

University of Salford  
A Greater Manchester  
University

University of Essex

ESSEX  
BUSINESS  
SCHOOL

International Centre for Entrepreneurship Research

The General  
Jonas Zemaitis  
Military Academy  
of LithuaniaMinistry  
of National Defence  
Republic of LithuaniaVilnius Gediminas  
Technical University

RISEBA

Estonian  
Business  
SchoolNATO Energy  
Security  
Centre  
of ExcellenceENTREPRENEURSHIP AND  
SUSTAINABILITY CENTER

AVADA

**JOURNAL OF SECURITY AND SUSTAINABILITY ISSUES**

ISSN 2029-7017 print/ISSN 2029-7025 online

2018 March Volume 7 Number 3

[https://doi.org/10.9770/jssi.2018.7.3\(1\)](https://doi.org/10.9770/jssi.2018.7.3(1))**ENERGY SECURITY ISSUES IN CONTEMPORARY EUROPE****Josef Abrhám<sup>1</sup>, Igor Britchenko<sup>1,2</sup>, Marija Jankovic<sup>3</sup>,  
Kristina Garškaitė-Milvydienė<sup>4</sup>**<sup>1</sup>*University of Economics, Prague, Winston Churchill Sq. 4, 130 67, Prague, Czech Republic*<sup>2</sup>*Faculty of Technical and Economic Sciences State Higher Vocational School Memorial of Prof. Stanislaw Tarnowski  
Henryka Sienkiewicza 50, 39-400, Tarnobrzeg, Poland*<sup>3</sup>*Faculty of Business studies, University of Mediterranean, Vaka Đurovića bb., Podgorica, Montenegro*<sup>4</sup>*Vilnius Gediminas Technical University, Saulėtekio 11, 10223 Vilnius, Lithuania**E-mails: <sup>1</sup>[abrham@vse.cz](mailto:abrham@vse.cz); <sup>3</sup>[marija.jankovic.mbs@gmail.com](mailto:marija.jankovic.mbs@gmail.com); <sup>4</sup>[kristina.garskaite@vgtu.lt](mailto:kristina.garskaite@vgtu.lt)**Received 27 May 2017; accepted 06 December 2017*

**Abstract.** Throughout the history of mankind, energy security has been always seen as a means of protection from disruptions of essential energy systems. The idea of protection from disorders emerged from the process of securing political and military control over energy resources to set up policies and measures on managing risks that affect all elements of energy systems. The various systems placed in a place to achieve energy security are the driving force towards the energy innovations or emerging trends in the energy sector.

Our paper discusses energy security status and innovations in the energy sector in European Union (EU). We analyze the recent up-to-date developments of the energy policy and exploitation of energy sources, as well as scrutinize the channels of energy streaming to the EU countries and the risks associated with this energy import. Moreover, we argue that the shift to the low-carbon production of energy and the massive deployment of renewable energy sources (RES) might become the key issue in ensuring the energy security and independency of the EU from its external energy supplies. Both RES, distributed energy resources (DER) and “green energy” that will be based on the energy efficiency and the shift to the alternative energy supply might change the energy security status quo for the EU.

**Keywords:** energy security, natural gas, oil, renewable energy, distributed energy resources, European Union

**Reference** to this paper should be made as follows: Abrhám, J.; Britchenko, I.; ; Jankovic, M. ; Garškaitė-Milvydienė, K. Energy security issues in contemporary Europe, *Journal of Security and Sustainability Issues* 7(3): 387–398.  
[https://doi.org/10.9770/jssi.2018.7.3\(1\)](https://doi.org/10.9770/jssi.2018.7.3(1))

**JEL Classifications:** C10; F64, Q20, Q41

**1. Introduction: energy balance in European Union**

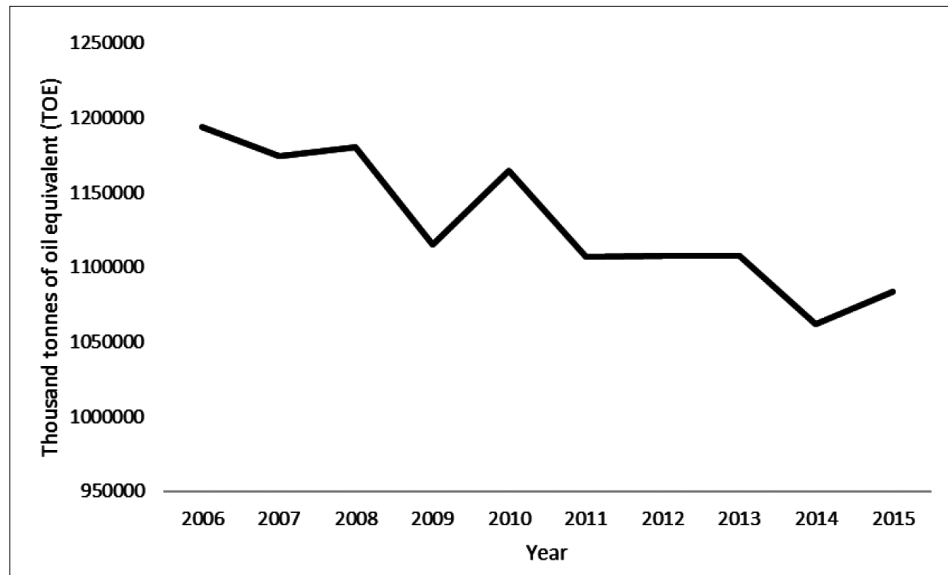
The question of European Union’s energy security has intensified on the political agenda in Europe from the mid-2000s, since progresses in the global energy industry have progressively been viewed as a risk by the European Union organizations as well as the member countries governments (Metais 2013). The externalization of the internal energy market of EU has accordingly been perceived as a way of ensuring energy security.

Recent years have seen the contemporary Europe focus more consideration to various energy security concerns, particularly in the Eastern and Central Europe including the depletion of oil and other fossil fuel, renewable sources and other alternative sources of energy, and environmental concerns, especially climate change. However, the European energy industry is in the process of great revolution which could form its profiles for years to come. Shifting global environment, the views of energy itself, innovations and technologies, new sources of conventional, but as well renewable energy, need a sufficient answer from the energy firms in Europe but also nations and global institutions. In general, there are several energy security issues which Europe is addressing and must address in the future. Thus, this paper discusses some of the major energy security problems facing the modern Europe, as well as the innovations which are being made to tackle these challenges and ensure energy security. The European Union (EU) energy sector has experienced unpredictable changes over the centuries. These changes are driven by the global agency to mitigate the climate change and decarbonize the energy sector, which has a direct effect on in power supply expenses. The European Commission (EC) has long ago set up a legally binding target for renewable energy sources (RES) to ensure more than 20% of the total energy consumption in the countries of the European Union (EU) by the year of 2020. The fundamental principle of an operative meaning of energy security is that there are uninterrupted, stable supplies at prices which are affordable. Nevertheless, from the perspective of established research on energy security, various features may be presented: the necessity to guarantee necessary investments, the exporters' reliability, or threats associated with passage nations and technical structures, which may result in temporary interruptions (Asif and Muneer 2007). The last factor is possibly the most mentioned when the topic of energy security is talked about across Europe following gas transportation crises from 2006 to 2009 between Ukraine and Russia that led to extreme impacts on some European Union member states. Fascinatingly, the energy market itself, presented as the energy security issues' solution, may correspondingly be a component of the threat if its arrangement becomes unfavorable to customer nations.

## **2. Paris Agreement and energy consumption**

The Paris Agreement was reached in December 2015 (although it came to force after its ratification in 2016). The Agreement set very demanding and sometimes ambiguous goals and promises for the EU and other countries (Committee on Climate Change, 2016). In order to achieve these goals, the European Union Member States committed to reaching their own national renewable targets that were set from 10% in Malta to 49% in Sweden (see Calliess and Hey 2013). Additionally, they further have required that 10% of transportation fuel to be produced from renewable power by the year 2020 (Drom 2014). All EU national Member States adopted national renewable targets depicting what measures they were planning to make in order to meet their renewable targets using their objectives. This strategy in cooperates sectoral targets for heating, transport and cooling; planned policy measures; the various mix of renewable innovations they expect to employ and the planned use of cooperation mechanism. The European Union also encourages public interventions such as support systems which remain essential for making renewable energy reforms effective and ensuring the EU energy security objectives.

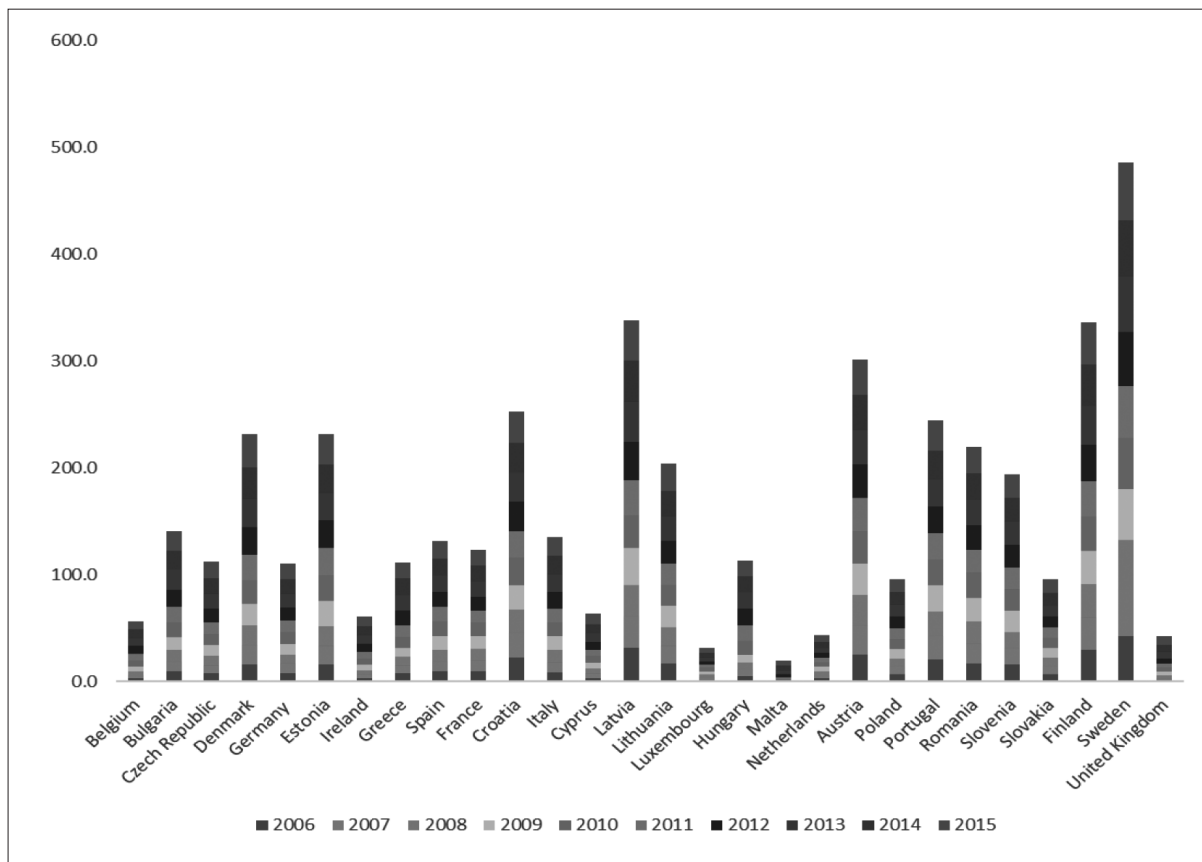
Figure 1 that follows, shows the final energy consumption in EU-28 countries throughout the ten years between 2006 and 2015. The decrease is apparent, so is the consumption of energy, all thanks to the introduction of RES. This process allows to decrease the energy dependency and to diversify the energy security of the European Union.



**Fig. 1.** Final energy consumption in EU-28 countries (2006-2015)

*Source:* Eurostat (2017)

With regard to the above, it would be useful to demonstrate the shares of RES by the EU Member States. Figure 2 that follows, reports the share of energy from RES in the EU.



**Fig. 2.** Share of energy from RES in EU-28 countries (2006-2015)

*Source:* Eurostat (2017)

When looking into the issue of energy security and energy dependency of the EU, one has to mention the topic of natural gas consumption. With regard to this, Balitskiy *et al.* (2014) point out that channels along which natural gas is supplied to the EU energy markets represents dependence from the Russian supply of gas which presents a threat to the European energy security. They show that there is a long-run relationship between economic growth, natural gas consumption, labor and capital. In the short run, there is bidirectional causality between natural gas consumption and economic growth. The causality running from economic growth to natural gas consumption is positive.

In essence, energy is of greatest significance as many contemporary activities depend on it. Thus, according to Korkmaz (2010), one of the main energy security issues in Europe is secure supplies of energy, in order to offer stable energy supplies along with affordable prices to the users. The issue is of most significance for Eastern and Central Europe in which energy security, as a result of history, together with geopolitical aspects, always remains high on the agenda. The interruption in gas supplies experienced in recent years, the continuing Ukraine-Russia conflict and the announcement by Gazprom to halt transportation to Europe via Ukraine after 2019, lead to persistent uncertainty over the stability of Russian gas supplies to Europe. Such concerns are increased by preparations to construct new lines of the Nord Stream gas pipeline along with the European Commission’s latest decision to give Gazprom augmented capacity utilization of the OPAL pipeline. Similarly, there is a current debate on a suggestion for a revised, regulation on the gas supply’s security, on the basis of a regional approach.

Furthermore, another critical challenge in the aspect of gas supply is the likely natural resources’ depletion. In fact, Metais (2013) states that the International Energy Agency had predicted that the international demand for major sources of energy could amplify by thirty-six percent from 2008 to 2015, where fossil energies would account for more than half of the total growth in main demand of energy. In the European Union alone, the demand for gas was set to grow by 24 percent from 2005 to 2025. Such may partially be described by global policy keenness to minimize carbon dioxide emissions, due to the favorable features of natural gas with regard to ecological issues, and as well by its concrete capability to be an alternative for other energies in electric power production (see Figure 3). Further, the Fukushima nuclear power plant accident as a consequent of tsunami and earthquake in 2011 has a potential of contributing to an amplified gas demand in the EU since nuclear energy skeptics will advocate a switch to plants powered by gas. Yet, although there will be an inclination to shift to other sources of energy, in every sector for economic and environmental reasons, oil will continue to be the key fossil energy in the global principal energy combination till 2035.

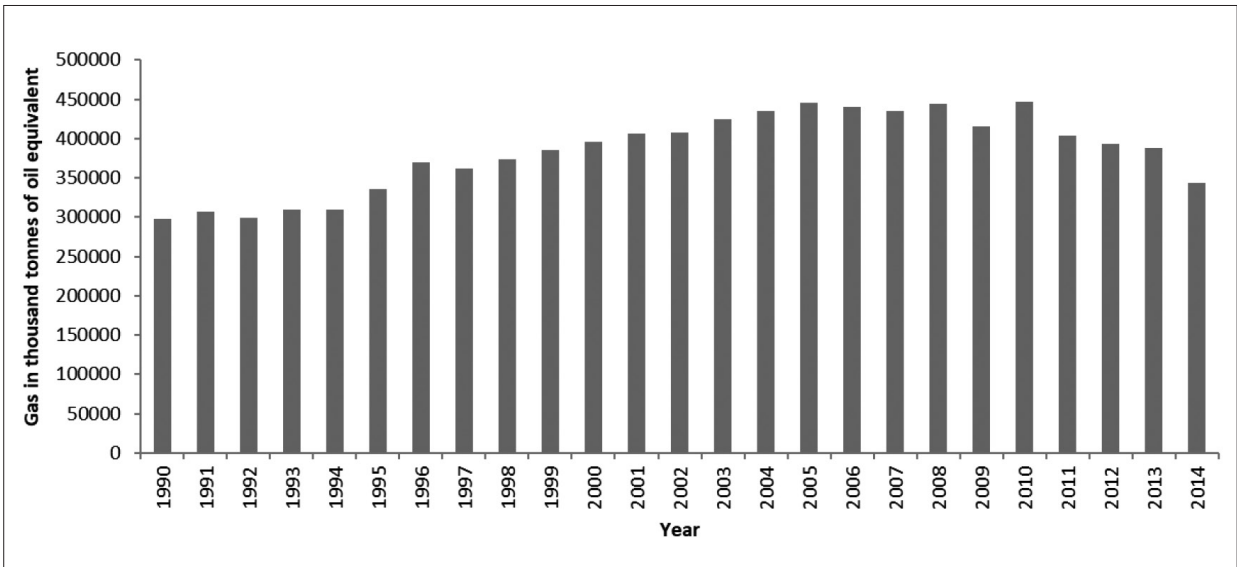


Fig. 3. Natural gas consumption in the EU (1990-2014)

Source: BP (2017)

Apart from these changes, the smart technology, which advocates for the creation of “smart” cities, health, logistics, international trade and transport, poses an energy security threat for Europe (Franki and Višković 2015; Čábelková et al. 2015; Brodzicki 2016; Štreimikienė et al. 2016; Vasylchak and Halachenko 2016; Varanavicius et al. 2017). The smart technology depends on the use of ICT in production and distribution of a digitalized energy. The use of ICT in power generation and distribution decentralizes energy system and substantially the position of a consumer in the energy value chain hence affecting the energy’s procurement cost. Although, smart energy system is primarily advocated for it does have loopholes in its security details. These security gaps are proven by the newly sophisticated cyber-attacks seen in the smart digital ecosystem currently (Abrhám and Wang 2017). To curb these attacks, the government of European Union Member States governments collectively established independent mechanism and measure for protecting her energy systems from external threats called the Cyber Security Strategy System (Chalvatzis and Ioannidis 2017).

### **3. Literature review: energy security and the new challenges**

When studying such issues as energy security in contemporary Europe, one has to mention the issues of innovations in energy sector. Innovations constitute an important part of the energy research and the progress in energy extraction, transmission and consumption.

The main security issue for Central and Eastern Europe in the power industry is the loop-flows phenomena which are unscheduled flows of power across the boundaries of countries in the Eastern and Central Europe. They are due to congestions in the Germany’s internal power grid, unable to successfully transmit electricity from renewable sources, largely from wind farms in the north, to the South of Germany and further down Austria. Consequently, the Czech Republic and Poland’s power grids are more frequently utilized by such spontaneous flows (Noreng 2009). Likewise, they block a large portion of transmission capacities on the boundaries of these nations. Such, in turn, both limits prospects for trade and represents a major risk for power grids’ stability.

Similarly, there is also the issue of modernizing the power generation park and also the transmission lines, a requirement for long-term security for power supply. Many of the EU-11 plants built for power generation are old and thus, there is a threat that in the mid-term outlook, the power shortages, as witnessed in summer 2015 in Poland, could occur more frequently (Noreng 2009). It is critical to note that due to the impromptu loop flows which block the border between Poland and Germany, Poland was not able to import electricity at that point for the purpose of alleviating its balancing issue of the day. All in all, the contemporary Europe has recognized that a modern energy infrastructure is important for an energy market that is integrated and to allow the European Union to fulfill its energy and climate goals. Europe should expand and modernize its energy network in order to absorb energy from renewable sources along with secure supplies all over. Such needs substantial investment in the current electricity and gas networks, with fast expansion of the interconnections. Undeniably, supply security, sustainability or competitiveness goals can never be fulfilled without smart, reliable and resilient energy networks (Yergin 2011).

However, another important issue is the link between innovations and sustainable economic growth and development. There is a plethora of studies that confirm the existence of this link therefore advocating for the importance of innovations in energy sector and sustainable development (Rezk *et al.* 2016; Laužikas *et al.* 2016; Tvaronavičienė 2016; Akhter 2017; Barberis *et al.* 2017). Other studies draw the examples of other (non-EU) countries to prove the same point. For example, Pauceanu 2016 is studying the case of Oman and is coming to the similar conclusion with regard to the link between the two. All in all, energy security represents a new challenge that involves looking for the new technological solutions in energy, transport, household heating and other sectors. With the raise of the sharing economy that was popularized by the services such as the car-sharing and ride-sharing service Uber and house-sharing service AirBnB, the energy sector is entering into the new concept of Industry 4.0 (see Prause 2014).

In December 2015, the European Council and Parliament agreed on the formation of an Energy Protection Reform Commission called the Network and information systems (the so-called “NIS Directive”). The commission was charged with the responsibility of protecting the European cyber framework. The framework en-

compassed the Digital Single Market, strategy and the Energy Union package. Its main mandate is to create the right conditions for trade and consumer benefits in the digitalization trend currently going on all over the globe (Zielińska 2016). For the smooth running of the European’s Digital Single Market, general data protection, and the digital energy available, there is a need for a trustworthy online environment hence the body was formed to curb any energy security threat. The framework is designed to respond coherently and very fast in case of an emergency linked to cybersecurity.

The majority of energy supply that is currently used in the European Union is based on energy that is generated from oil and gas burning technologies, while the sources of this oil and gas can often be traced to the neighboring regions and countries which are represented by Russian Federation, Norway, and Algeria, that in total provide about 80% of EU power supply. In the same time, such volatile countries as Ukraine, Turkey, and Belarus serve as the vital energy transit routes to and from the European Union.

Figure 4 shows the final energy consumption in Turkey and Ukraine. It becomes clear how little is the consumption in these countries in comparison with the EU patterns and how potentially interested they might be hampering the energy supply for their own political benefits. One can therefore deduce that there is a clear need to have a secure energy supply framework and good political relationship with these EU neighboring countries.

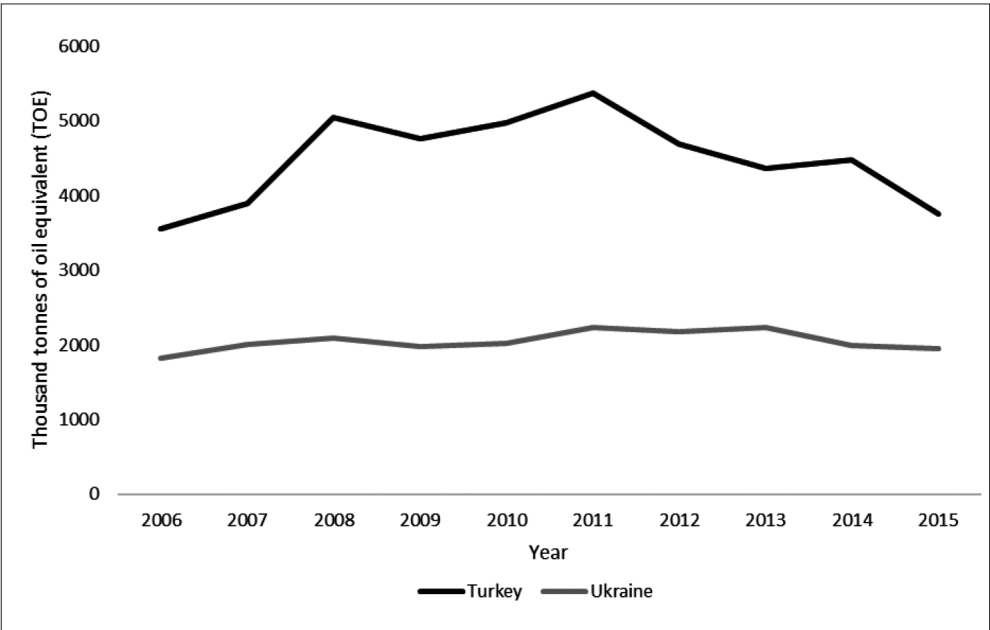


Fig. 4. Final energy consumption Turkey and Ukraine (2005-2015)

Source: Eurostat (2017)

Additionally, the energy system transition will result in a new shifting geographic state that poses a threat to Europe’s energy markets as technology and interconnections broaden energy trade around the world. The uncertainty in the energy shifting geographies creates tension and hence the need to for Europe to redefine the approaches to energy security (Markovska et al. 2016; Strielkowski and Bilan 2016). Given that the Europe’s wealth, prosperity, and security purely depend on securing a stable and affordable supply of energy, she needs to protectively address energy shifts and the energy landscape to avoid being a victim in the transition. Secondly, the geopolitical outlook around Europe, her political status, and presence in the northern hemisphere as a kingpin directly poses a direct threat to her energy security. It is purely supported by the recent developments in certain European countries that have vastly invested in military power, openly disregarded liberal values and support for illiberal movements intended to create dissension (Weisser 2007). To keep these issues in check, Europe established Energy Community committee aimed at creating a “ring of friends” in the energy trade. Apart from the geopolitical status of Europe and her environs the Middle East and Northern Africa’s civil wars,



political structures, migrations and leadership transitions threatens to erode the existing borders in the regions which are Europe's chief energy supplier. The political, multipolar world and economic relations in energy sector not only provides an opportunity for Europe's energy advancement but also is awake up call for Europe to formulate a strategic approach to ensure the security of her energy. Some countries have grown politically hence increasing the completion in the power corridors while shifting the energy trade patterns posing a challenge to Europe's competitiveness and ability to shape the energy business standards (Pearson 2011).

Europe developed the Energy Regulatory Authority who is charged with the responsibility of ensuring sustainability, security of supply and competitiveness. The body ensures that the consumers are not by any way exploited by the energy producers through legislation energy per unit retail price. There has been a two-sided social power conflict in the view of static versus the dynamic energy efficiency. The static energy side seeks to keep the wholesale price lower so that the producers do not have to make huge profits at the expense of the consumers. On the other hand, to ensure productive efficiency, the European government brought investment incentives in the energy supply sector. She too comes up with research funds for other natural energy sources exploration for example, solar and natural gas, which can be used for backups during an emergency or when reliable source fails to deliver hence maintaining the secure energy supply all the time. However, the diversion of time and location of the supply and consumption of energy still poses a conflict in the wholesale market. Since the electricity from the regulatory authorities is very cost effective, it is made available at a marginal cost.

The regulation also states that all electricity networks should maintain supply even if one of its components fails. It forces the producers to upgrade their systems to avoid power shortages, which bring blackouts. The bodies also come up with the capacity market incentives in both the supply and consumer end to ensure regular supply even during the peak demands (Aslani 2013). Both the storage and generator companies of electricity receive a predictable revenue stream for proving reliable capacity (Pearson 2011). Europe developed the capacity markets commission, which has the objective of providing long-term cost recovery for markets and maintaining a reserve. The body is responsible for keeping the supply chain constant and reliable even during peak demand. The producers and non-producers of energy receive a predictable reward for proving strong energy capacity. It internal acts as a sure investment in the energy supply security. It also assures the suppliers of revenue if they guarantee supply even during a power outage. These measures ensure no blackouts since there is overcapacity embedded in the system to avoid power shortages.

#### **4. Innovations for security in the energy sector**

Despite the emerging trends in energy sector across the globe, Europe's energy infrastructure is still largely shaped by her history. Her centralized generation and control system cause the situation. Her energy landscape is dominated by the large energy generating plants and Transmission System Operators (TSO) with the consumer network system consisting of a simple one-way energy flow from the few major productions centers. The primary energy source was coal and oil products. However, these various systems in Europe are beginning to embrace these changes in generation and energy delivery (Pearson 2011). The evolution of the ICT to control energy infrastructure in the recent times has European nations to embrace the green energy act advocacy by inventing the use of renewable energy and use of decarbonized energy. The electricity grid in Europe has developed much that it is no longer a simple network of wires but a more intelligent system that depends on communications and software (Limba et al. 2017). These developments have led to the demand for further investment in the ICT infrastructure mostly in the DSOs operational capabilities priorities and the transmission networks.

Another great invention is the computation of the smart grid, which provides information on power consumption. The invention aimed to increase the efficiency of operations. The grid is a computer-based and remote-control system that supports central grid operators in the network management (Noailly and Batrakova 2010). The grid also has the capability of producing electric energy from the consumer end. The grid too can regulate energy voltage hence meeting inflexible demands. In order to meet the supply-demand European Union should come with a storage plan that involves the use of excess electricity to pump water into a reservoir and later release it into turbines to produce electricity during high demand hence securing energy supply. Also, the

EU massively introduces the smart meters that control the energy supplied record the about amount used up (Noailly and Batrakova 2010; Rausser *et al.* 2017). These meters have two-way communication between itself and the control center through the networks. These meters also have the capability of detecting and preventing fraud since it can generate and store secure data communications. Nevertheless, it often appears that households eager to change their electricity consumption with the help of smart meters would also be those who are eager to alter their consumption patterns in order to yield the positive impact on environment.

Speaking about RES, one can clearly see that the renewable power is frequently used in four critical areas: power generation, water and air heating and cooling, transport, and rural (off-grid) energy assistance. Renewable energy stocks exist over broad geographical regions, in contradiction to other energy reservoirs, which are clustered in a limited number of nations. Accelerated utilization of renewable electricity and energy performance is resulting in vital energy security, climate change reduction, and financial advantages. When greenhouse gas (GHG) emitters start to be held answerable for injuries occurring from GHG discharges leading to climate change, a high price for responsibility mitigation would give compelling grounds for deployment of renewable energy innovations. In global public appraisal surveys, there is substantial support for supporting renewable sources of power such as wind power and solar power. At the national level, about 30 nations around the globe now have renewable energy contributing more than 20 percent of power reserves. State renewable electricity requirements are prognosticated to grow steadily in the coming years. Some nations and at least a couple countries, Norway and Iceland, generate all their electricity using renewable power promptly, and many other countries have set an aim to reach 100% clean power in eventuality.

All in all, it might be that saving on energy can be more relevant for people who do not have their own place to live and are renting their accommodation and experiencing financial difficulties. Not everyone is eager to change her or his “energy behavior”, so many people would rather keep their old habits and waste energy just because they are used to that. The EU has to launch an educational and promotional campaign that would educate its citizens how to save energy and to contribute to the overall energy security.

## 5. Empirical model: determinants of energy security in the European Union

With regard to the discussion outlined above and the provisions discussed and presented in the previous sections of this article, it appears interesting to take a closer look at the determinants of energy security in the European Union. In order to test this causality, we would take a look at the regression analysis model of the influence of renewable energy sources (the share of renewables in the total energy consumption) for the sample of the EU-28 countries for the period from 1990 until 2016. The models for determining the influencing factors are quite common in economics and include the wide range of aspects from regional development, agricultural economics and entrepreneurship to a variety of fields (Janda *et al.* 2013; Strielkowski *et al.*, 2017). Our empirical model is based on testing the causality between the total deployment of renewable energy sources (RES) and the economic growth. We employ the Kao cointegration test for testing the hypothesis that the higher the share of RES, the better off is the job market and the higher is the economic growth which is caused both by the increase in the number or jobs created by and for the RES sector (various jobs in “green energy” economy) and by the higher usage of various alternative sources of energy (solar, wind, small-scale hydro, and biomass). All in all, our results would be able to confirm this relationship and to make clear the interdependence between the share of RES in the economy of the EU countries and their economic independence and hence economic and energy security.

Therefore, our formal model can also be expressed in the following formal way (1):

$$GDP_{pp} = \alpha + \beta_1 K_s + \beta_2 L_s + \beta_3 E_{RES} + \varepsilon \quad (1)$$

where:

$GDP_{pp}$  – is an average value of GDP per capita in the EU-28 countries

$K_s$  - stock of capital represented by gross fixed capital formation gross domestic fixed investment in the EU-28 countries;



$L_s$  – stock of labor given by total labor force in a country represented by people older than 15 years, who is economically active according to the definition of International Labor Organization (ILO) in the EU-28;

$E_{RES}$  – energy (RES) consumption is a proxy for energy consumption given by the share of RES in the total energy output thousands of tons of oil equivalent (TOE);

$\varepsilon$  – is an error term.

Our test of cointegrated relationship developed by Kao (1999) is based on Augmented Dickey-Fuller (ADF) statistics (2)

$$Y_{i,t} = \alpha_i + \beta X_{i,t} + \varepsilon_{i,t} \quad t = 1, \dots, n; \quad i = 1, \dots, n \quad (2)$$

where  $i = 1, \dots, n$  represent each country in the panel,  $t = 1, \dots, t$  represent the time period.

The null hypothesis suggests that there is no cointegration between variables  $H_0: \rho_i = 0$ . For statistical analysis we used automatic lag length selection based on the Schwarz Information Criterion (SIC). When applying the Kao test for the purposes of our specific model, one can describe the relationship in the following system of equations (3), (4), (5), (6):

$$\ln GDP_{it} = \alpha_{1i} + \beta_{11} \ln K_{it} + \beta_{12} \ln L_{it} + \beta_{13} \ln GC_{it} + \varepsilon_{1it} \quad (3)$$

$$\ln K_{it} = \alpha_{2i} + \beta_{21} \ln GDP_{it} + \beta_{22} \ln L_{it} + \beta_{23} \ln GC_{it} + \varepsilon_{2it} \quad (4)$$

$$\ln L_{it} = \alpha_{3i} + \beta_{31} \ln GDP_{it} + \beta_{32} \ln K_{it} + \beta_{33} \ln GC_{it} + \varepsilon_{3it} \quad (5)$$

$$\ln GC_{it} = \alpha_{4i} + \beta_{41} \ln GDP_{it} + \beta_{42} \ln K_{it} + \beta_{43} \ln L_{it} + \varepsilon_{4it} \quad (6)$$

The results of Kao residual cointegration test between four variables (LL, LGDP, LK and LGC) are presented in Table 1 that follows.

**Table 1:** The results of Kao residual cointegration test

Kao Residual Cointegration Test				
			t-Statistic	Prob.
ADF			1.70	0.038
Residual variance			0.00037	
HAC variance			0.00053	
Augmented Dickey-Fuller Test Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.096	0.056	-3.68	0.0059
D(RESID(-1))	0.24	0.081	4.94	0.0001
D(RESID(-2))	0.15	0.086	3.32	0.031
D(RESID(-3))	0.20	0.085	4.19	0.0026
D(RESID(-4))	-0.011	0.084	-1.18	0.75
D(RESID(-5))	0.17	0.074	4.14	0.0029
R-squared	0.68	Mean dependent variable		0.0035
Adjusted R-squared	0.66	S.D. dependent variable		0.026
S.E. of regression	0.064	Akaike info criterion		-6.57
Sum squared residual	0.049	Schwarz criterion		-6.48
Log likelihood	757.69	Hannan-Quinn criterion		-6.53
Durbin-Watson stat	1.74			

Source: Own results

The results of Kao residual cointegration test based on Augmented Dickey-Fuller statistics suggest that there is cointegrated relationship between L, GDP, K and GC on significance level of 5 %. Therefore, one can conclude that we found cointegrated relationship between LL, LGDP, LK and LGC. The majority tests show that these variables are cointegrated between each other, where LL is taken as dependent variable. Our results confirm the importance of renewable energy sources (RES) for the economic growth and the creation of jobs in the EU-28 countries.

## 5. Conclusions and discussions

One has to admit that energy security is a very complex concept. The need to ensure energy security raises a lot of issues which modern Europe needs to address. There are a number of energy security issues in the modern Europe as discussed above. One major energy security issues in Europe is secure supplies of energy, which makes it hard for Europe to offer stable energy supplies along with affordable prices to its consumers. Another issue is the possible depletion of gas supply as a result of likely depletion of natural resources. Further, since gas is essentially carried via permanent pipelines that construct direct, lasting interdependency between the buyers and producers, it becomes a challenge to transit the gas when the relation between the two countries is broken-down.

To sum it up, it appears that adequate protection of vital energy systems is necessary since it prevents both the long and short-term shocks, which result in system malfunctioning, war, accidents and unsustainable energy demand graph in European Union. This seems to be a very crucial task for the EU, since 80% of its energy is imported from outside. With regard to this, one has to note that during transmission from one set of paradigms to another the system is very vulnerable. Therefore, it is very important to minimize transmission window time.

With regard to electricity, the key security issue for Central and Eastern Europe (CEEC) in the power industry is the unscheduled flows of power across the boundaries of countries in the Eastern and Central Europe. Similarly, there is the issue of modernizing the power generation park and also the transmission lines, a requirement for long-term security for power supply. However, Europe is looking forward to solving these challenges through innovation and technologies. The EU has established the SET-Plan, which aims to promote innovation for low-carbon energy sources such as renewable energy sources. Besides, many countries in Europe are promoting the use of electricity smart grids and the development of nuclear power plants as alternatives to the at-risk fossil fuels.

Decentralization of the energy system also provides security benefits making it very easy to isolate impacts of attacks to a local part of the scheme. The interdependency among the systems brought about by the energy digitalization should be well understood and preempt ways in which the attackers might use to attack the system and provide the appropriate actions to be taken when such attacks happen. The political will and good relationships should be embraced among the European nations and her neighbors to eliminate cyber-attacks. Moreover, one can also mention that the innovations seen in Europe are geared towards reducing the energy supply shortages and to the massive deployment of renewable energy sources (RES).

Overall, it appears that RES might smooth the transition to the low-carbon economy and to reduce the risks to the energy security in the European Union. Independent alternative energy sources might become a solution to the pending threats the European energy security is facing nowadays.

As for the pathways of further research on this topic, we would recommend exploring such interesting ideas and distributed energy generation in the EU remote areas, as well as looking into the concepts that were brought by the sharing economy. For instance, it would be very interesting to see how the peer-to-peer market of electric energy would work in the EU countries and whether this would be able to bring in the new implications for energy efficiency, sufficiency and security. For example, it would be very useful to find and utilize the data on the new projects involving P2P electricity markets as well as to assess the potential of electric vehicles (EV) in EU countries. Some countries, such as the Netherlands, have declared that they would ban the sales of any gasoline-based vehicles starting from 2020 in favor of EVs which is going to create an interesting natural experiment worth exploring by all economists and social scientists alike.

Massive deployment of EVs that is often associated with the introduction of RES in the EU countries, also represents an interesting field of research due to their increased pressure on peaks and the creation of unforeseeable situations on the electricity markets. It might be that the EU countries would still need lots of oil and gas to deal with the effects of the massive decarbonization causing the large-scale sales of EVs and a consequent charging of these EVs by the consumers.

We can conclude by saying that energy security in Europe is an uneasy task and it is also a very complicated and complex problem. However, solutions have to be traced for and various options have to be presented and analyzed in order to get the EU countries ready for the volatile changes in the energy balance and sustainable economic growth of the forthcoming decades.

## References:

- Abrhám, J.; Wang, J. 2017. Novel trends on using ICTS in the modern tourism industry. *Czech Journal of Social Sciences, Business and Economics* 6(1):37-43. <https://doi.org/10.24984/cjssbe.2017.6.1.5>
- Akhter, F. 2017. Unlocking digital entrepreneurship through technical business process, *Entrepreneurship and Sustainability Issues* 5(1): 36-42. [http://doi.org/10.9770/jesi.2017.5.1\(3\)](http://doi.org/10.9770/jesi.2017.5.1(3))
- Asif, M.; Muneer, T. 2007. Energy supply, its demand and security issues for developed and emerging economies. *Renewable and Sustainable Energy Reviews* 11(7): 1388-1413. <https://doi.org/10.1016/j.rser.2005.12.004>
- Aslani, A. 2013. Private sector investment on renewable energy utilization in developing countries. *Journal of Technology Innovations in Renewable Energy* 2(2): 155-164. <http://dx.doi.org/10.6000/1929-6002.2013.02.02.8>
- Balitskiy, S.; Bilan, Y.; Strielkowski, W. 2014. Energy security and economic growth in the European Union, *Journal of Security and Sustainability Issues* 4(2): 123-130. [https://doi.org/10.9770/jssi.2014.4.2\(2\)](https://doi.org/10.9770/jssi.2014.4.2(2))
- Barberis, S.; Roncallo, F.; Traverso, A. 2017. Towards innovative district energy management: a case study with stochastic renewable generators, *Entrepreneurship and Sustainability Issues* 4(3): 294-309. [https://doi.org/10.9770/jesi.2017.4.3S\(5\)](https://doi.org/10.9770/jesi.2017.4.3S(5))
- BP 2017. Natural gas consumption per capita. Available at: <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/natural-gas/natural-gas-consumption.html>
- Brodzicki, T. 2016. Does variety matter? Export pattern of Poland prior and after the accession to the EU, *International Economics Letters* 4(2):103-118. <https://doi.org/10.24984/iel.2016.4.2.5>
- Čábelková, I.; Strielkowski, W.; Mirvald, M. 2015. Business influence on the mass media: a case study of 21 countries. *Transformation in Business & Economics* 14(1): 65-75
- Calliess, C.; Hey, C. 2013. Multilevel Energy Policy in the EU: Paving the Way for Renewables? *Journal for European Environmental & Planning Law* 10(2): 87-131. <http://dx.doi.org/10.1163/18760104-01002002>
- Chalvatzis, K. J.; Ioannidis, A. 2017. Energy Supply Security in Southern Europe and Ireland, *Energy Procedia* 105: 2916-2922. <http://dx.doi.org/10.1016/j.egypro.2017.03.660>
- Drom, R. 2014. Electricity Capacity Markets: A Primer, *Natural Gas and Electricity* 30(10): 1-8. <http://dx.doi.org/10.1002/gas.21758>
- Eurostat 2017. Energy trends. Available from: [http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy\\_trends](http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_trends)
- Franki, V.; Višković, A. 2015. Energy security, policy and technology in South East Europe: Presenting and applying an energy security index to Croatia, *Energy* 90: 494-507. <http://dx.doi.org/10.1016/j.energy.2015.07.087>
- Janda, K.; Rausser, G.; Strielkowski, W. 2013. Determinants of profitability of Polish rural micro-enterprises at the time of EU Accession. *Eastern European Countryside*, 19: 177-217. <https://doi.org/10.2478/eec-2013-0009>
- Korkmaz, D. 2010. Internal and external dynamics of European energy security. The 5<sup>th</sup> Pan-European Conference on EU Politics, ECPR, pp. 23-26.
- Laužikas, M.; Miliūtė, A.; Tranavičius, L.; Kičiatovas, E. 2016. Service Innovation Commercialization Factors in the Fast Food Industry, *Entrepreneurship and Sustainability Issues* 4(2): 108-128. [https://doi.org/10.9770/jesi.2016.4.2\(1\)](https://doi.org/10.9770/jesi.2016.4.2(1))

Limba, T.; Plêta, T.; Agafonov, K.; Damkus, M. 2017. Cyber security management model for critical infrastructure, *Entrepreneurship and Sustainability Issues* 4(4): 559-573. [https://doi.org/10.9770/jesi.2017.4.4\(12\)](https://doi.org/10.9770/jesi.2017.4.4(12))

Markovska, N.; Duić, N.; Mathiesen, B.; Guzović, Z.; Piacentino, A.; Schlör, H.; Lund, H. 2016. Addressing the main challenges of energy security in the twenty-first century—Contributions of the conferences on Sustainable Development of Energy, Water and Environment Systems, *Energy* 115: 1504-1512. <https://doi.org/10.1016/j.energy.2016.10.086>

Metais, R. 2013. Ensuring Energy security in Europe: the EU between a market-based and a geopolitical approach. College of Europe.

Noailly, J.; Batrakova, S. 2010. Stimulating energy-efficient innovations in the Dutch building sector: Empirical evidence from patent counts and policy lessons, *Energy Policy* 38(12): 7803-7817. <http://dx.doi.org/10.1016/j.enpol.2010.08.040>

Noreng, O. 2009. Energy security for Europe: A choice of suppliers and partners. Political Economy of Energy in Europe, Berlin, Berliner Wissenschafts-Verlag, pp. 207-235

Pauceanu, A. M. 2016. Innovation and entrepreneurship in Sultanate of Oman – an empirical study, *Entrepreneurship and Sustainability Issues* 4(1): 83-99. [https://doi.org/10.9770/jesi.2016.4.1\(8\)](https://doi.org/10.9770/jesi.2016.4.1(8))

Pearson, I. L. (2011). Smart grid cyber security for Europe. *Energy Policy* 39(9): 5211-5218. <http://dx.doi.org/10.1016/j.enpol.2011.05.043>

Yergin, D. 2011. *The quest: Energy, security, and the remaking of the modern world*. Penguin Books

Prause, G. 2016. E-Residency: a business platform for Industry 4.0?, *Entrepreneurship and Sustainability Issues* 3(3): 216-227. [https://doi.org/10.9770/jesi.2016.3.3\(1\)](https://doi.org/10.9770/jesi.2016.3.3(1))

Rausser, G.; Strielkowski, W.; Štreimikienė, D. 2017. Smart meters and household electricity consumption: A case study in Ireland, *Energy & Environment*, 0958305X17741385

Rezk, M. A.; Ibrahim, H. H.; Radwan, A.; Sakr, M. M.; Tvaronavičienė, M.; Piccinetti, L. 2016. Innovation magnitude of manufacturing industry in Egypt with particular focus on SMEs, *Entrepreneurship and Sustainability Issues* 3(4): 307-318. [https://doi.org/10.9770/jesi.2016.3.4\(1\)](https://doi.org/10.9770/jesi.2016.3.4(1))

Štreimikienė, D.; Strielkowski, W.; Bilan, Y.; Mikalauskas, I. 2016. Energy dependency and sustainable regional development in the Baltic states: A review, *Geographica Pannonica* 20(2): 79-87. <https://doi.org/10.18421/GP20.02-04>

Strielkowski, W.; Bilan, Y. 2016. Economics of electricity pricing and consumer protection, *Economic Annals-XXI* 162(11-12): 28-31. doi: <https://doi.org/10.21003/ea.V162-06>

Strielkowski, W.; Lisin, E.; Astachova, E. 2017. Economic sustainability of energy systems and prices in the EU, *Entrepreneurship and Sustainability Issues* 4(4): 591-600. [https://doi.org/10.9770/jesi.2017.4.4\(14\)](https://doi.org/10.9770/jesi.2017.4.4(14))

Tvaronavičienė, M. 2016. Start-ups across the EU: if particular tendencies could be trace, *Entrepreneurship and Sustainability Issues* 3(3): 290-298. [https://doi.org/10.9770/jesi.2016.3.3\(6\)](https://doi.org/10.9770/jesi.2016.3.3(6))

Varanavicius, V.; Navikaite, A.; Bilan, Y.; Strielkowski, W. 2017. Analysis of Consumer Behaviour in Regional Energy Consumption, *Economy of Region* 13(1): 147–156. <https://doi.org/10.17059/2017-1-14>

Vasylychak, S., Halachenko, A. 2016. Theoretical basis for the development of resort services: regional aspect, *International Economics Letters* 5(2):54-62. <http://dx.doi.org/10.24984/iel.2016.5.2.3>

Weisser, H. 2007. The security of gas supply—a critical issue for Europe? *Energy Policy* 35(1): 1-5. <http://dx.doi.org/10.1016/j.enpol.2005.10.002>

Yergin, D. 2011. *The quest: Energy, security, and the remaking of the modern world*. Penguin Books

Zielińska, A. 2016. Information is a market products and information markets, *Czech Journal of Social Sciences, Business and Economics* 5(4):31-38. <https://doi.org/10.24984/cjssbe.2016.5.4.4>

**Igor Britchenko**

**ORCID:** 0000-0002-9196-8740