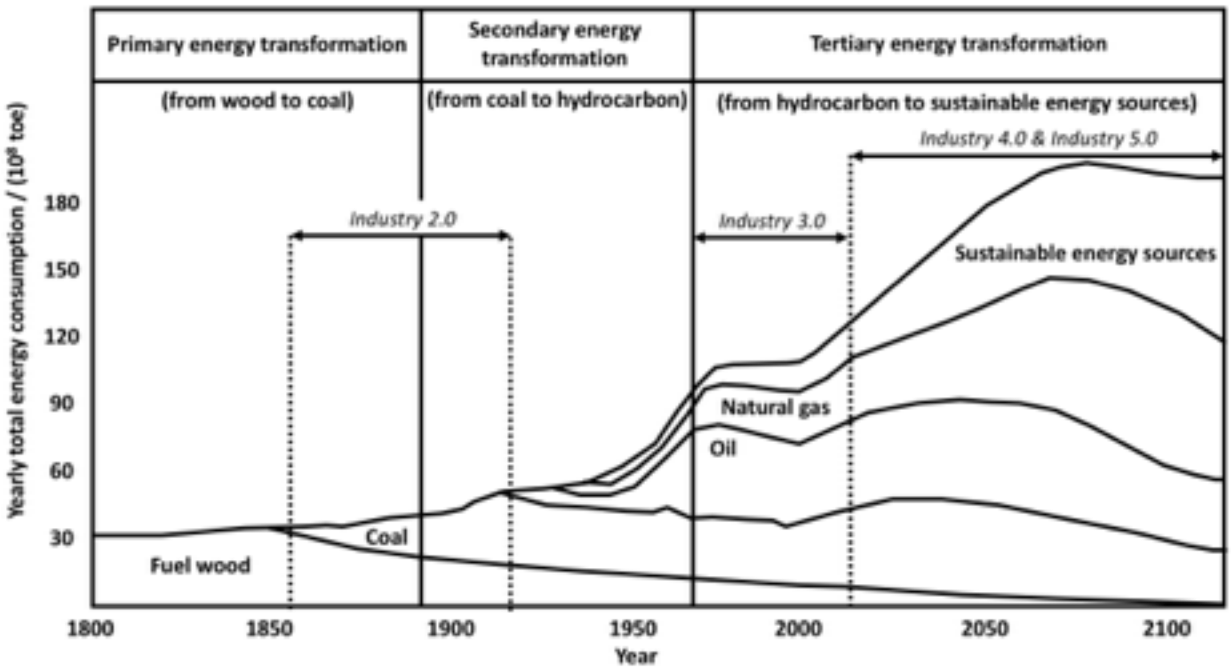
Sustainable energy security is achievable if the international community works together and encourages the development and diffusion of sustainable innovative solutions in the energy field. To achieve this, the SDG7 states that by 2030 the international community will 1) ensure universal access to affordable, reliable and modern energy services; 2) increase substantially the share of renewable energy in the global energy mix; and 3) double the global rate of improvement in energy efficiency. The stated intent of these efforts are meant to a) enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology; and b) expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and landlocked developing countries, in accordance with their respective programs of support (Heads of State and Government and High Representatives, 2015). Ultimately, SDG7 commits the international community to search for new ways and technologies that move beyond "low-carbon energy transitions" (Bridge, Bouzarovski, Bradshaw, & Eyre, 2013, p. 331; Geels, 2014, p. 30; Goldthau & Sovacool, 2012, p. 232); to support the adoption of carbon-free, "smart and sustainable" (Elias G. Carayannis & Rakhmatullin, 2014, p. 212) energy, especially in developing and least developed countries. Given that the share of renewables in final energy consumption is increasing at a rate of 0.2% per year — for example, between 2014 and 2015 it increased from 17.3% to 17.5% — with only half of that derived from "modern forms of renewable energy" (Guterres, 2018, p. 7), SDG7 is currently positioned to fail.

At the national levels, investments into green entrepreneurship have also fallen short of expectations. This is emphasized by the fact that in 2016, for example, 41% of the world's population "were still cooking with polluting fuel and stove combinations" (Guterres, 2018, p. 7). Furthermore, at the international level, the International Energy Agency (IEA) — a supranational alliance oil consumers created in the wake of the 1973 oil sanctions imposed by the Organization of Arab Petroleum Exporting Countries (OAPEC) — has been particularly slow in adopting sustainable energy transformations as part of its core mission. This shortfall is embodied in IEA's definition of energy security as the reliable, stable, and uninterrupted supply of energy sources at an affordable price. In its construct, SDG 7 replaces the need for reliability with the need for sustainability; effectively and urgently calling for a global partnership of developed and developing countries shifting focus to sustainable energy security.

While the IEA emphasizes that long term energy prospects must be in line with "environmental needs" (IEA, 2019), we propose that the IEA definition of energy security has been built from the perspectives of industry, government, and academia — specific of the Second and Third Industrial Revolutions — ignoring its 'media-based and culture-based public' and 'civil society' (Elias G. Carayannis & Campbell, 2009) considerations, as well as the sustainable entrepreneurship requirements of cleaner 'natural environments of society and economy' (Elias G. Carayannis & Campbell, 2010). The SDG7 significant epistemological transformation of energy security (from the IEA focus on reliability to sustainability), specific of the Fourth Industrial Revolution, emphasizes that the transition to carbon-free smart and sustainable energy within a geo-PESTE — geopolitical, geo-economic, geo-socio-cultural, geo-technological, and geo-ecological (Elias G. Carayannis, 2011) — construct is a requirement for peace (Gnansounou, 2008, p. 3742; Haghighi, 2008, p. 466; Pamir, 2007, p. 262; Peters, 2004, p. 190; Stefanova, 2006, p. 91; Verrastro & Ladislaw, 2007, p. 101; Von Hippel, Savage, & Hayes, 2011, p. 6712; Yi-chong, 2006, p. 265) and prosperity (Atsumi, 2007, p. 28; Balitskiy, Bilan, & Strielkowski, 2014, p. 123; Bambawale & Sovacool, 2011/5, p. 1949; Climent & Pardo, 2007/1, p. 522; Intharak, 2007, p. 6; Murad, Alam, Noman, & Ozturk, 2019, p. 22). This chapter argues that the transition to sustainable energy security cannot be achieved in the absence of targeted entrepreneurship options that are part of a quintuple helix innovation ecosystem.

The Current Understanding of Energy Security under the Traditional IEA Construct

Reliable, stable, and uninterrupted supply of energy sources at an affordable price has led to the record economic growth of the 19^{th} century, when coal fueled the Second Industrial Revolution (Cheema, 2011). During this time, energy security was defined from the pure industrial lenses, at least until 1912, when the British Royal Navy transitioned from coal to diesel-ran engines (Jones, 1977). It wasn’t until after WWI — when the navies of the great powers transitioned from domestic coal to dependency on imported oil — that energy security became important from geo-political lenses, and a key driver of economic and foreign policies (McCain, 2007, p. 32). Since then, energy security has been traditionally viewed from bipolar (industry-government) perspectives, and almost exclusively constrained by the security of oil supplies (Yergin, 1988). With no other single issue viewed “as fundamental to [a nation’s] future as energy” (Raphael & Stokes, 2014, p. 184), energy security became "a question of national strategy" (Yergin, 2006, p. 69). After the end of the Cold War, the Third Industrial Revolution introduced the field of renewable energy as a requirement for energy security (particularly from the perspective of the academia), promoting low-carbon energy transitions, rather than sustainable energy (based on zero-carbon energy transformations). In this construct, the IEA definition of energy security through industry, government, and academic points of view (a top-down triple helix approach), did not replace the old construct, but rather added to it (Jewell, 2013, p. 7). The main concern remained access to supply rather than the promotion of sustainable energy transformations (as embodied by SDG7 and reflected in figure 1).



Source: Adapted from Zou, Zhao, Zhang, & Xiong, 2016, p. 8.
Figure 1: Technology transformation to energy transformation outlooks.

Within the top-down triple helix construct (industry, government, and academia) three schools of thought emerged to address threats to energy supplies and their infrastructures: sovereignty (or Westphalian), robustness, and resilience. These three perspectives, which differ in response strategies and focus (Elias G. Carayannis & Rakhmatullin, 2014), "have their roots in separate academic disciplines: political science (the sovereignty perspective), natural sciences and engineering (the robustness perspective), and economics (the resilience perspectives)" (Cherp & Jewell, 2011/9, p. 207).

The sovereignty perspective:

The sovereignty perspective takes a government-centric approach to defining energy security (O'Sullivan, 2013), and is concerned primarily with the influence and capabilities that foreign entities — from terrorists (Toft, Duero, & Bieliauskas, 2010) to nation states (He & Qin, 2006, p. 101) — have on disrupting energy supplies (Cherp & Jewell, 2011/9, p. 206). Risk-minimization strategies presented by this perspective include "switching to more trusted suppliers or weakening a single agent's role through diversification, substituting imported resources with domestic ones, and casting military, political and/or economic control over energy systems" (Cherp & Jewell, 2011/9, p. 206).

The robustness perspective:

The robustness perspective is concerned with the anticipation of stresses to energy systems — disruptions that may affect "the long-term access to" energy supplies (Deane, Gracceva, Chiodi, Gargiulo, & Gallachóir, 2015) — and the application of "appropriate energy risk management instruments" (Van der Linde, 2007, p. 51) to prevent them. These stresses include "growth in demand, scarcity of resources, aging of infrastructure, technical failures, or extreme natural events" (Cherp & Jewell, 2011/9, p. 207). Responses encompass "upgrading infrastructure, switching to more abundant energy sources, adopting safer technologies, and managing demand growth" (Cherp & Jewell, 2011/9, p. 207).

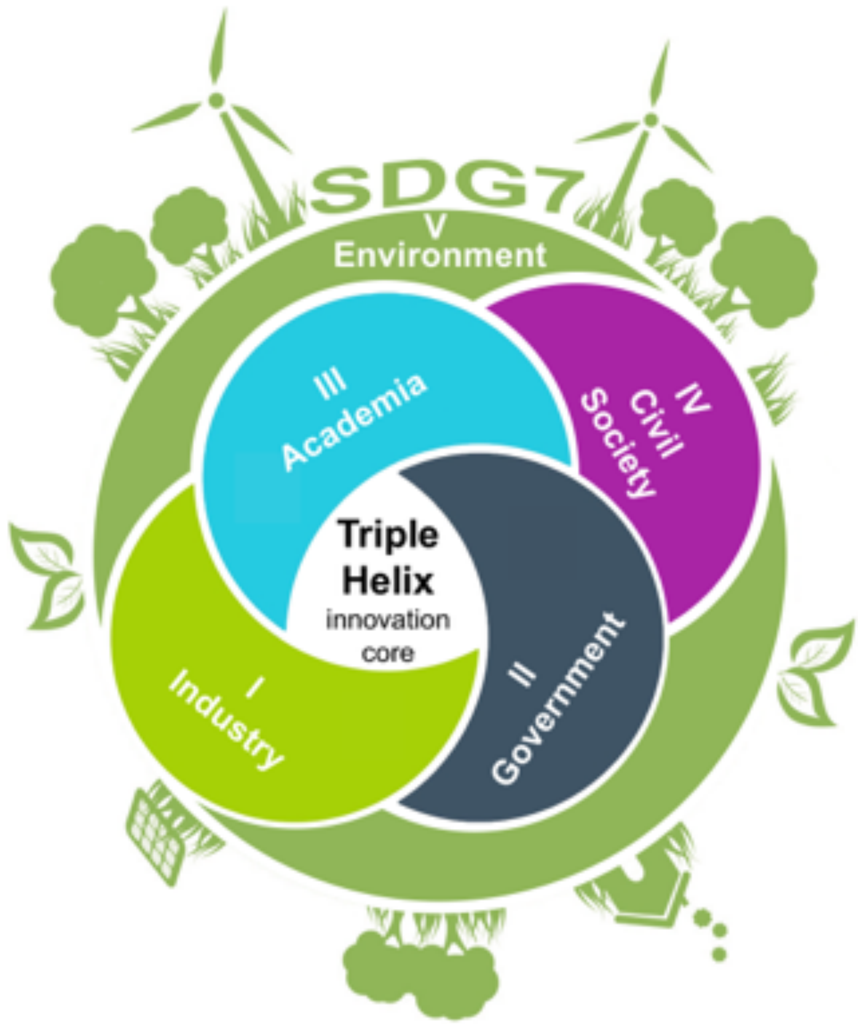
The resilience perspective:

The resilience perspective focuses on the capacity of industry to bounce back from "regulatory changes, unforeseeable economic crises (or booms), change of political regimes, disruptive technologies, and climate fluctuations" (Cherp & Jewell, 2011/9); or from other "sudden and transient shocks, such as the interruption of a major supply source" (Gracceva & Zeniewski, 2014, p. 5). Responses to these disruptions include planning for surprises and diversification of energy supplies (Cherp & Jewell, 2011/9).

The IEA's definition of energy security as "the uninterrupted availability of energy sources at an affordable price" (IEA, 2019) incorporates these perspectives, but without really addressing the sustainability dimension. In this context, for the IEA, the ends (that is, the uninterrupted availability of energy sources at an affordable price) justify the means (the world's over-reliance on dirty energy sources, such as coal and oil). With the SDG7 in mind, we argue that the IEA must change its definition of energy security to the uninterrupted availability of sustainable energy sources at an affordable price. This change is needed to encourage its member states to do more for the achievement of SDG7, to include shifting focus to entrepreneurship options and innovation in the energy field.

Redefining Energy Security in a Quintuple Helix Innovation Ecosystem

Whereas during the Second and Third Industrial Revolutions, energy security was defined through government, university and industry (Elias G. Carayannis & Rakhmatullin, 2014) points of view (a top-down triple helix GUI approach), the definition of energy security at the dawn of Industry 4.0 is evolving in a 'Mode 3 Innovation Ecosystem', where the need for sustainability can equal (and in certain circumstances even outweigh) the need for profitability. Within this context, SDG7 calls for urgent action to ensure access to affordable, reliable, sustainable and modern energy for all; which goes beyond the resilience, sovereignty, and robustness perspectives in the literature of energy security. Within a sustainable Mode 3 Innovation Ecosystem people, technology, cultures, and the natural environment "meet and interact to catalyze creativity, trigger invention and accelerate innovation across scientific and technological disciplines, public and private sectors (government, university, industry and non-governmental knowledge production, utilization and renewal entities) and in a top-down, policy-driven as well as bottom-up, entrepreneurship-empowered fashion" (Elias G. Carayannis & Campbell, 2009). This calls for a Quintuple Helix understanding (see figure 2) of energy transformations, where the natural environments of society and economy do not only apply to ensuring sustainable energy security (SDG7), but to ensuring energy security as a whole. The Quintuple Helix model stresses the need for socio-ecological transformations of society. It goes beyond the resilience, sovereignty and robustness perspectives, adding 'media-based and culture-based public' and 'civil society', as well as the natural environments of society and economy as fourth and fifth perspectives (Elias G. Carayannis & Campbell, 2009).



Source: Adapted from Elias G. Carayannis, Barth, & Campbell, 2012, p. 3.
Figure 2: The socio-ecological transition of SDG7 from a Triple Helix model to a Quintuple Helix Innovation model.

Even before SDG7 was adopted by all the member states of the United Nations, the European Commission stressed (in 2009) the European Union's requirement for a socio-ecological transformation by 2025 through sustainable ways "of producing, of consuming, of living, of moving, etc." (Rossetti di Valdalbero, 2009, p. 22). This goal was also emphasized by the EU's Clean Energy for All Europeans initiative (European Commission, 2019). With existential environmental threats (climate change, extreme weather, natural disasters) threatening our way of life (World Economic Forum, 2019, p. 4), we propose that the addition of 'media-based and culture-based public' and 'civil society', as well as the natural environments of society and economy perspectives (embodied in SDG7) is not a matter of choice, but one of necessity. Energy security can no longer be defined outside of the ecological impact — that is, the effect on "living organisms and their nonliving environment" (United Nations, 1997) — of primary energy supplies. The main research question of this chapter is, then, not whether an epistemological and factual transition to sustainable energy security is needed, but how new people-centric and environmental-centric perspectives can be built using a Quintuple Helix Innovation model.

Green transformations refer to democracies, economies and societies where top-down and bottom-up approaches are used to support sustainable development by implementing initiatives that encourage green (environmentally responsible) public-private investments (United Nations, 2010). The success of SDG7 is dependent on targeted public-private investments, which require a full analytical understanding of all perspectives of energy security and "the continuous involvement of the whole disciplinary spectrum, ranging from the natural sciences (because of the natural environment) to the social sciences and humanities" (Elias G. Carayannis & Campbell, 2010, p. 62). The systems that form the Quintuple Helix Innovation model — as an enabler and enactor of co–opetitive entrepreneurial ecosystems (E. G. Carayannis, Grigoroudis, Campbell, Meissner, & Stamati, 2018) — build on each other through know-how, which translates into knowledge, and ultimately, sustainable development (see figure 3). The success of SDG7 requires, thus, targeted investments and promotion of entrepreneurship within all systems of the Quintuple Helix Innovation model (Elias G. Carayannis et al., 2012).

Source: Adapted from Elias G. Carayannis et al., 2012, p. 7
Figure 3: Circulation of knowledge in a Quintuple Helix Innovation model for sustainable energy.

The value of the Quintuple Helix Innovation model to SDG7 lies in the revelation that sustainable energy development does not come only from government and industry (top-down) approaches, but also from civil society and academia (bottom up) through the application of ecologically sensitive entrepreneurial approaches.

Conclusion

The Quintuple Helix Innovation model contextualizes in theory and practice "the sum of the social (societal) interactions and the academic exchanges in a state (nation-state) in order to promote and visualize a cooperation system of knowledge, know-how, and innovation for more sustainable development" (Elias G. Carayannis et al., 2012, p. 4). It reveals that public acceptance of green entrepreneurial options is key in the energy transformation process envisioned by SDG7 (O'Brien et al., 2011). In a Quintuple Helix Innovation construct, ecological awareness (particularly in the context of climate change) is transforming the way that industry, government, academia, and civil society look at energy transformations — where ecological considerations are no longer a preference, but a requirement. This holds significant implications for how nation states and international organizations define and measure sustainable energy security. We emphasize that a step in the right direction was the development of IEA's Model of Short-Term Energy Security (MOSES) tool, which differentiates green energy apart from the total production and consumption mix using a systems approach at national levels (Jewell, 2011, p. 1). More action is needed, however, by both nation states and international organizations to promote sustainable energy transformations through green entrepreneurship and to support the successful implementation of SDG7.

References

Atsumi, M. (2007) Japanese Energy Security Revisited. *Asia-Pacific Review*, *14*(1), 28–43.

Balitskiy, S., Bilan, Y., & Strielkowski, W. (2014) Energy security and economic growth in the European Union. *Journal of Security & Sustainability Issues*, *4*(2).

Bambawale, M. J., & Sovacool, B. K. (2011/5) China's energy security: The perspective of energy users. *Applied Energy*, *88*(5), 1949–1956.

Bridge, G., Bouzarovski, S., Bradshaw, M., & Eyre, N. (2013) Geographies of energy transition: Space, place and the low-carbon economy. *Energy Policy*, *53*, 331–340.

Carayannis, E. G. (2011, March) *The Open Innovation Paradigm and Strategic Options for EU-U.S. Innovation Partnerships. The FREIE Concept in the Context of Open Innovation Diplomacy*. Presented at the BILAT 2011, Vienna, Austria.

Carayannis, E. G., Barth, T. D., & Campbell, D. F. J. (2012) The Quintuple Helix innovation model: global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship*, *1*(1), 2.

Carayannis, E. G., & Campbell, D. F. J. (2009) “Mode 3” and ’Quadruple Helix': toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management = Journal International de La Gestion Technologique*, *46*(3-4), 201–234.

Carayannis, E. G., & Campbell, D. F. J. (2010) Triple Helix, Quadruple Helix and Quintuple Helix and how do knowledge, innovation and the environment relate to each other: A proposed framework for a trans-disciplinary analysis of sustainable development and social ecology. *International Journal of Social Ecology and Sustainable Development (IJSESD)*, *1*(1), 41–69.

Carayannis, E. G., Grigoroudis, E., Campbell, D. F. J., Meissner, D., & Stamati, D. (2018) The ecosystem as helix: an exploratory theory–building study of regional co–opetitive entrepreneurial ecosystems as Quadruple/Quintuple Helix Innovation Models. *R&D Management*, *48*(1).

Carayannis, E. G., & Rakhmatullin, R. (2014) The Quadruple/Quintuple Innovation Helixes and Smart Specialisation Strategies for Sustainable and Inclusive Growth in Europe and Beyond. *Journal of the Knowledge Economy*, *5*(2), 212–239.

Cheema, P. I. (2011) Pakistan as an Energy Corridor for Iran and Central Asia: The EU’s Interests. *Journal of European Studies* 27(2).

Cherp, A., & Jewell, J. (2011/9) The three perspectives on energy security: intellectual history, disciplinary roots and the potential for integration. *Current Opinion in Environmental Sustainability*, *3*(4), 202–212.

Climent, F., & Pardo, A. (2007/1) Decoupling factors on the energy–output linkage: The Spanish case. *Energy Policy*, *35*(1), 522–528.

Deane, J. P., Gracceva, F., Chiodi, A., Gargiulo, M., & Gallachóir, B. P. Ó. (2015) Assessing power system security. A framework and a multi model approach. *International Journal of Electrical Power & Energy Systems*, *73*, 283–297.

European Commission (2019, August 20) Clean Energy for all Europeans Package. Retrieved August 25, 2019, from https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans.

Geels, F. W. (2014) Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. *Theory, Culture & Society*, *31*(5), 21–40.

Gnansounou, E. (2008) Assessing the energy vulnerability: Case of industrialised countries. *Energy Policy*, *36*(10), 3734–3744.

Goldthau, A., & Sovacool, B. K. (2012) The uniqueness of the energy security, justice, and governance problem. *Energy Policy*, *41*, 232–240.

Gracceva, F., & Zeniewski, P. (2014) A systemic approach to assessing energy security in a low-carbon EU energy system. *Applied Energy*, *123*, 335–348.

Guterres, A. (2018) *The Sustainable Development Goals Report 2018* (No. 18-03826). United Nations.

Haghighi, S. S. (2008) Energy Security and the Division of Competences between the European Community and its Member States. *European Law Journal*, *14*(4), 461–482.

Heads of State and Government and High Representatives. Transforming Our World: The 2030 Agenda for Sustainable Development, Pub. L. No. A/RES/70/1, Resolution adopted by the General Assembly (2015).

He, F., & Qin, D. (2006) China's Energy Strategy in the Twenty-first Century. *China & World Economy*, *14*(2), 93–104.

IEA. (2019). Energy Security. Retrieved August 25, 2019, from https://www.iea.org/topics/energysecurity.

Intharak, N. (2007) *A Quest for Energy Security in the 21st Century*. (A. A. Aponte, Ed.). Asia Pacific Energy Research Centre.

Jewell, J. (2011) The IEA model of short-term energy security (MOSES). IEA: Report No. 2011/17.

Jewell, J. (2013) Energy Security and Climate Change Mitigation. the interaction in long-term global scenarios. *Environmental Sciences and Policy. Central European University*. Retrieved August 25, 2019, from http://www.etd.ceu.hu/2013/jewell_jessica.pdf

Jones, G. G. (1977) The British government and the oil companies 1912-1924: the search for an oil policy. *The Historical Journal*, *20*(3), 647–672.

McCain, J. (2007) An Enduring Peace Built on Freedom - Securing America's Future. *Foreign Affairs*, *86*(6).

Murad, M. W., Alam, M. M., Noman, A. H. M., & Ozturk, I. (2019) Dynamics of technological innovation, energy consumption, energy price and economic growth in Denmark. *Environmental Progress & Sustainable Energy*, *38*(1), 22–29.

O'Brien, M., Bleischwitz, R., Bringezu, S., Fischer, S., Ritsche, D., Steger, S., Samus, T., Geibler, J. von, Giljum, S., Polzin, C. (2011) *The eco-*

innovation challenge: pathways to a resource-efficient Europe. Annual report 2010. Eco-Innovation Observatory. Retrieved August 25, 2019, from https://epub.wupperinst.org/frontdoor/index/index/docId/4035

O'Sullivan, M. L. (2013) The entanglement of energy, grand strategy, and international security. *The Handbook of Global Energy Policy*, 30–47.

Pamir, N. (2007) The Black Sea: A Gateway to Energy Security and Diversification. *Southeast European and Black Sea Studies*, *7*(2), 245–263.

Peters, S. (2004) Coercive western energy security strategies: "resource wars" as a new threat to global security. *Geopolitics*, *9*(1), 187–212.

Raphael, S., & Stokes, D. (2014) US oil strategy in the Caspian Basin: Hegemony through interdependence. *International Relations*, *28*(2), 183–206.

Rossetti di Valdalbero, D. (2009) *The World in 2025: Rising Asia and Socio-Ecological Transition* (No. EUR 23921 EN). European Commission.

Stefanova, B. (2006) Regional Integration as a System of Conflict Resolution: The European Experience. *World Affairs*, *169*(2), 81–93.

Toft, P., Duero, A., & Bieliauskas, A. (2010) Terrorist targeting and energy security. *Energy Policy*, *38*(8), 4411–4421.

United Nations (1997) *Glossary of Environment Statistics, Studies in Methods* (No. Series F, No. 67). New York: United Nations.

United Nations (2010) *A Greener Footprint for Industry: Opportunities and Challenges of Sustainable Industrial Development* (No. V.09-85821). United Nations Industrial Development Organization: Vienna, Austria.

Van der Linde, C. (2007) The art of managing energy security risks. *EIB Papers, ISSN 0257-7755*, *12*(1), 50–78.

Verrastro, F., & Ladislaw, S. (2007) Providing Energy Security in an Interdependent World. *The Washington Quarterly*, *30*(4), 95–104.

Von Hippel, D., Savage, T., & Hayes, P. (2011) Introduction to the Asian Energy Security project: Project organization and methodologies. *Energy Policy*, *39*(11), 6712–6718.

World Economic Forum (2019) *The Global Risks Report 2019* (No. 14). World Economic Forum. Retrieved August 25, 2019, from http://www3.weforum.org/docs/WEF_Global_Risks_Report_2019.pdf

Yergin, D. (1988) Energy Security in the 1990s. *Foreign Affairs*, *67*, 110.

Yergin, D. (2006) Ensuring Energy Security. *Foreign Affairs*, *85*(2), 69–82.

Yi-chong, X. (2006) China's energy security. *Australian Journal of*

International Affairs, *60*(2), 265–286.
Zou, C., Zhao, Q., Zhang, G., & Xiong, B. (2016) Energy revolution: From a fossil energy era to a new energy era. *Natural Gas Industry B*, *3*(1), 1–11.