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ECONOMIC SUSTAINABILITY OF ENERGY SYSTEMS AND PRICES IN THE EU

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Abstract. Economic sustainability of energy system and energy prices in the European Union (EU) constitutes an important issue that includes many multidimensional perspectives and calls for non-trivial solutions. Our paper tackles these issues in a critical manner attempting to analyse the interdependence between the economic growth and the energy prices.
We employ an empirical analysis of energy prices and economic growth in the European Union (EU-28 Member States) and make conclusions based on the results of this analysis. Our conclusions can be used by the relevant stakeholders and policy-makers who are responsible for the regulation of energy systems or setting up the energy tariffs and the prices of energy.

Keywords: economic development, energy systems, sustainability, energy pricing, security, European Union

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1. Introduction

Sustainability and energy economic security are based on the smooth and uninterrupted supply and demand mechanisms of energy sources. In the recent decades the governments of many countries have shifted towards climate and energy policy that favors renewable energy sources (RES), implementation of green technologies (Traversari et al. 2017; Passerini et al. 2017; Gandini et al. 2017; García-Fuentes, de Torre 2017; Zemlickiene et a. 2017) and change of consumption patterns (Tvaronavičienė 2016).

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Alas, traditional carbon fuels represented by mostly oil, natural gas and coal still play an important role in the world economy (Lisin et al. 2015).

It is apparent that long-term development of any country's economy is impossible without the extensive use of carbon fuels and a respectful attitude toward the environment that should go together hand in hand. Everyday's management applied to the national economy should not only be aligned with the demands of contemporary society but should also seek ways to secure the fair living conditions for future generations to come (Balitskiy et al. 2014).
According to *Limits to Growth*, a study published by the Club of Rome in 1972, population growth coupled with production growth and the resulting environmental strain will ultimately lead to one of the two possinle outcomes (Gómez-Baggethun and Naredo, 2015). The exponential population growth will eventually result either in a complete crash of the existing consumer-driven economy, or a severe crisis with consequences that can be mitigated by adjusting the social production structure to reach an agreement between social, environmental, and economic indicators of national welfare.

Population growth brings about increased needs that can only be satisfied if there is a steady production process, which in turn depends on the sufficiency and availability of carbon fuels extracted from the environment. Moreover, the production process is always associated with generation of waste that pollutes the environment. Experts in global environment issues and energy policy cite different projections of the limit to population growth and pollution rate; however, all of them agree that such a limit does exist and has been approached quite closely by mankind.

Avoiding collapse at the national level requires adjusting national economies to prioritize qualitative development – balancing consumption with the environment's capability for recovery of resources expended on the production of economic assets.

Power industry is a key industry of the national country's economy from the standpoint of ensuring economic stability. National security hinges on the efficiency and reliability of the energy sector. The energy sector necessarily leads the development of other sectors of the economy to accommodate the ever-growing demand for electricity.

2. Literature review

Evaluation of world data on construction of all kinds of generating facilities allows for the conclusion about considerable energy consumption growth over the last 30 years. Figure 1 that follows shows the distribution of plant capacity global type in the world according to the types of energy sources.

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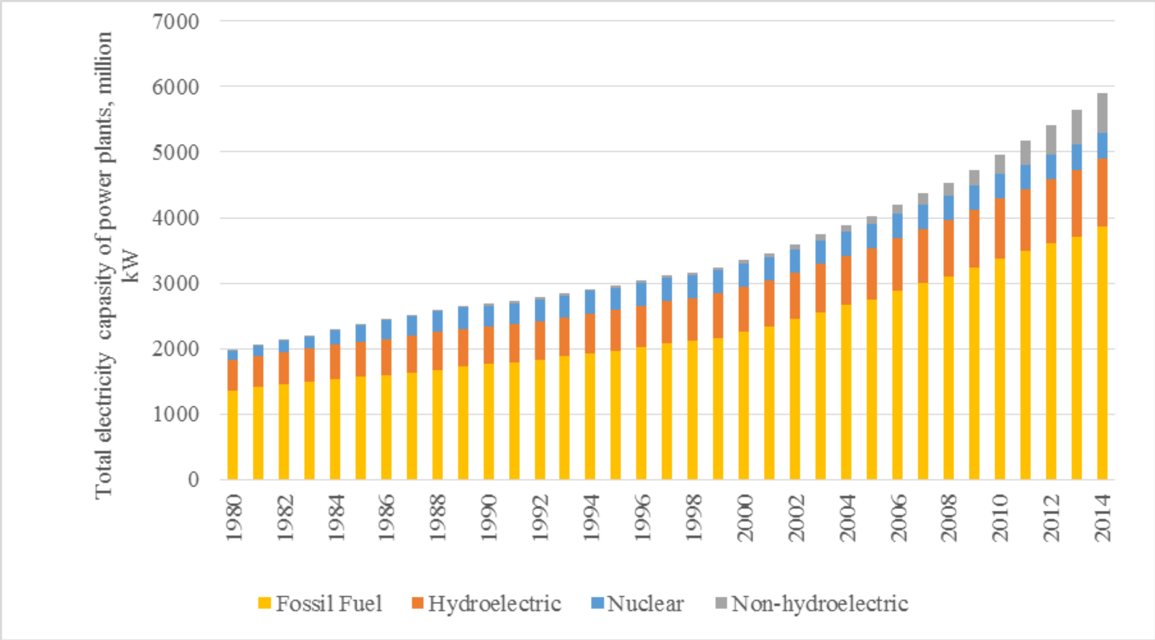

Figure 1. Plant capacity global change according to types of energy sources
Source: U.S. Energy Information Administration: International Energy Statistics (2016), own compilations

Figure 2 that follows shows complete energy balances for the the EU-28 countries: one can clearly see that the share of solid fuels and total petroleum products is giving way to te renewables with roughly the same share of nuclear heat that remains unchanged over the past 25 years (see Figure 2).

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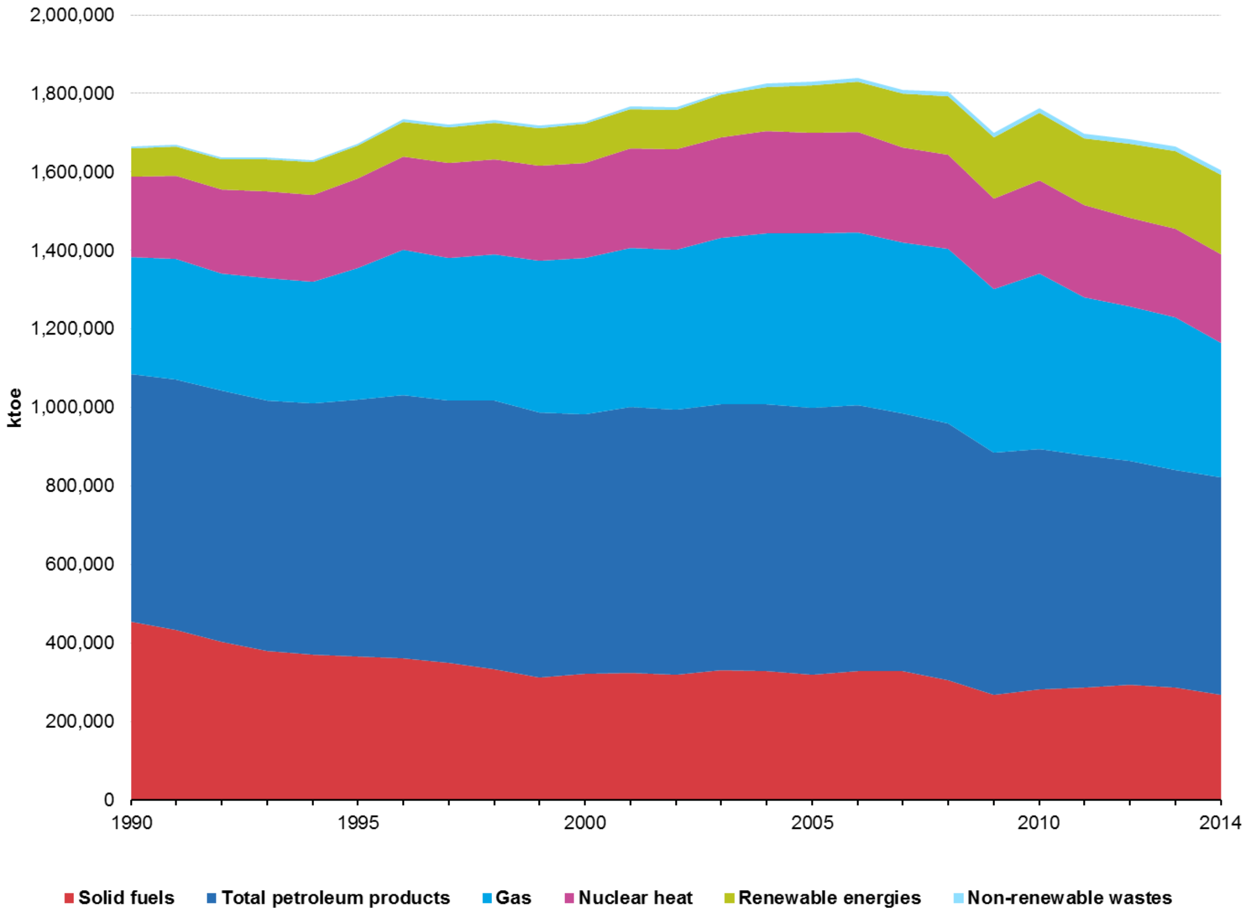

Figure 2. Complete energy balances for the EU-28 countries
Source: Eurostat (2016)

Despite the achieved capacity gain of alternative and renewable energy sources over the past decade, the increase of typical fuel and energy resources (oil, gas, coal) consumption is observed, and traditional thermal power industry based on chemical transformation of carbon fuel still dominates.

A thermal power plant (TPP) is the basic generating unit in the traditional thermal generation field. Intense use of carbon fuels at TPPs to meet the demand for electric energy, coupled with the scarcity of this resource, is a major driver behind the development of efficient energy transformation technologies. According to a global forecast for power utilities development, classical thermal power plants will retain their dominating role in supplying the electricity needs of national economies. A gradual transition from natural gas to coal as the primary fuel will take place at the same time.

Today from oil is produced about 7% of world electricity. This is a significant share, and in the context of lowering prices for this energy carrier, it is projected to increase its use in the energy sector. At the same time, it is advisable to use oil in areas where natural gas and coal are more difficult to deliver.

Thermal power plants use a fuel oil as fuel, which is a heavy fraction of oil. Most often, fuel oil is used as a backup fuel for TPPs using gas as the main fuel. At the same time, fuel oil is not the only petroleum product,

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which uses to produce the electricity. To drive electric generators, gasoline or diesel internal combustion engines are used. Their low power and low efficiency are compensated by the compact size of the station and low installation and maintenance costs.

The use of fuel oil as fuel for power plants is gradually declining. This is largely due to the global modernization of the refinery in order to increase the production of light petroleum products, respectively, to reduce the output of heavy oil. In the future, oil will be used more actively as a valuable raw material for the chemical industry. And the electric power industry will rely on renewable energy sources.

The sustainable development concept specifies three stability conditions for an energy system:

- Renewable resources should not be depleted faster than their recovery rate;
- The rate of depletion of nonrenewable resources must not exceed the pace at which substitutes based on other renewable resources are developed to replace the nonrenewable resource;
- The pollution rate should not be faster than the rate at which the environment is able to assimilate such pollution.

This allows for increased rates of resource consumption provided that the energy system remain stable there is a commensurate increase in the rate of resource recovery or the pace of substitute development. The logical corollary to these sustainable development considerations is that the national economy growth rate will be capped by the rate of recovery of consumed resources, with either nature or state-of-the art technology determining the latter. Development and introduction of efficient technologies will ensure reduction in the consumption of nonrenewable resources together with faster recovery of renewable resources, thus increasing the consumption of goods without compromising the stability of the energy system.

The environmental aspect of energy sector development is specified in terms of exposure limits for various types of emitted pollutants. Thermal power plant operation is associated with direct environmental impact in the form of pollutant emissions such as sulfur oxides (SO_x) and nitrogen oxides (NO_x). Maximum permitted concentrations of harmful pollutants are specified for different countries at every stage of implementation of the energy strategies. Exceeding specified thresholds makes the power plants liable for a fine.

Technological methods of nitrogen oxides NO_X suppression, particularly three-stage combustion, are the most mastered ways for improvement of environmental characteristics of power plant units. Also, the concentration of NO_X in the flue gases may be reduced by 30–65% by using the selective non-catalytic reduction technology which is widely applied in the EU, USA and Japan.

Table 1 represents the data on pollutant emissions by thermal power plants in EU and abroad.

Table 1. Comparative data on environmental performance of high-capacity thermal power plants in EU and abroad

Emissions of flue gases		EU standard emissions	Active thermal power plants in Russia	Japan emissions
NO_x	mg/m^3	200	300-570	80-100
SO_2	mg/m^3	200	700	70-100
Ashy particles	mg/m^3	30	50	10-20

Source: Own results

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The urgency of the climate crisis necessitates swift action on the part of governments to reduce emissions from the energy sector. Climate scientists warn that in order to avoid the worst effects of rising global temperatures, greenhouse gas emissions must peak between 2015 and 2020 and fall dramatically thereafter.

Approximately 39% of CO2 emissions in the EU are generated by the electricity sector. By mandating an emission limit CO2 of 350 g/kWh of for carbon fossil energy, EU policymakers have sent a clear signal to power plants that only the cleanest fossil fuel power stations can have a place in the future.

The EU's main policy in the field of climate is the development of an emissions trading system. Currently, there are about 10,000 power plants in the energy and industrial sectors, which together are responsible for almost half of CO2 emissions in the EU, and for 40% of all greenhouse gas emissions. CO2 emissions quotas traded at ICE Futures Europe in London at an average price of 6 €/t CO2 in 2016.

In many key world countries, such as China, Russia or the United States, the majority of energy systems is quite obsolete and requires modernization and innovation. In spite of the recent focus on RES, they are still dependent on the traditional sources of energy and have to set their energy pricing mechanisms based on the existing prices of energy sources on the market. Due to their position on the world geopolitical arena, the rest of the world has to take this into account. It is hard to imagine fulfilling the declared goals of decarbonization and sustainable development without these global players helping along.

Economic subjects try to optimize regardless of ecological or sustainability concerns. Paradoxically, when the oil prices plunged once again in 2016, many energy companies in the EU Member States shifted from the renewables to the traditional carbon fuels (mostly coal) due to the economical reasons. The market force takes the advantage over the policies of implementing RES in order for reaching ultimate decarbonization in the nearest decades.

The price of oil has a particular importance and impact on the world economic relations and international trade. When the breakdown of the Bretton Woods regime occurred in 1971 and the primary oil shocks first appeared in 1973, they challenged classical macroeconomic schema represented by the transmission mechanism. The rise in oil prices in 1973 that was caused by the oil embargo deliberately imposed by the Organisation of the Petroleum Exporting Countries (OPEC) led to the worldwide global recession.

The European Union also faces issues with energy systems and prices. European energy security represents a multidimensional dilemma with multiple facets impersonated by the dependence on Russian gas and its energy policy strategy that has to satisfy all EU Member States. Furthermore, changes to the existing energy and climate strategies are envisaged due to Brexit which shifted the balance of power and the stability of the EU in many ways.

In general, there is a plethora of studies on the relationship or correlation between oil prices or oil price shocks and the economic activity or economic growth (see e.g. Rasche and Tatom, 1981; Darby, 1982; Hamilton, 1983; Kilian and Vigfusson, 2013; Kilian and Hicks, 2013; Dezellus et al. 2015; Arezki et al. 2017).

3. Dynamic panel data model and its estimations

The main objective of our empirical study is to test if crude oil price had any impact on real GDP rate in the EU-28 countries in the period 2011-2015. The data for real GDP rate were provided by Eurostat, while crude oil price data are taken from World Bank database. Some dynamic panel data models are built using these two variables.

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In total, we estimated three types of system dinamic panel data models: i) usual standard model, ii) models with robust errors, and iii) general method of moments (GMM) estimation. All these models in question indicated that GDP rates had an average tendency of increase in the EU-28 from a year to another. The GDP rate in the previous year had a positive impact on the current GDP rate. However, the oil price had a negative influence on economic growth. An increase in the oil prices generated a decrease in the real GDP.

Table 2. System dynamic panel data for explaining the impact of oil price on real economic growth in EU-28 (2011-2015)

	Coef.	Std. Error	z	P>[z]	95% conf. interval	
GDP rate						
L1	0.588	0.133	6.01	0.000	0.463	0.912
Oil price	- 0.167	0.039	-4.27	0.000	-0.243	-0.090
Constant	18.314	4.206	4.35	0.000	10.070	26.558
Wald chi2(2)	46.08					
Prob > chi2	0.0000					
N of groups	28					
N	111					

Source: Own results

The moment conditions in case of GMM estimators require the test of independence for the idiosyncratic errors. In this case, the first difference of white noise is automatically auto-correlated and the second and higher autocorrelation should be checked.

Let us introduce the estimation with robust errors (RE) for cross-cheching our results from the previous model. Table 3 that follows reports the results of the estimations of system dynamic panel data with robust errors for explaining the impact of oil price on real economic growth in EU-28 (2011-2015).

Table 3. System dynamic panel data with robust errors: oil price on real economic growth in EU-28 (2011-2015)

	Coef.	Std. Error	z	P>[z]	95% conf. interval	
GDP rate						
L1	0.688	0.114	5.16	0.000	0.426	0.948
Oil price	- 0.167	0.027	-6.08	0.000	-0.221	-0.113
Constant	18.314	2.921	6.27	0.000	12.588	24.041
Wald chi2(2)	53.97					
Prob > chi2	0.0000					
N of groups	28					
N	111					

Source: Own results

Our results confrm that this model is valid, because the errors at second order are not serial correlated at 5% level of significance. In addition, we performed the Arellano-Bond test for zero autocorrelation in first-differenced errors. The results can be presented in the following manner (see Table 4 that follows).

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Table 4. Arellano-Bond test for zero autocorrelation in first differenced errors

Order	z	Prob > z
1	-3.311	0.0009
2	1.524	0.125
H0	No autocorrelation	

Source: Own results

Moreove, Table 5 that follows employs the generalized method of moments (GMM) for explaining the impact of oil price on real economic growth in EU-28 via the system dynamic panel data.

Table 5. System dynamic panel data (generalized method of moments) for explaining the impact of oil price on real economic growth in EU-28 (2011-2015)

	Coef.	Std. Error	z	P>[z]	95% conf. interval	
GDP rate						
L1	0.688	0.114	6.01	0.000	0.463	0.912
Oil price	- 0.167	0.039	-4.27	0.000	-0.243	-0.090
Constant	18.314	4.206	4.35	0.000	10.070	26.558
Wald chi2(2)	46.08					
Prob > chi2	0.0000					
N of groups	28					
N	111					

Source: Own results

4. Discussion of results

Our results for EU-28 are consisitent with the study of Ftiti et al. (2016) for some OPEC countries. Indeed, if the oil prices increase, then aggregate supply reduces, because companies purchase less energy at higher energy prices.

The results show that the GDP rate in the EU-28 increases with an average stable tendency. There is a lag in the GDP rate, since the value of the GDP in the previous year has a positive impact on the current GDP rate. Moreover, the results show that the oil price had a negative influence on economic growth meaning that an increase in the price of oil should result in a subsequent decrease in the real GDP and therefore economic growth and economic performance.

The results of all three models (system dynamic panel data model, panel data model with robust errors, and panel data with generalized method of moments) seem to be consistent and tell the same and consistent story. Raising prices of energy sources impact the economic growth making it to slow down and therefore hampering the economic security and stability of energy systems.

Conclusions and policy estimations

All in all, it appears that energy systems and energy prices in the European Union are going through many structural and existentional changes. The EU-28 countries have to deal with the changing prices of energy, as well as with the alternative sources of energy represented by the renewable energy sources (RES) that include, above all, solar, wind, and hydro power. The shift from the traditional sources of energy might lead to the distortion of the current market mechanisms and lead to the changing prices of energy that, in turn, might result in the structural shifts in the energy systems and their balance.

We conducted an empirical analysis of the correlation between the traditional carbon energy prices represented by the prices of crude oil and the economic growth in the EU-28 Member States. The analysis was based on the similar studies conducted around the world, most notably in the United States and employing the data for the U.S. economy.

Our analysis of the available data demonstrates that the increase in the prices of the traditional energy resources results in the worsening of the economic well-being. These results are quite informative and might be important for the economic and energy security of the European Union. The recent decrease in the price of oil that worsened the economic situation in Russia, might have also resulted in the increase of economic performance across the EU states. Moreover, the shift from the traditional energy sources represented by oil, gas and coal, towards the renewable sources of energy, would also increase the economic performance of the energy systems without threatetning the life standards of the population. Economic and energy sustainability of the energy systems in the European Union as well as in the rest of the world rests upon the wise selection of the energy sources and prices that are paid for those sources. Stakeholders and policy-makers need to take this into account when designing the optimal energy strategies and selecting the mix of energy sources for achieving the sustainable economic development and growth.

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