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JOURNAL OF SECURITY AND SUSTAINABILITY ISSUES
ISSN 2029-7017 print/ISSN 2029-7025 online
2017 September Volume 7 Number 1
http://dx.doi.org/10.9770/jssi.2017.7.1(11)

ENERGY SECURITY AND ECONOMIC DEVELOPMENT: RENEWABLES AND THE INTEGRATION OF ENERGY SYSTEMS

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Received 10 January 2017; accepted 4 July 2017

Abstract. Our paper is dealing with the issues of energy security and economic development. Our focus is on the changes and challenges that are posed in front of the many countries with regard to the threat of the shortages of energy sources and the depletion of the existing carbon sources. Economic, social and demographic changes in the world call for the novel solutions that would include innovative ways how to secure the smooth and undisrupted flow of energy for maintaining the daily lives of the citizens. We are particularly interested in showing how the integration of energy systems or the coordination between neighboring energy systems might contribute to the sustainable development and operation of the energy sector. The paper uses an example of hydro energy storage in order to show the shortcomings of the battery energy storage and the ways how it can be solved. Our results and findings show that renewable energy sources might become a viable solution to the problems specified above. Well-balanced and well-placed usage of renewables might cushion the shortcomings of the traditional energy systems and prevent major shocks to the energy security through the world and in the European Union countries.

Keywords: energy, energy security, economic growth, renewable energy sources, European Union

Reference to this paper should be made as follows: Melas, V.; Lisin, E.; Tvaronavičienė, M., Peresadko, G.; Radwański, R. 2017. Energy security and economic development: renewables and the integration of energy systems, *Journal of Security and Sustainability Issues* 7(1): 133–139. http://dx.doi.org/10.9770/jssi.2017.7.1(11)

JEL Classifications: L90, Q20, Q30, Q43

1. Introduction

Energy is an essential resource for all forms of a business field that covers the providers of energy, transport businesses, energy associated industries and service suppliers of energy. According to International Energy Agency (IEA, 2007), energy security is the continuous availability of the sources of energy which are reason-

ably priced. Energy security means self-assurance and belief in its constant ability to obtain economical and reliable energy (Bielecki, 2002). It is regarded to be important for both day-to-day operations and long-term investments (Chamberlin, 2015; Kalyugina et al., 2015; Koudelková et al., 2015; Ehrenberger et al., 2015). Again, energy security comprises multiple scopes – long-term energy security primarily relates to appropriate investments for supplying energy in alignment with economic growth and needs for sustainable economic development (Strielkowski et al., 2017). On the other hand, short-term energy security emphasizes on the capability of the energy system to respond on time to unexpected variations in the balance between the supply and demand of energy. Thus, the absence of energy security is associated with the negative social and economic effects of either physical obtainability of energy or uncompetitive or excessively volatile prices. This process is equally vital and important for rural and urban areas (Chmielewska and Horváthová, 2016; Zielińska, 2016; Jankelová et al., 2017; Jankurová et al., 2017) and is widely reported in mass media and discussed by the general public (Čábelková et al., 2015).

The modern era has experienced the rising focus as well as awareness towards the energy security issue which, in a way, becomes a new religion (Strielkowski and Čábelková, 2015; Strielkowski, 2017). In a report by Nematollahi et al. (2016), there is a lot of fear and apprehension such as the depletion of fossil and oil fuel, reliance on foreign energy sources, firmness of countries which supply energy, the energy demands of developing and third world nations, and increasing demands from developed countries, environmental problems and economic efficiencies (Ignatavičius et al. 2015; Tvaronavičienė et al. 2015; Tvaronavičienė, Černevičiūtė 2015; Tvaronavičienė 2016; Dobrovolskienė et al. 2017; Tvaronavičienė 2017)

Internationally, there has been an outburst of many energy crises that have resulted in more focus on energy security. Access to fairly economical energy has turned out to be vital to the operation of contemporary economies. Nevertheless, the unbalanced delivery of energy supplies amongst nations has caused substantial vulnerabilities (Lisin and Strielkowski, 2014; Lisin et al., 2017).

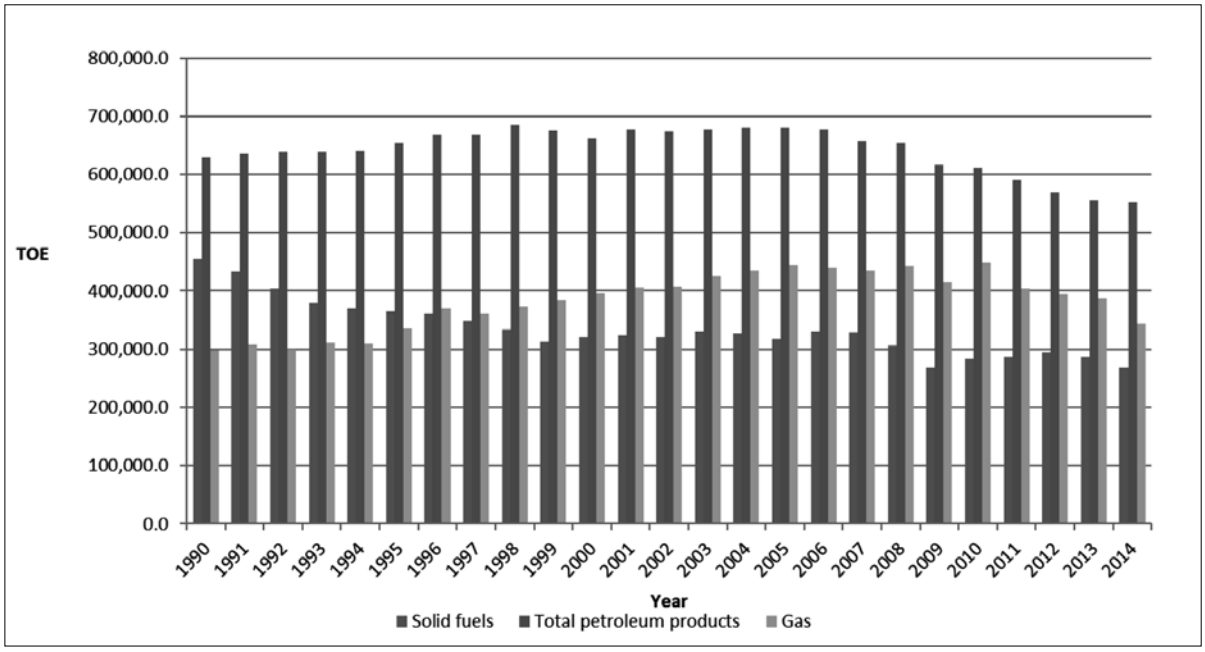
This paper is organized as follows: Section 2 outlines and discusses threats to energy security that stem from dependence on traditional carbon energy sources. Section 3 describes long-term of energy security, while Section 4 contradicts with outlining the concepts of long-term energy security. Section 5 elaborates on the energy storage issues and makes implication for the integration of energy systems. Finally, the Conclusions section summarizes our reasoning and findings and provides the pathways for further research to follow.

2. Threats to energy security

The contemporary world depends on a large supply of energy for fueling everything ranging from communication to transportation, to health delivery and security systems. Energy is an important player in the national security of all countries as a fuel for powering the trade and industry engine. Certain sectors depend on energy more greatly compared to others. Today, there are many threats to energy security including the rivalry over sources of energy, energy supplies manipulation, attacks on the infrastructure for supply, political instability of different energy producing nations, accidents, dependence on foreign nations for oil, terrorism, and natural disasters.

Chart 1 that follows reports how the gross inland consumption of energy in the EU-28 countries has shifted over the last 25 years. It is clear that the share of the total petroleum products and solid fuels has diminished considerably with the total rise of the share of gas.

Chart 1. Gross inland consumption of energy in thousand tonnes of oil equivalent (TOE) for the EU-28 countries



Source: Own compilations based on the Eurostat (2017)

Foreign supplies of energy are susceptible to abnormal interruptions from internal conflict, interests of exporters, and non-state players who target the distribution and transport of the resources of oil. The economic and political instability as a result of warfare or other aspects like strike action may correspondingly prevent the appropriate operation of the energy industry in an oil producing country. For instance, the oil nationalization in Venezuela has prompted protests and strikes, whereby the rates of oil production in the country are yet to recuperate (Yetiv and Lu, 2007). Exporters could have an economic or political incentive for limiting their overseas sales or causing interferences in the supply chain. Terror attacks which target oil fields, refineries, tankers, pipelines and oil facilities are so prevalent that they have become risks to the energy industry. Infrastructure for the production of the resources is very vulnerable to interruption. Fresh threats to energy security have arisen due to increased global completion of resources of energy triggered by the raising speed of industrialization in nations like China and India, coupled with the amplifying impacts of climate change (Yetiv and Lu, 2007). Augmented rivalry over energy resources can as well result in the establishment of security agreements for enabling an equitable supply of gas and oil between main powers. Yet, such could occur at the expense of economies which are less developed.

3. Long-term energy security

Long-term actions to promote energy security focus on the reduction of reliance on any single source of energy that is imported, increment of the suppliers' number, exploitation of natural renewable energy or fossil fuel, and the reduction of overall demand through measures for energy conservation. Besides, it may involve signing international agreements to cement global energy trading relationships, like the Energy Charter Treaty (ECT) in Europe (Haghighi, 2007). Each concern which comes from security threats on long-term security measures of oil resources will help in reducing the future cost of importation and exportation of fuel into and out of nations without worrying about the damage which comes to the transit goods.

The effect of the oil crisis of 1973 and the advent of the OPEC cartel was a specific milestone which triggered some nations to intensify their energy security. Virtually entirely reliant on imported oil, Japan, progressively introduced the usage of nuclear power, natural gas, high-speed mass systems of transit, and effected measures of energy conservation. The UK started the exploitation of North Sea oil as well as gas reserves and grew into a

net energy exporter during the 2000s (Haghighi, 2007). In other nations, energy security has traditionally been a lesser priority. For example, the US has continued increasing its reliance on imported oil, though after the prices of oil increased from 2003, the creation of biofuels has been proposed as a way of dealing with this (Barton et al., 2004). Furthermore, the increment of security is among the reasons behind a block in the establishment of natural gas in Sweden. Higher investments in natural renewable energy technologies along with energy conservation are rather envisaged. India is performing a major search for national oil to reduce its dependence on OPEC, whereas Iceland is well progressive its strategies to become energy independent as of 2050 by using 100 percent renewable energy (Lior, 2012).

4. Short-term energy security

According to Cordesman (2006) and Zlyvko et al. (2014), crude oil (petroleum) has turned into the most used energy resource by nations globally, including China, Russia, and the US. Due to the location of oil wells across the globe, energy security has turned out to be a major issue to guarantee the safety of the petroleum which is being generated. Oil fields in the Middle East have become a key target for sabotage since most of the world countries depend on them for oil (Yetiv and Lu, 2007). Most of the nation-states keep strategic petroleum reserves to act as a cushion against the political and economic consequences of an energy crisis. In comparison to petroleum, dependency on imported natural gas leads to substantial short-term vulnerabilities.

As reported De Vries et al. (2007), most of the European nations saw an abrupt decrease in supply after the halting of the Russian gas supplies throughout the 2006 Russia-Ukraine gas dispute. Natural gas has become a sustainable energy source globally. However, natural gas providers are being faced with one of the biggest challenges today – the ability to store and transport it. Because of its low density, it is hard to create adequate pipelines in North America for transporting enough natural gas to equate demand. Nuclear gas has also become one of the main energy sources, and it presently generates 13 percent of the total electricity worldwide.

The use of renewable technologies normally upturns the diversity of sources of electricity and, through local production, leads to the system's flexibility and its fight against fundamental shocks. For the nations where increasing reliance on imported gas is an important energy security problem, renewable technologies may offer alternative electric power sources along with shifting electricity demand by direct production of heat (De Vries et al., 2007). Renewable biofuels for transportation represent a major source of diversification from crude oil products. Lior (2012) asserts that, due to the fact that the resources which have been very important for survival across the globe to this day begin decreasing in numbers, nations will start recognizing the necessity for a renewable source of energy will be as critical as ever. As a result of the generation of new energy types such as wind power, biofuel, hydroelectric, geothermal and solar energy, there is adequate energy for powering the world.

Water storage currently dominates the world's conventional electrical energy storage (EES), rapid ongoing decrease in the cost of batteries raises hopes that chemical will offer a new and attractive storage option. Newbery and Strbac (2016) summarize estimates for 2020 battery energy storage (BES) costs which range from €253-€345/kWh for the battery pack as opposed to the today's costs of about €1117. Energy stored in batteries from renewable energy source such as wind turbines during off peak periods could be discharged during peak periods as opposed to running non-renewable sources such as natural gas turbines which are more expensive. The value obtained from storing cheap or free energy obtained from renewable sources during off-peak or low-demand periods which could be sold during peak hours (which are mostly in the afternoon) can be calculated by simply taking the market price difference between the time periods.

5. Battery storage and energy issues

Nowadays, battery energy storage accounts for just 1% of world's EES with Pumped Hydroelectric Energy Storage (PHES) making up the remaining 99% (Newbery, 2016). Pumped Storage Plants (PSP) first introduced in the 1960s represent the overwhelmingly established bulk EES technology with an operation output capacity reaching about 164 GW in 2016 (Barbour et al., 2016). This capacity has been growing for past 8 years at an

average of 2.7% per annum (EIA, 2016). Since 2008, the rate of development of PHES has increased to harness the growing energy demand in the 1990s and 2000s and anticipation of increased wind generation. The most recent PHES projects in Europe have been commissioned in Austria and Spain (2013-2014). Comparing to other regions of the world, Europe has the most PHES capacity with about 80% of it developed in 1960-1990. Most of the facilities can be found in the mountainous regions of Austria, France, Germany, Italy, Spain, and Switzerland. The development of PHES was coordinated with significant increases in nuclear capacity, although some countries that do not have nuclear power (e.g. Austria) also installed considerable PHES capacities (Barbour et al., 2016).

The world hydro capacity in 2012 was 979 GW, generating 3,288 TWh/year (or 16% of world total electricity output) (EIA, 2016). Germany had 6.8 GW output capacity and stored 50 GWh, or 7.4 hours on average, while Britain with 2.86 GW output stored 26.7 GWh, or 9.3 hrs. For the 45 GW of PSPs for which capacity is available, total storage is 1.7 TWh (although the top four by capacity have 75% of this total and a very low output, corresponding more to storage hydro). The remaining PSPs have 10.9 hours, duration so if this is representative of the remaining PSPs, the total global storage capacity is 2.9 TWh (compared to roughly 23.4 GW storage hydro and 70 TWh in dams in Norway alone). Assuming the capacity factor is related to storage capacity as in Norway, the capacity would be 3.7 months. At 3 months, storage capacity would be 2,144 TWh, or 2,700 times the global PSP capacity (Newbery, 2016). The example of Norway represents an important lesion in the possibility of the integration of energy systems. Provided the efficient transfer of energy is ensured (e.g. via the cables in the North Sea), the viable integration of energy systems of the United Kingdom and Norway can be achieved which would ensure the smooth supply of renewable hydro energy from Norway to the United Kingdom.

Overall, it might seem if the indirect use of hydro power (as well as the electric transport envisaged in the future) were accessible at reasonable cost, they would be cheaper than conventional EES. Moreover, there is still no battery revolution for a future smarter energy system in sight despite the plethora of research focused on improving performance and reducing costs of battery storage across electrochemical, and mechanical and thermal devices. However, everything is not that simple as it seems. It is true that opposed to batteries that draw from the chemical energy, have short lifetimes and prove inviable under the current electricity prices (Staffell and Rustomji, 2016), the hydro power EES use the free storage medium (water) and can operate for more than 100 years. But their potential of gravitational energy is remarkable weak compared to chemical energy and their high capital costs and their distance from demand centres sometimes make them less favourable options then BES.

Conclusions

Energy security is a troubling issue for many nations nowadays. Depleting carbon energy resources, growing demand for energy and volatile energy prices make this issue to be of the life and death importance in both energy-abundant countries and countries short on energy resources. The whole world is in the search of solution how to deal with the constantly increasing need for the constant supply of cheap and efficient energy.

In our analysis, we argue that renewable energy sources and noteworthy prospects for energy efficiency are present over extensive geographic regions, contrary to other sources of energy, which are concentrated in a few countries globally. Rapid utilization of renewable energy sources along with energy efficiency, and industrial expansion of energy sources could lead to significant economic benefits as well as energy security. Since no nation is self-reliant based on energy requirements, they may ensure access to dependable, cheap and ecologically sound energy through partnerships and collaboration. The major concern is the depleting energy sources. Accordingly, it is important to create a new energy system that could provide sufficient, cost-effective and non-polluting energy.

When it comes to the pathways for the further research that found themselves outside the scope of this paper, it would be interesting to conduct a more in-depth analysis of the world's regions and to make a comparison of their potential when it comes to energy sources and their exhaustion. Also, it would be interesting to assess the potential for renewable energy sources (e.g. hydro, wind, solar) in various regions of the world and to make as-

sumption about which regions might specialize in which renewables and how the potential trade might be conducted. This seems to be a particularly interesting discussion since the concept of the comparative advantage and the principles of the international trade can be embedded into the analysis of energy. Moreover, it would also be interesting to focus more on the perspective of the integration of energy systems worldwide.

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