Sustainable Energy in Post-Communist East-Central Europe - A Comprehensive Study

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SUMMARY

Energy is managed in a complex way by the theories of sustainability. All three pillars of sustainability (society, environment, and economy) are inseparable from the energy sector, because energy consumption causes so many externalities that threaten welfare in the long run. Most environmental problems are in close connection with energy use and production, such as nuclear waste management, oil spills, emission, etc. Furthermore, energy is an integral part of the economic and social development, and sustainable energy is a core issue. In this review a previously developed but recently improved methodology is presented which is suitable for the measurement of sustainable energy. Using panel data and estimating a Fixed Effects Model, we examine whether economic development contributes to the effectiveness of policy implementation for sustainable energy development in East-Central Europe.

Keywords: sustainable energy, energy dependence, energy efficiency, panel data, fixed effects model, East-Central Europe
Journal of Economic Literature (JEL) codes: C23, Q43
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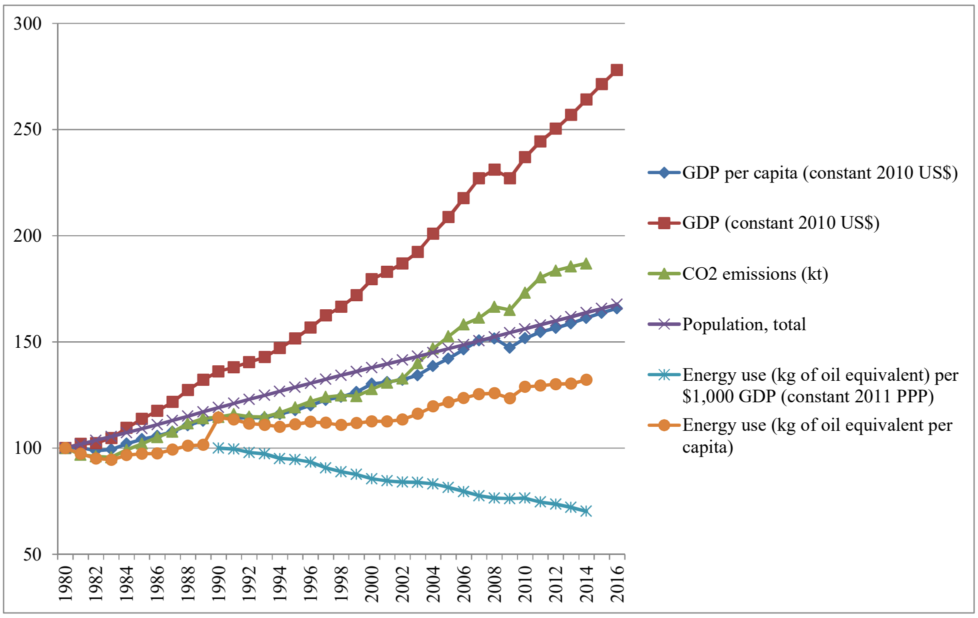
INTRODUCTION

The global population has increased rapidly in the past century: according to the United Nations (2004) it barely exceeded 2.5 billion in 1950, reached 4 billion in 1974, then 7 billion in 2012 and the 9 billion mark is projected for 2030. The situation is exacerbated by the sources of the population growth in the future, approximately 90 percent of which will stem from developing countries and 90 percent living in overcrowded cities (Buday-Sántha 2006).

Population growth is closely connected with energy consumption: energy is an essential resource not only in developing countries but in developed countries as well. It is needed for economic and social development and reducing poverty (Bindra & Hokoma 2009). According to the World Energy Council (2012) – assuming the stability of energy prices – the world energy demand in 2020 will be 50-80 percent higher than in 1990. But the main demand for energy, mainly for crude oil, does not stem from the industrialized, developed nations, but from the emerging economies, such as China and India. The modernization processes in these countries strongly contribute to the increasing energy hunger (Zhang et al. 2011). With regard to the development of the BRIC countries (Brazil, Russia, India, and China) the centers of the world economy have shifted and trade relations are changing. The financial crisis (2008-2009) accelerated these tendencies: the economic growth of the Triad (USA, Europe and Japan) declined and energy consumption decreased, so the center of demand moved to the emerging countries. While the developed nations try for sustainability and energy savings in all economic sectors, the energy consumption of the BRIC countries is continuously increasing because of their rapid economic and population growth (Figure 1).



Source: World Bank database (2017)

Figure 1. The main economic and energy statistical data of the world (1980-2016)

The issue of energy security has become more and more important. The high volatility of oil prices and the increasing competition for the crude oil resources provide opportunities which are exploited by some producing nations to reach their economic and political goals. The Russian remonstrance to the third energy package of the European Union or the conflict between Iran and the international community (before the nuclear agreement) with regard to the Iranian nuclear program are good examples. It is enhanced by the new "big consumers", such as China, looking for crude oil sources in those countries (such as Iran, Sudan, Venezuela) with problematic diplomatic and political relationships with old consumers, such as the developed core countries (Europe and North America) (Róbel, 2006). According to the IEA (2017) the share of the Chinese energy consumption was 7 percent of world consumption in 1973, while the share of the OECD countries was 61.4 percent. This ratio has changed in the past four and half decades: in 2015 the share of China was 21.9 percent, while the consumption share of the OECD countries had decreased to 38.5 percent. Today China is the 2nd biggest oil importer and the 6th biggest oil producer (IEA 2017).

It has been estimated that if a significant improvement in energy efficiency had not occurred after the 1973 oil price shock, current energy consumption would be 50 percent higher (Dinya 2010: 914). According to the Energiaklub (2006), energy consumption would be 40 percent higher in the European Union without the development in technology and legislation and campaigns that have been carried out.

Increasing energy consumption causes a lot of other problems: greenhouse gas emissions generated by the burning of fossil fuels are responsible for global climate change. Energy efficiency is thus justified not only for economic reasons but also by many environmental factors.

Hereinafter, we examine the relationship among energy use, energy management and sustainability. Our research question are whether the index of effectiveness of energy policy implementation shows similar results with the rank determined by the Energy Trilemma Index and whether the national energy policies serve well the concept of sustainable energy.

In the theoretical background the definition of sustainable energy, energy management and energy security are presented. We describe the complex condition systems of sustainable energy and the necessity for energy efficiency improvements is highlighted as well. The Energy Trilemma Index shows the current result of the sustainable energy measurement. Using a slightly modified formula we attempt to calculate the effectiveness of energy policy implementation and we analyze the connection between this index and GDP growth with the estimation of a Fixed Effects Model.

Theoretical Background

The starting point is to define *energy management*, *sustainable development, sustainable energy* and *energy security*. Energy management is "every practical activity to ensure and manage the utilization of the available energy sources and reserves in the most economical way, meet the energy needs safely and economically, decrease the energy losses and diminish the unnecessary loss of resources" (Barótfi et al. 2003: 3.). Its four main parts are exploitation, conversion, distribution and consumption; the main issue is to minimize the energy needs through energy saving policies.

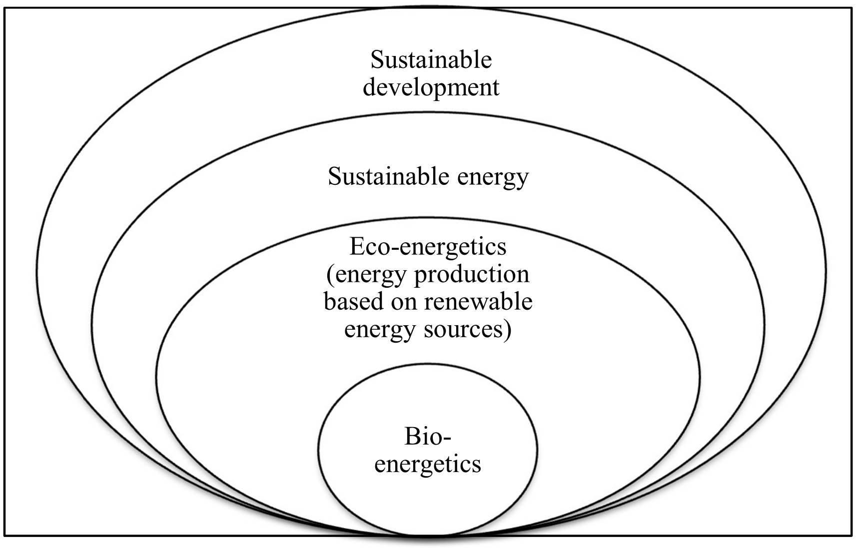
The most frequently quoted definition of sustainable development is from the Brundtland Report: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (UN, 1987: 41).

A new but frequently used term is sustainable energy, which is a narrower category than sustainable development: “it means the socially, economically and ecologically integrated implementation of the complex process of energy production, storage, transport, and use. So it is converting classical energy management with regard to the sustainability principles” (Dinya 2010: 914). We note here that the starting point of the models, describing sustainable development, the limits of economic growth and the possibility of substitution, was the recognition of the scarcity of fossil fuels (Cleveland 2003). Naturally, the long-term goal of sustainable energy is sustainable development, which ensures economic and social welfare. The two pillars of sustainable energy are increasing the share of renewable energy sources and decreasing energy consumption. The latter can be performed by promoting energy saving (energy conservation) and improving energy efficiency (Rohonyi 2007).

Figure 2 illustrates the relationship of sustainable energy and its more specific areas to sustainable development. Energy is managed in a complex way by the theories of sustainability. Each of the three pillars of sustainability (society, environment, and economy) is inseparable from the energy sector, because energy consumption causes so many externalities that threaten welfare in the long run. environmental problems are in tight connection with energy use and production, such as nuclear waste management, oil spills, emission, etc. Furthermore, energy management is an integral part of the economic and social development: millions of people live in energy poverty (the World Energy Council (2012) estimates 1.6 billion people do not have access to electrical energy), and according to the World Health Organization (2012) database as many people (circa 1.6 million people) die from respiratory diseases per year as from AIDS because of inappropriate energy use.

Energy security is closely related to energy management. Energy security means the ability of the economy to contribute to the economic and social welfare with sustainable energy services (Blum 2012. p.1988.). According to Blum and Legely (2012) energy security is characterized by three main attributes from the perspective of the ecological economist: 1) resilience, 2) adaptability, and 3) transformability. Resilience is a widely used term; it is widespread in environmental and ecological economics and in finance and organization theories as well. In energy management it means “a measure of the economy’s ability to handle energy related (temporary and permanent) effects”, while adaptability is “the preparedness to respond to sudden energy related changes”, and transformability is “the capacity to evolve towards a more energy secure configuration” (Blum 2012:1984). Energy security can be characterized by the following 4R conception (Chaturvedi & Samdarshi 2011: 4651):

1. Understanding the problem (Review).
2. Shifting to secure sources (Replace).
3. Limiting new demand to secure sources (Restrict).
4. Using less energy with energy efficiency improvements and energy savings (Reduce).



Source: own compilation on the basis of Dinya, 2010, p. 914

Figure 2. Sustainable energy

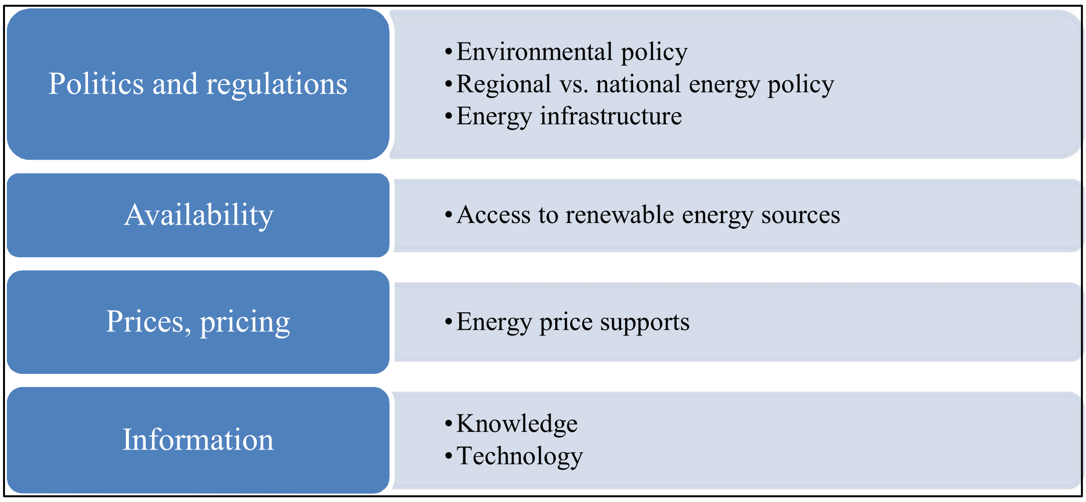
Complex Condition Systems of Sustainable Energy

The complex condition systems of sustainable energy (Figure 3) are shown by Press and Arnould (2009). Efficient environment and energy policy are inseparable. The main objective of the energy policy is to "ensure the citizens' welfare and the efficient operation of the economy; normal (uninterrupted) access to the energy services for every private and industrial consumers in payable price and to take into consideration the environmental aspects, and the shifting towards the sustainable development" (Buday-Malik et al. 2012: 14).

Political issues are related to infrastructure and energy markets. The reduction of state interventions and the liberalization of the energy markets contribute to the efficient use of energy sources and to energy security. Regional approaches have to be enforced by the utilization and support of renewable energy sources. With regard to the European Union's targets and the principle of subsidiarity, an efficient regional energy policy is needed with the decentralization of the energy production and the increasing share of renewables (Csákberényi-Nagy 2005: 7). The main task of the state is to develop a predictable and stable market environment where the energy market players are committed to the energy security with infrastructural investments and developments in the long run.

The availability of different kinds of energy sources – with special regard to the renewable sources – is one of the main pillars of sustainable energy. The restrain of each energy source (even if it is caused by technical conditions) – such as wind energy – cannot be acceptable in the long run, because it sets back the diversification of the sources, which should be one of the core elements of energy strategies.

The price control of the energy sources in the household sector (with special regard to price support) apparently means an advantage for the consumers, but in the long run it reduces the competitiveness of the energy sector, distorts the market and eliminates the energy efficiency measures. The extensive information and education of the general public contributes to the validation of consumer rights and the wider adoption of the existing technologies (Press & Arnould 2009) "The illusion of cheap and unrestricted energy sources does not encourage the consumers to save energy and to replace old low-efficiency equipment, so efficiency improvements do not prevail among the end consumers" (Energiaklub 2006: 14).



Source: own compilation based on Press and Arnould (2009)

Figure 3. Criteria of sustainable energy

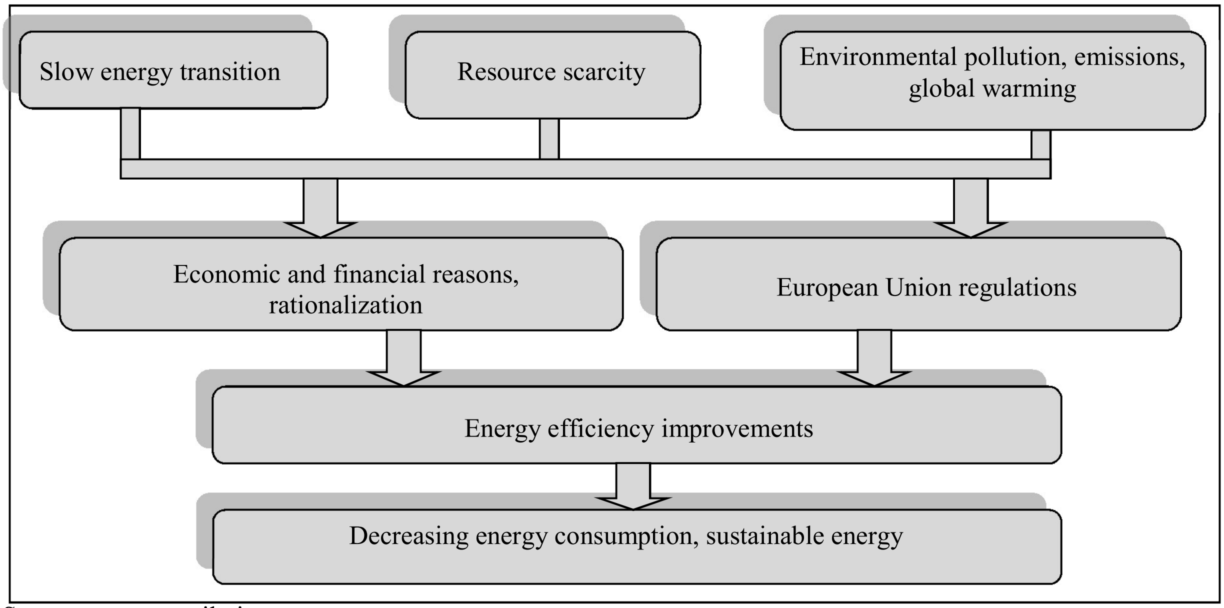


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Figure 4. The necessity for energy efficiency improvements

Sustainable energy is composed of several parts: the increasing use of renewable energy sources, rationalization of the supply chain, and the energy efficiency improvements that contribute to achieve it. The need for energy efficiency improvements is confirmed by many factors, as shown in Figure 4. The economic factors (such as households and the production sector) try to achieve energy efficiency because of financial considerations and rationalization. The scarcity of these sources plays a role as well, and unfortunately the limits are becoming visible. Global climate change and greenhouse gas emissions can be reduced by actions taken for energy efficiency, which is a basic element of many official European Union documents (where the main strategies determine specific goals). A less well-known argument is energy transition, meaning that a long time horizon is needed for energy systems to switch their energy source. According to Smil (2009) and Vajda (2004), these energy transitions last for many decades and they are characterized by extremely high inertia. The development of new sources to the point of market readiness and replacement of the technologies take long decades, which conserve the given energy source. So in the short run the improvement of energy efficiency is the only solution. Energy efficiency has many positive effects, not only on sustainable economic development but on sustainable energy as well (Hertwich 2005).

Energy Trilemma Index

The World Energy Council (2016) has developed the Energy Trilemma Index (ESI) to measure the sustainable energy, which assess the world countries with regard to three dimensions:

1. Energy security: Effective management of primary energy supply from domestic and external sources, reliability of energy infrastructure, and ability of energy providers to meet current and future demand.
2. Energy equity: Accessibility and affordability of energy supply across the population.
3. Environmental sustainability: Encompasses achievement of supply- and demand-side energy efficiencies and development of energy supply from renewable and other low-carbon sources. (World Energy Council 2016: 7)

Taking a look at the East-Central region, we see that in 2016 Slovenia was 12th among the 125 countries that took part in the study, Slovakia was 16th, the Czech Republic 19th, Hungary 21st and Poland was 36th. The study makes recommendations for policy decision makers to achieve energy sustainability:

- Policy choices, and creating a regime to support a robust energy sector, are critical to lasting energy trilemma performance regardless of a country's resources or geographic location.
- Policies and investments intended to change energy supply and demand at a national level will take time and will likely be disruptive. Countries must act now to progress on the trilemma with secure, equitable and environmentally sustainable energy to support a thriving energy sector, a competitive economy and a healthy society. (World Energy Council 2016: 19)

Table 1
Review of basic indicators of the effectiveness of energy policy implementation

Data	**Unit**	**Source**	**Indicator**
Primary energy production (all products)	Thousand tonnes of oil equivalent (TOE)	Eurostat	**EI** - Energy independence, % (Primary energy production/ Gross inland energy consumption) **PRES** - Energy production from renewable sources, % (Primary production of renewable energies/ Primary energy production) **EPP** - Energy production per capita, kg of oil equivalent per capita (Primary energy production/Population) **ECP** – Energy consumption per capita, kg of oil equivalent per capita (Gross inland energy consumption/Population)
Gross inland energy consumption (all products)	Thousand tonnes of oil equivalent (TOE)	Eurostat	
Primary production of renewable energies	Thousand tonnes of oil equivalent (TOE)	Eurostat	
Population	Total	Worldbank	

Source: own compilation

DATA AND METHODOLOGY

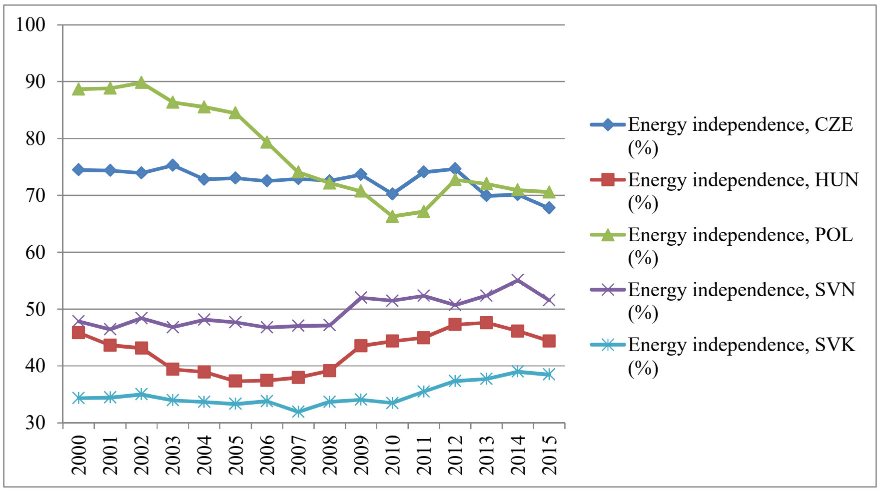
One way to measure sustainable energy was worked out by Golusin et al. (2011) using the following formula:

$$EEP = EI * wc_1 + PRES * wc_2 + EPP * wc_3 - ECP * wc_4$$

where EEP is the effectiveness of energy policy implementation, EI is the energy independence (from energy imports), PRES is the energy production from renewable energy sources, EPP is the energy production per capita, ECP is the energy consumption per capita and wci are the selected weight factors (wc_1=30, wc_2=20, wc_3=15, wc_4=25). These components are presented in Table 1.

The survey (Golusin et al. 2011) was carried out for Southeast Europe (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Hungary, Macedonia, Montenegro, Serbia, Slovenia, and Romania) for 2010. According to its results the energy policies of Hungary and Greece are not sustainable, Slovenia is a borderline case for energy sustainability. In their view mainly economic growth is the primary goal in these three countries, sustainability is just of secondary importance.

We modified this formula in order to estimate the effectiveness of energy policy implementation in the region of East-Central Europe. From a methodological view one small problem is that the sum of the values of the weight coefficients is not equal to 100, rather just 90. The difference of 10 is distributed equally among all the weights. Table 1 shows the basic indicators applying in the formula. The examined time period is 2000–2015, and the geographical field is the region of East-Central Europe (Hungary, Poland, the Czech Republic, Slovakia, and Slovenia).



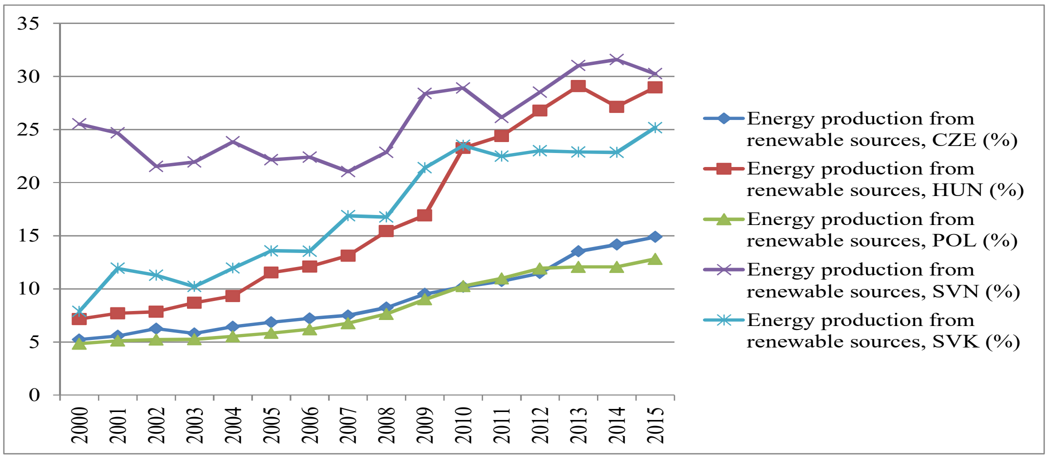
Source: own compilation on Eurostat (2017) database

Figure 5. Energy independence in East-Central Europe, 2000–2015 (%)

The countries in the region of East-Central Europe are characterized by high energy dependence. These are not independent and they should import energy to cover their needs. With the exception of Poland and the Czech Republic energy independence stagnates or slightly increases and no significant shift can be observed. An interesting fact is that the economic crisis in 2008-2009 did not influence the energy systems (in comparison to other economic indicators), which can be explained by the high inertia of these systems and the inelastic energy demand (Figure 5).

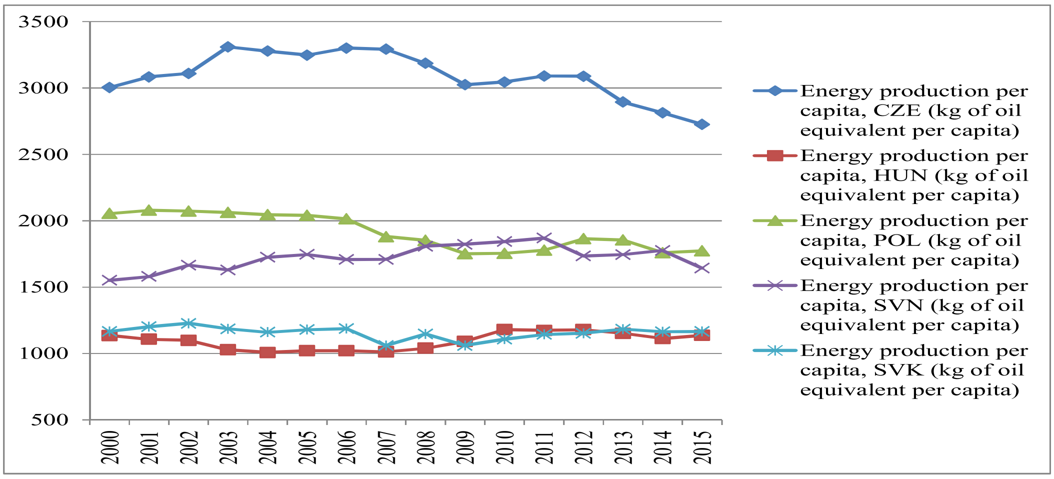
The European Union in the Energy 2020 strategic document set a target for increasing the share of renewable energy sources in gross final energy consumption: "In 2007 the European Council adopted ambitious energy and climate change objectives for 2020 – to reduce greenhouse gas emissions by 20%, rising to 30% if the conditions are right, to increase the share of renewable energy to 20% and to make a 20% improvement in energy efficiency" (Energy 2020: 2) On average the countries of the examined region have undertaken a goal of 16.43 percent: Slovenia has the highest (25 per cent to 2020), Poland 15.48 per cent, Hungary 14.65 per cent, Slovakia 14 per cent and the Czech Republic 13 per cent. Now (in September 2017) we are beyond halfway and some countries have achieved high growth in the past decade, although the 2008-2009 recession caused a minor setback in Poland, the Czech Republic and Slovakia (Figure 6).

Figure 7 shows that the energy production per capita is roughly constant in Hungary and Slovakia. This can be explained by the decreasing population, the rate of energy imports (with special regard to electricity) and improving energy efficiency. In Poland this ratio slightly decreases, in Slovenia slightly increases and in 2014 it was nearly equal in these two countries. The Czech Republic is the only nation where the energy production per capita has decreased from the early 2000s.



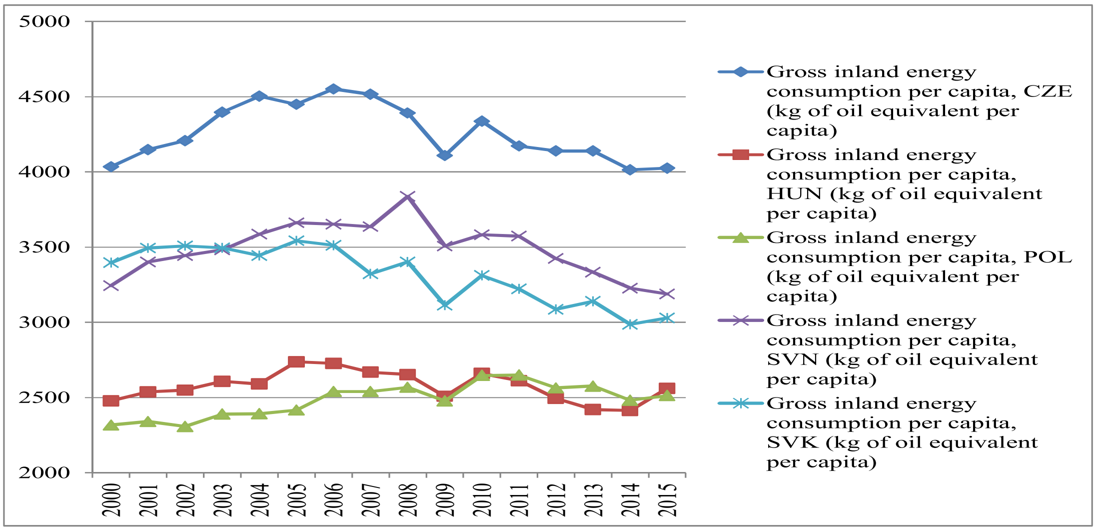
Source: own compilation from Eurostat (2017) database

Figure 6. Energy production from renewable sources in East-Central Europe, 2000–2015 (%)



Source: own compilation on Eurostat (2017) and World Bank (2017) database

Figure 7. Energy production per capita in East-Central Europe, 2000-2015 (koe/ capita)



Source: own compilation based on Eurostat (2017) and Worldbank (2017) databases

Figure 8. Energy use per capita in East-Central Europe, 2000-2015 (koe/capita)

The energy consumption per capita strongly improved in Slovenia and in the Czech Republic until 2008. But in the other countries of the region rather stagnation or slight decrease can be observed due to the energy efficiency improvements and the recession as well. Actually, there are significant differences among the energy use per capita which is explained by the heterogeneous geographical and climatic conditions and the different economic structures (Figure 8).

EMPIRICAL RESULTS

Diversity and different units of the examined indicator raise some questions and problems. To avoid the problems created when indicators are represented in different units, all of the data have been ranked using their absolute values. The highest one has got the value of 100 and the others were proportioned to it (the method is called scale transformation).

The indicators were placed on a scale based on the maximum value (it has got value of 100); Table 2 shows a template for the year 2000. The effectiveness of energy policy implementation – the EEP indicator – in the Czech Republic is calculated using the 2000 data as follows:

$$EEP_{CZ,\,2000}=32.5*0.84 + 22.5*0.2 + 17.5*1 – 27.5*1 = 21.9$$

Results are shown in Figure 9. The indicator of the effectiveness of energy policy implementation improved throughout the region. The most significant growth can be observed in Slovakia and in Hungary. These results roughly confirm the rank determined by the Energy Trilemma Index. The only exception is Poland, which is the most successful nation with regard to the effectiveness of energy policy implementation, but according to the Energy Trilemma Index it would be the last one because of the weak evaluation of energy security.

Table 2
State of scaled indicator in East-Central-Europe in 2000

	EI		**PRES**		**EPP**		**ECP**	
CZE	74.48	*84*	5.23	*20*	3004.28	*100*	4033.81	*100*
HUN	45.85	*52*	7.16	*28*	1135.87	*38*	2477.56	*61*
POL	88.67	*100*	4.84	*19*	2054.58	*68*	2317.06	*57*
SVN	47.82	*54*	25.53	*100*	1551.14	*52*	3243.56	*80*
SVK	34.35	*39*	7.90	*31*	1166.79	*39*	3396.32	*84*

Source: own compilation

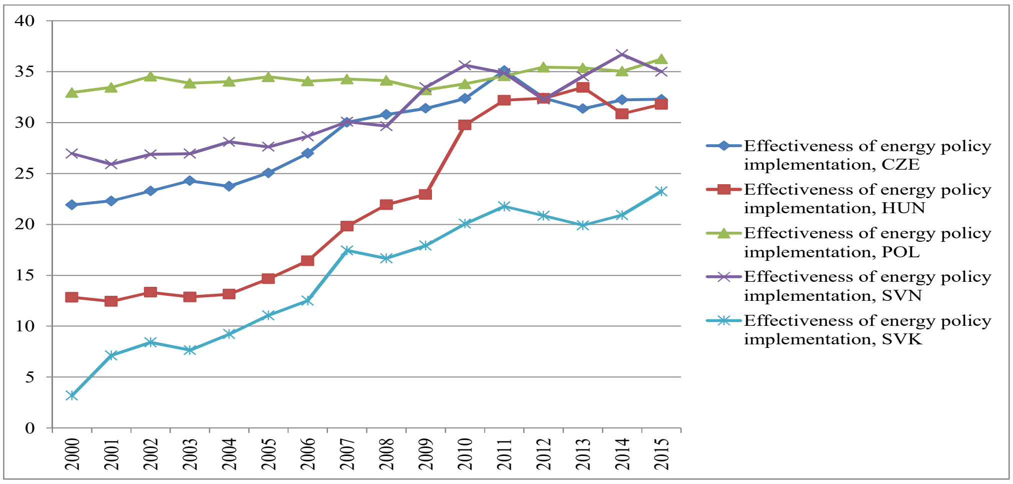


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Figure 9. Effectiveness of energy policy implementation in East-Central Europe, 2000–2015

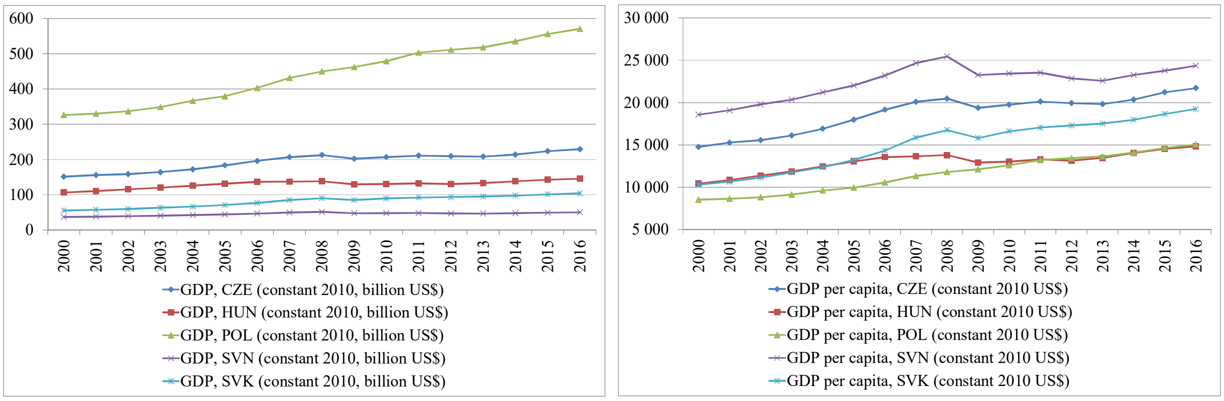
The question arises as how changes in GDP and economic development affect energy sustainability. To measure the welfare and economic development many kinds of alternative indicators are available, such as the *Measure of Economic Welfare* (MEW) developed by Nordhaus and Tobin (1972), or the *Index of Sustainable Economic Welfare* (ISEW) of Daly et al. Slightly modified versions of the ISEW are the *Genuine Progress Indicator* (GPI) and the *Sustainable Net Benefit Index* (SNBI). To calculate social development the *Human Development Index* (HDI) assesses the countries on three dimensions: health, education and economy. In parallel with the GPI the index of *Ecological Footprint* (EF) was worked out, which "tracks on the demand side, how much land and water area a human population uses to provide all it takes from nature. This includes the areas for producing the resource it consumes, the space for accommodating its buildings and roads, and the ecosystems for absorbing its waste emissions such as carbon dioxide." (Global Footprint Network, 2014). Mally (2011) developed the *Development Balance Index* (DBI) with the combination of the HDI and the EF, which weights the three dimensions of the HDI and the EF, unifying their advantages.

The IEA worked out the Energy Development Index (EDI) in 2004 to measure the connection between the energy use and the human development. It takes into consideration not only the quantity of the energy consumption but the quality of it as well. It applies the principle that energy use is not the consequence but the cause of economic development. According to its results, among the developing nations the Gulf States have the highest EDI values, while the lowest ones belong to the African region. Based on the 2030 forecast the value of EDI will increase in the developing nations, especially in India and in Africa. In spite of that, the indicator will still be far from the values of OECD countries (IEA 2004)-

However, these indicators have not only advantages but disadvantages as well. A frequently mentioned disadvantage is that the theoretical foundations are really solid, and that these indicators approach the welfare and the development from monetary perspective (Niemi & McDonald 2004). Another negative feature is that in the calculation the costs and benefits are chosen with regard to the personal preferences of the analyst, so the subjectivity is rather high (Clarke & Lawn 2008). It is also problematic that these indicators are only available for a few countries (such as the United States of America), most of data are only cross-sectional, and time series are rare. The lack of data increases in parallel with aggregation level: at the regional or subregional level in just a few cases were the indicators calculated (such as in Victoria state – Australia, Alberta province – Canada). In our case – mainly because of the lack of data – we apart from the analysis of the welfare and the examination concentrate on the GDP but it should be noted that the GDP is not suitable for measuring the welfare and the economic development.

The connection between economic growth and energy consumption is not new in energy economics but most of the analysis focuses on the determination of the causality directions. Mostly the Granger causality directions between the GDP (or the GNI) and the primary energy production are examined with different kinds of econometric methods (usually using time series or panel data and applying Vector Autoregressive, Vector Error Correction, Fixed Effects or Random Effects models); see Sebestyénné Szép (2014) for a detailed overview. In an earlier analysis we concluded that there is a significant relationship between energy consumption and economic growth in East-Central Europe (Czech Republic, Hungary, Poland, Slovakia, and Slovenia). Energy consumption Granger causes the GDP in the long run, so energy consumption can induce economic growth.

Hereinafter we examine how changes in the GDP affected the EEP indicator. We assume that if the GDP increases, it affects the energy sustainability positively. Figure 10 presents the GDP growth (constant 2005 US$ in per capita and in absolute value) between 2000 and 2016 in East-Central Europe.



Source: Worldbank database

Figure 10. GDP growth in East-Central Europe, 2000–2016 (constant 2005 US$): absolute value (left), per capita (right)

To examine the relationship between the EEP and the GDP firstly a Pooled OLS (pooled least squares) method is estimated. Panel data are applied and the number of observations is 80 (5 countries and 16 years). Using the Breusch-Pagan test statistic (LM = 162.648 with p-value = prob(chi-square(1) > 162.648) = 2.98598e-037) we have to accept the first hypothesis against the null hypothesis (the null hypothesis is that the pooled OLS model is adequate, in favor of the random effects alternative), so secondly we calculate a random effects model. Testing the Hausman test statistic (H = 19.3889 with p-value = prob(chi-square(1) > 19.3889) = 1.06625e-005) the low p-value counts against the null hypothesis that the random effects model is consistent, in favor of the fixed effects model. So, finally with these data (GDP and the effectiveness of energy policy implementation) the Fixed Effects Model is estimated, obtaining the following equation:

$$lnEEP_{it} = \alpha_i + \beta lnGDP_{it} + u_{it}$$

All of the indicators are in logarithmic form. Estimates in Table 3 were tested for validity, all of the tests are performed.

It can be stated that the GDP growth has a positive effect on the effectiveness of energy policy implementation and can contribute to its improvement. Compared to Golusin et al. (2011), with regard to our long time series and panel data it is clear that the countries of East-Central Europe have moved towards sustainable energy and positive changes can be observed in their energy use.

Table 3
Fixed Effects Model (FEM). Effectiveness of energy policy implementation. Panel of countries in East-Central Europe.

	coefficient	std. error	t-ratio	p-value
constant	−29.8524	4.61709	−6.466	0.000 ***
ln(GDP)	1.47073	0.180424	8.151	0.000 ***
Number of observations	80	**Mean dependent var**		7.783157
Number of cross-sectional units	5	**S.D. dependent var**		0.465889
Time-series length	16	**Sum squared resid**		4.012382
LSDV R-squared	0.766003	**Durbin-Watson**		0.266907
Within R-squared	0.473111	**S.E. of regression**		0.232855
LSDV F (5, 74)	48.44879	**P-value (F)**		0.000 ***

Comment: * 10% significance level, ** 5% significance level; *** 1% significance level
Source: own compilation

CONCLUSION

A major difference between neoclassical economics and energy economics is their different opinions about the role of energy in economic development. According to neoclassical theory, energy is just an intermediary input among other production factors (land, capital and workers) that determine economic development directly or indirectly. For energy economists (such as C.J. Cleveland, H. Herring, or D.I. Stern) energy affects the income and the welfare significantly, and the economy depends on changes in energy consumption. Energy consumption, economic growth and sustainable development and the relationship of these variables were core topics as early as the industrial revolution and continue to be relevant today. The recognition of global problems has forced nations to determine economic goals to reduce emissions by improving energy efficiency and increasing the share of renewable energy sources in final energy consumption. These are the main dimensions of sustainable energy.

In post-communist East-Central Europe the process of the structural change occurring in the last two decades has strongly affected the energy systems and economic development. In this time period energy efficiency increased dynamically. This development stemmed mainly from the industrial sector, where development occurred mostly through structural changes. The most important issue is to what extent the energy systems are sustainable.

In our analysis we reviewed the main pillars of the sustainable energy and quantified the effectiveness of energy policy implementation based on the methodology of Golusin et al. (2011). Our survey covered five countries in the region of East-Central Europe using long time series (2000-2015). During that period the effectiveness of energy policy implementation improved due to increasing energy efficiency and the growing share of the renewable energy sources, implementing the goals of the EU Energy 2020 strategic document. In this region the countries are in different economic stages: the most developed nation is Slovenia with regard to the GDP per capita, while the lowest ones are Hungary and Poland. After a panel data analysis (applying the Fixed Effects Model) it has been verified that the economic development (measured here with the GDP) affects the energy systems and the implementations of sustainable energy significantly.

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