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

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Abstract. *Energy is managed in a complex way by the theories of sustainability. All of the three pillars of sustainability (society, environment, and economy) are inseparable from the energy sector, because energy consumption causes so many externalities which threat the welfare in the long run. Most of the environmental problems are in tight connection with energy use and production, such as nuclear waste management, oil spills, emission, etc. Furthermore, energetics 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 the economic development contributes to the effectiveness of policy implementation for sustainable energy development in East-Central Europe.*

Keywords: *energy consumption, energy dependence, energy efficiency, energy strategy, sustainability, Central-East Europe.*

1 Introduction

The global population has increased rapidly in the past century: according to UN (2004) it barely exceeded 2.5 billion in 1950, reached 4 billion in 1974, 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 in overcrowded cities.

Population growth is in close connection with energy consumption: energy is an essential resource not only in developing but in developed countries as well. It is needed for economic and social development and reducing poverty (Bindra and 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 the energy consumption decreased, so the center of the 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).

The issue of energy security has become more and more important for today. The high 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 self-assertive action for the third energy package of the European Union or the conflict between Iran the international community with regard to the Iranian nuclear program are good examples. It is enhanced by that the new “big consumers” such as China look for crude oil sources in those countries (such as Iran, Sudan, Venezuela) whose diplomatic and political relationship is problematic with the old consumers, such as the developed core countries (Europe, North-America) (Róbel, 2006). According to the IEA (2012) the share of the Chinese energy consumption to the world was 7 percent in 1973, while the share of the OECD

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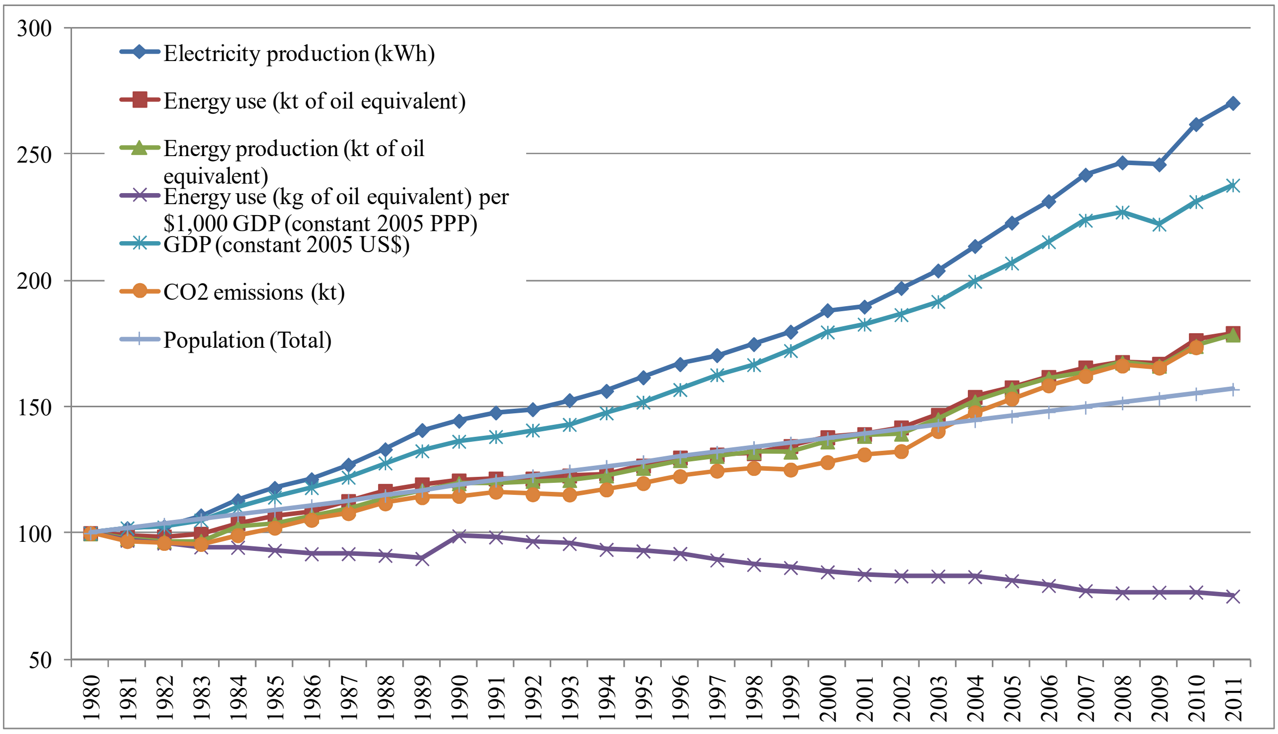

Figure 1 The main data of the world energy consumption (1980–2010)

Source: Worldbank database

countries was 61.4 percent. This ratio has changed in the past 30 years: in 2010 the share of China was 19.1 percent, but the consumption share of the OECD countries decreased to 42.4 percent. Today China is the second biggest oil importer and the 5th biggest oil producer (IEA, 2012).

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, p. 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 I examine the relationship among energy use, energy management and sustainability.

2 Theoretical background

The starting point is to define sustainable energy and sustainable development. Energetics or 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, p. 3). Four main parts of that are exploitation, conversion, distribution and consumption, the main issue is to minimize the energy needs through energy saving policies.

Sustainable development is (the most frequently quoted definition is from the Brundtland Report) development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

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 energetics with regard the sustainability principles" (Dinya, 2010, p. 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

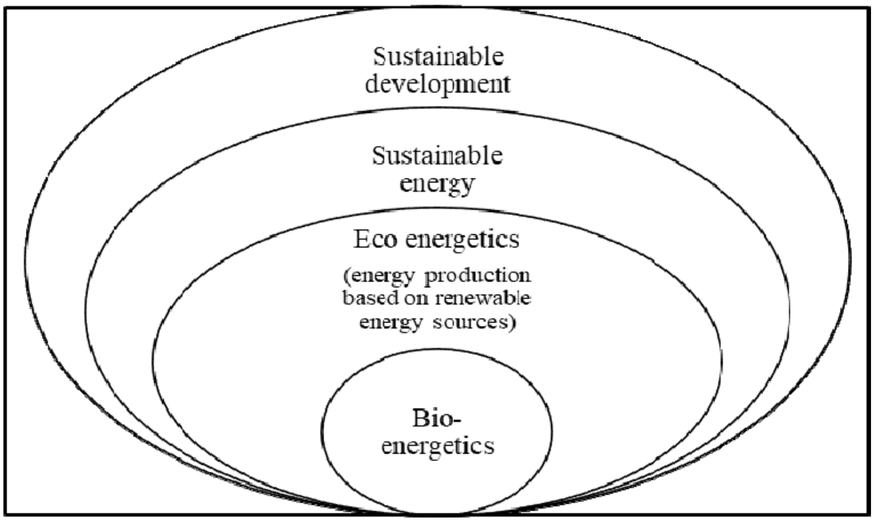

Figure 2 Sustainable energy

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

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. All of the three pillars of the sustainability (society, environment, and economy) are inseparable from the energy sector, because energy consumption causes so many externalities which threat the welfare in the long run. Most of the environmental problems are in tight connection with energy use and production, such as nuclear waste management, oil spills, emission, etc. Furthermore, energetics is an integral part of the economic and social development: millions people live in energy poverty (the World Energy Council estimates 1.6 billion people do not have access to electrical energy), according to the World Health Organization (2012) database as many people (circa 1.6 million people) die from respiratory diseases per year because of the inappropriate energy use as from AIDS.

Energy security is closely related to energy management and the former one 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 (2012) energy security is characterized by three main attributes from the perspective of the ecological economist: 1) resilience, 2) adaptability, and 3) transformability. The definition of resilience is a widely used term; it is widespread in environmental and ecological economics, finance and organization theories as well. In energetics it means "a measure of the economy's ability to handle energy related (temporary and permanent) effects". 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, p. 1984).

Energy security can be characterized by the following 4R conception (Chaturvedi, 2011, p. 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).

The complex condition systems of sustainable energy 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, p. 14). Energy use is related to many problems (external impacts) which have to be solved by the environmental policy: problems such as air pollution caused by emission, global climate change, exhausting fossil fuels, and in connection with that, the challenge of sustainability.

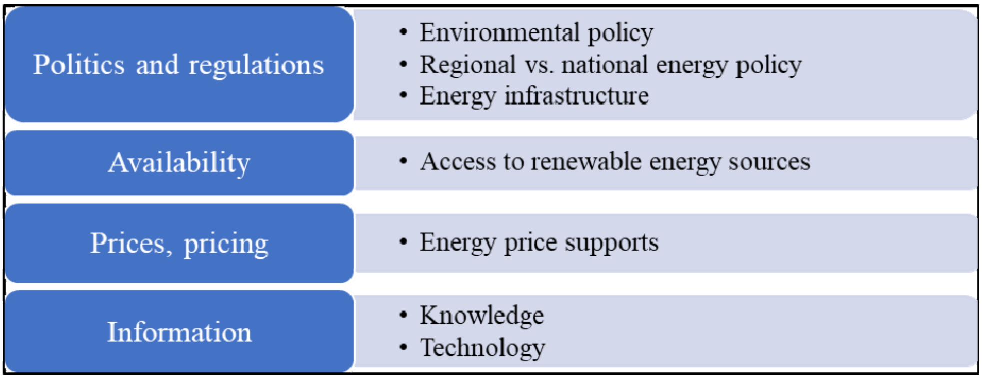

Figure 3 Criteria of the sustainable energy

Source: own compilation on Press M. (2009)

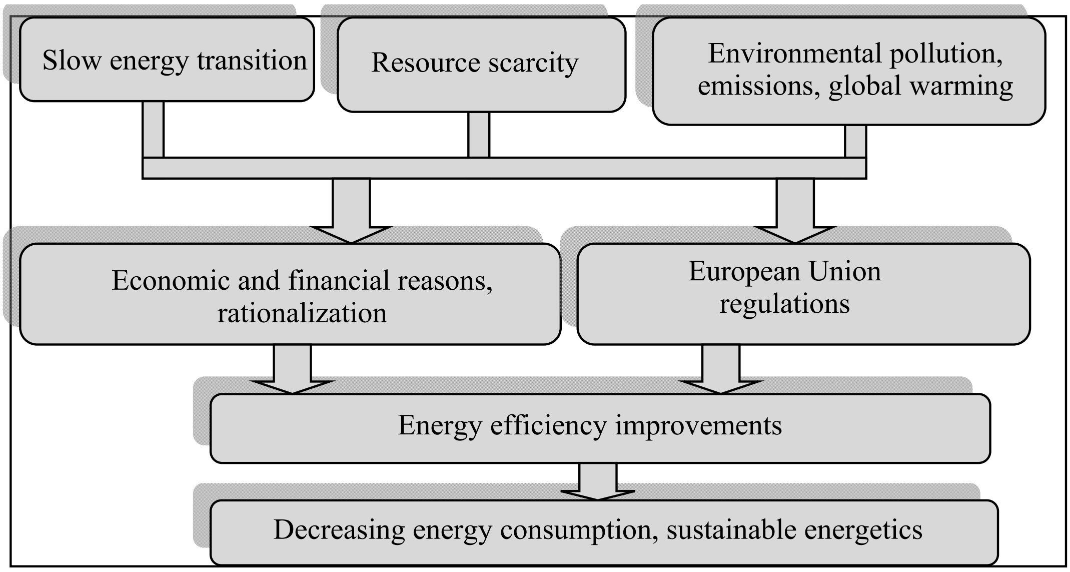

Figure 4 The necessity of energy efficiency improvements

Source: own compilation

The next part of the political issues is related to the infrastructure and the energy markets. The reduction of state interventions and the liberalization of the energy markets contribute to the efficient use of energy sources, and energy security. The regional approaches have to be enforced by the utilization and supports 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, p. 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 the 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 would be one of the core elements of energy strategies.

The official pricing (with special regard to the price supports) apparently means advantage for the consumers, but in the long run it reduces the competitiveness of the energy sector, it 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 and Arnould, 2009)

"The illusion of cheap and unrestricted energy sources does not encourage the consumers to save energy and to replace old low-efficiency equipments, so efficiency improvements do not prevail over the end-consumers" (Energiaklub, 2006, p. 14). (Figure 3).

The sustainable energy is composed of several parts, so the increasing use of the 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

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

Data	Unit	Source	Indicator
Energy production	kt of oil equivalent	Worldbank	**EI** – Energetic independence (%)
Energy use	kt of oil equivalent	Worldbank	
Primary production of renewable energy	1 000 tonnes of oil equivalent	Eurostat	**PRES** – Energy production from renewable sources (%)
Total production of primary energy	1 000 tonnes of oil equivalent	Eurostat	
Energy production	kt of oil equivalent	Worldbank	**EPP** – Energy production per capita (kg of oil equivalent per capita)
Population	Total	Worldbank	
Energy use per capita	kg of oil equivalent per capita	Worldbank	**ECP** – energy consumption per capita

Source: own compilation

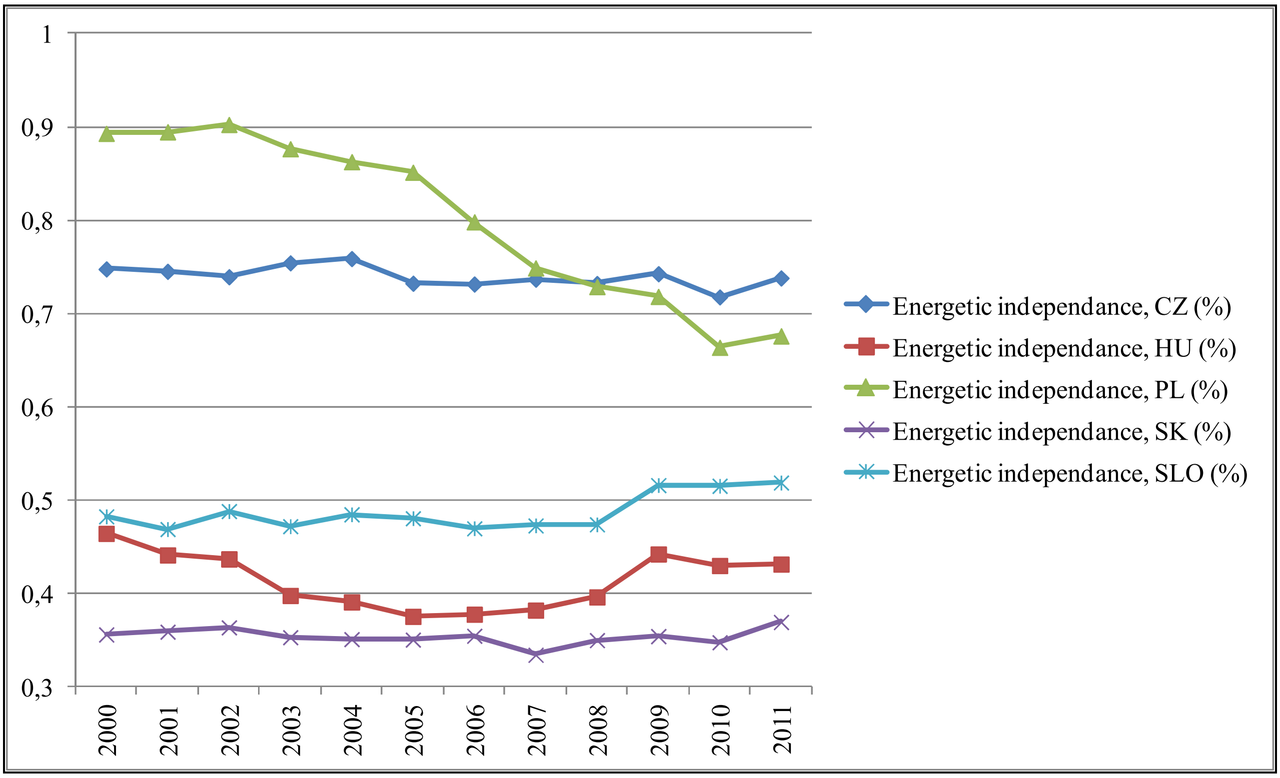

Figure 5 Energetic independence in East-Central Europe, 2000–2011 (%)

Source: own compilation on Worldbank database

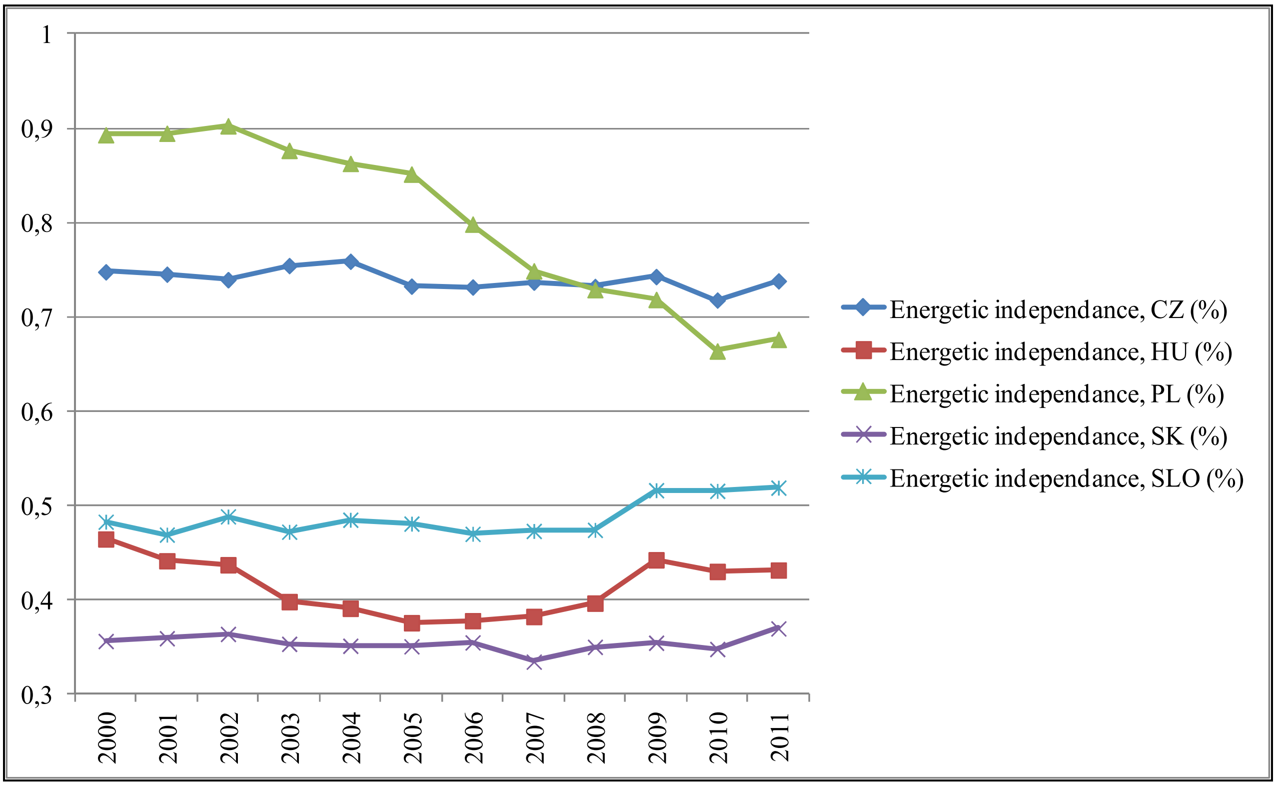

Figure 6 Energy production from renewable sources in East-Central Europe, 2000–2011 (%)

Source: Eurostat database

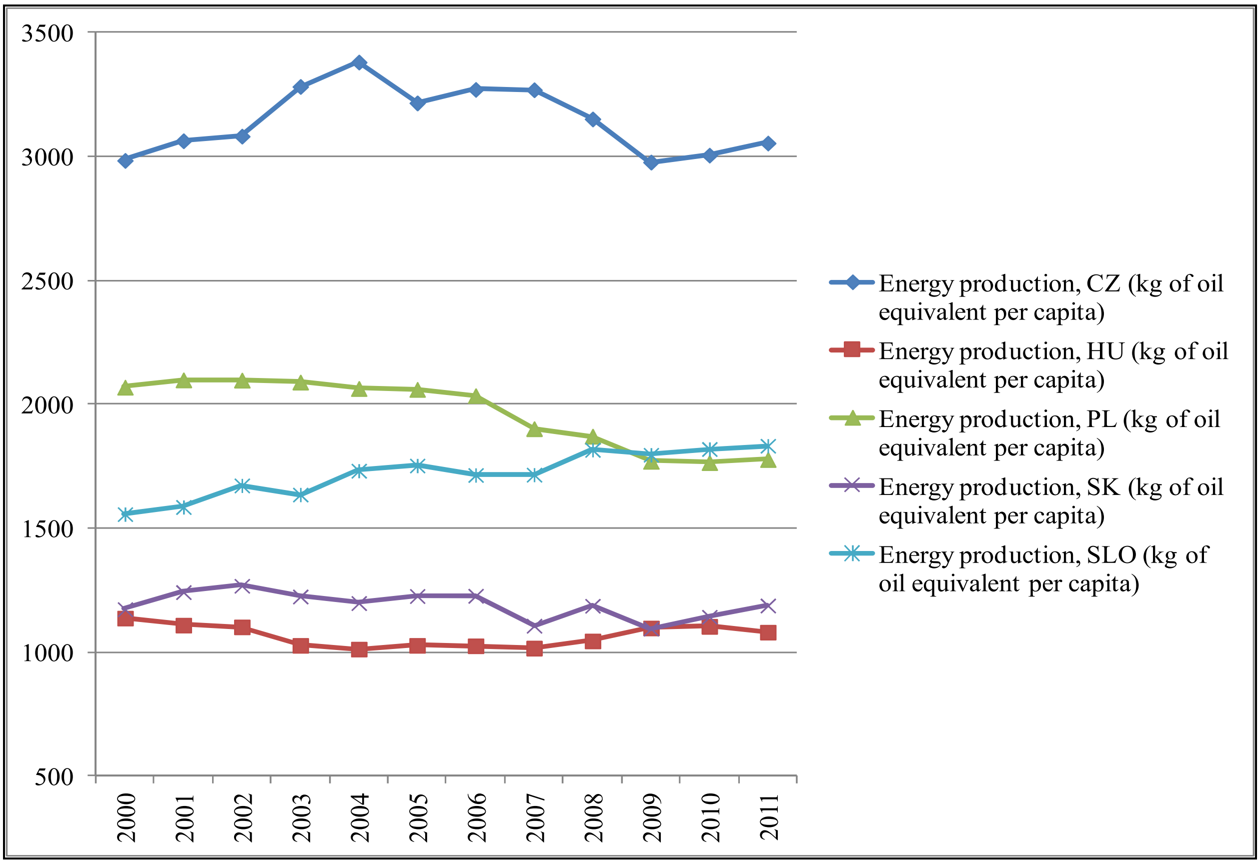

Figure 7 Energy production per capita in East-Central Europe, 2000–2011 (koe)

Source: Worldbank database

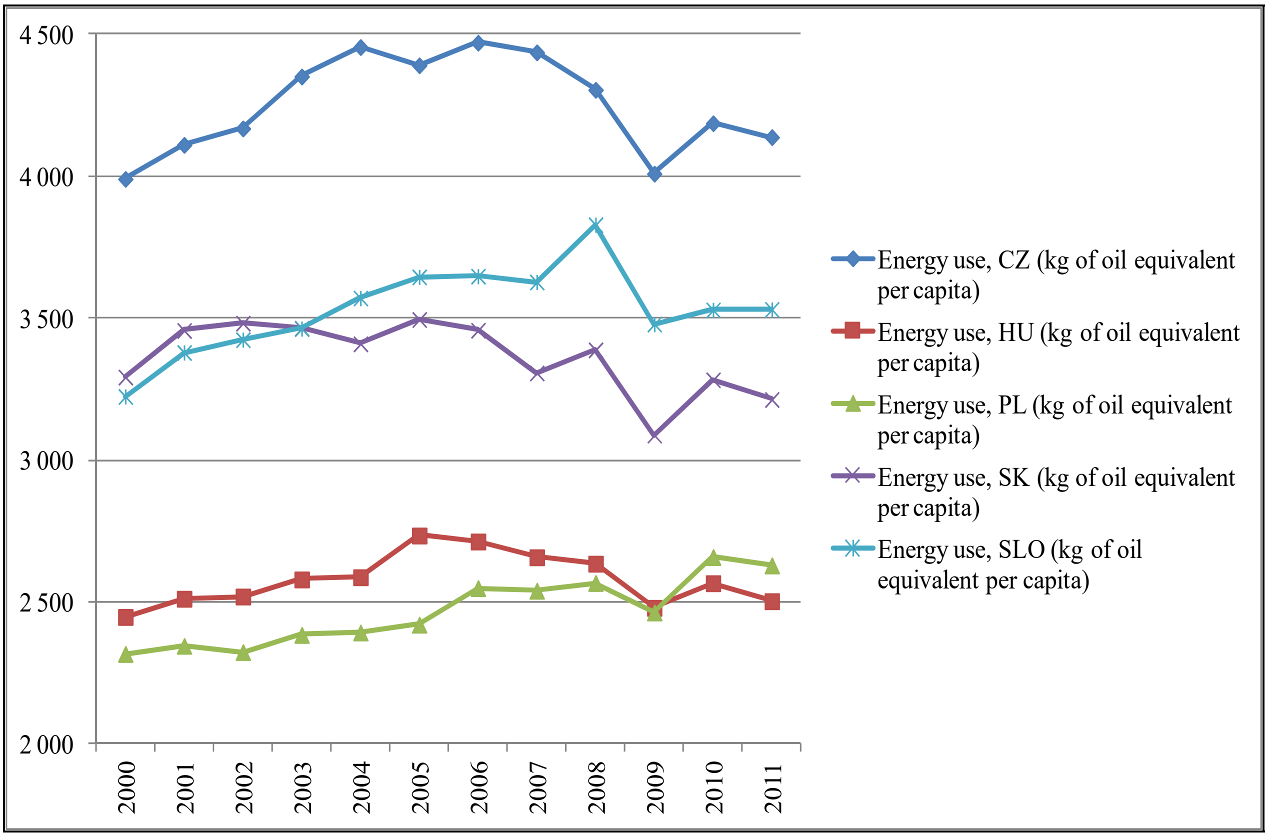

Figure 8 Energy use per capita in East-Central Europe, 2000–2011 (koe)

Source: Worldbank database

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

	EI		PRES		EPP		ECP	
CZ	0,75	*0,84*	0,04	*0,17*	2984,59	*1,00*	3990,67	*1,00*
HU	0,46	*0,52*	0,07	*0,28*	1137,77	*0,38*	2448,23	*0,61*
PL	0,89	*1,00*	0,05	*0,19*	2069,63	*0,69*	2317,48	*0,58*
SK	0,36	*0,40*	0,08	*0,31*	1173,98	*0,39*	3292,63	*0,83*
SLO	0,48	*0,54*	0,26	*1,00*	1557,47	*0,52*	3224,38	0,81

Source: own compilation

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 the 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 preserve/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 the sustainable economic development but on sustainable energy as well (Hertwich, 2005).

The World Energy Council (2012) has developed the Energy Sustainability Index (ESI) to measure the sustainable energy, which assess the world countries with regard to three dimensions:

“Energy security: For both net energy importers and exporters, this refers to the effective management of primary energy supply from domestic and external sources, the reliability of energy infrastructure, and the ability of participating energy companies to meet current and future demand.

For countries that are net energy exporters, this also relates to an ability to maintain revenues from external sales markets.

Social equity: This concerns the accessibility and affordability of energy supply across the population.

Environmental impact mitigation: This encompasses the achievement of supply and demand-side energy efficiencies and the development of energy supply from renewable and other low-carbon sources." (World Energy Council, 2012, p. 4).

In 2012 Slovakia was the 17th among the 94 countries that took part in the study, Hungary was the 19th, Slovenia 22nd, the Czech Republic 29th, and Poland was the 47th. The study makes recommendations for the policy decision makers to achieve energy sustainability:

– "Design coherent and predictable energy policies.

– Support market conditions that attract long-term investments.

– Encourage initiatives that foster research and development in all areas of energy technology" (World Energy Council, 2012, p. 4).

3 Methodology

One way to measure sustainable energy is 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 energetic policy implementation, EI is the energetic independence (from the energy import), PRES is the energy production from renewable energy sources, EPP is the energy production per capita, ECP is the energy consumption per capita, wci are the selected weight factors ($wc_1 = 30$, $wc_2 = 20$, $wc_3 = 15$, $wc_4 = 25$).

The survey was made for Southeast Europe (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Hungary, Macedonia, Montenegro, Serbia, Slovenia, and Romania) for 2010. According to its result the energy policies of Hungary and Greece are not sustainable, energetic sustainability is at the border of Slovenia. In their view mainly economic growth is the primary goal in these countries, sustainability is just of secondary importance.

Hereinafter using this formula but slightly modified we estimate the effectiveness of energetic policy implementation in the region of East-Central Europe. From methodological view it has a problem, the sum of the values of the weight coefficients is not equal to 100, it is just 90. The difference 10 is distributed equally among all the weights. Table 1 shows the basic indicators applying in the formula. The examined

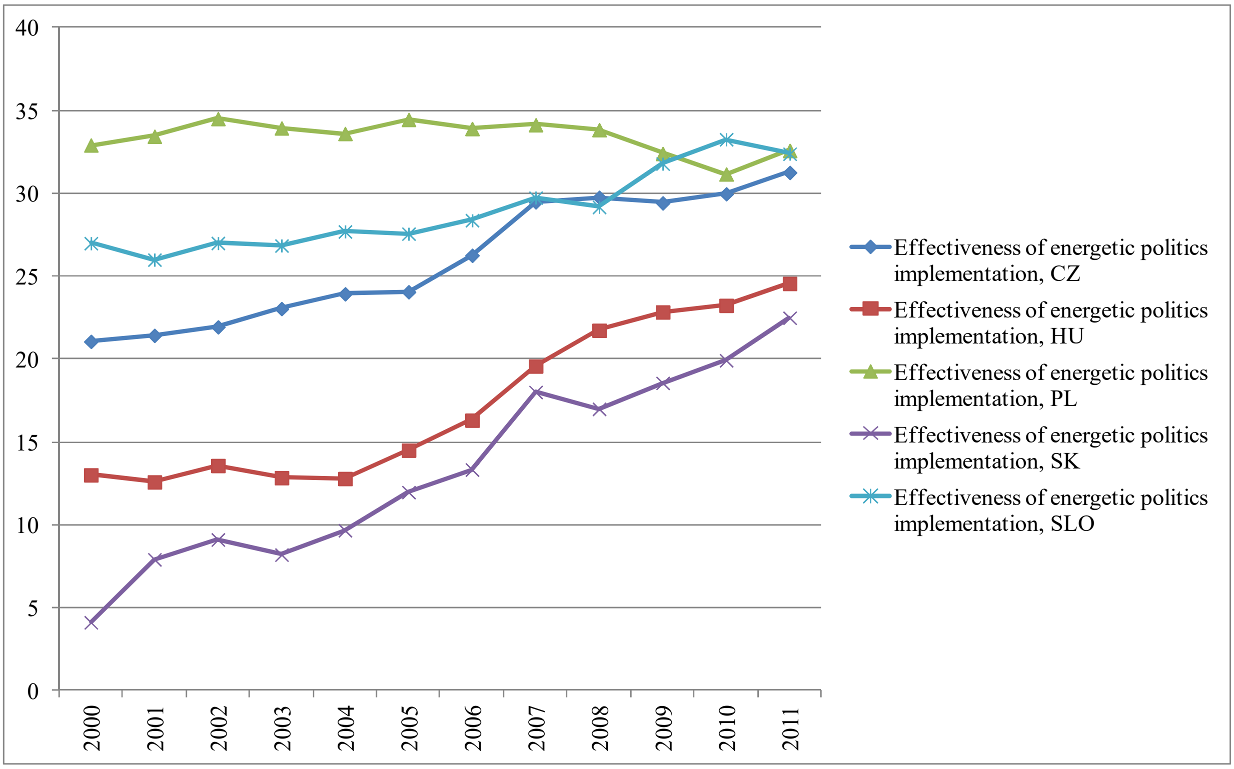

Figure 9 Effectiveness of energetic policy implementation in East-Central Europe, 2000–2011

Source: own compilation

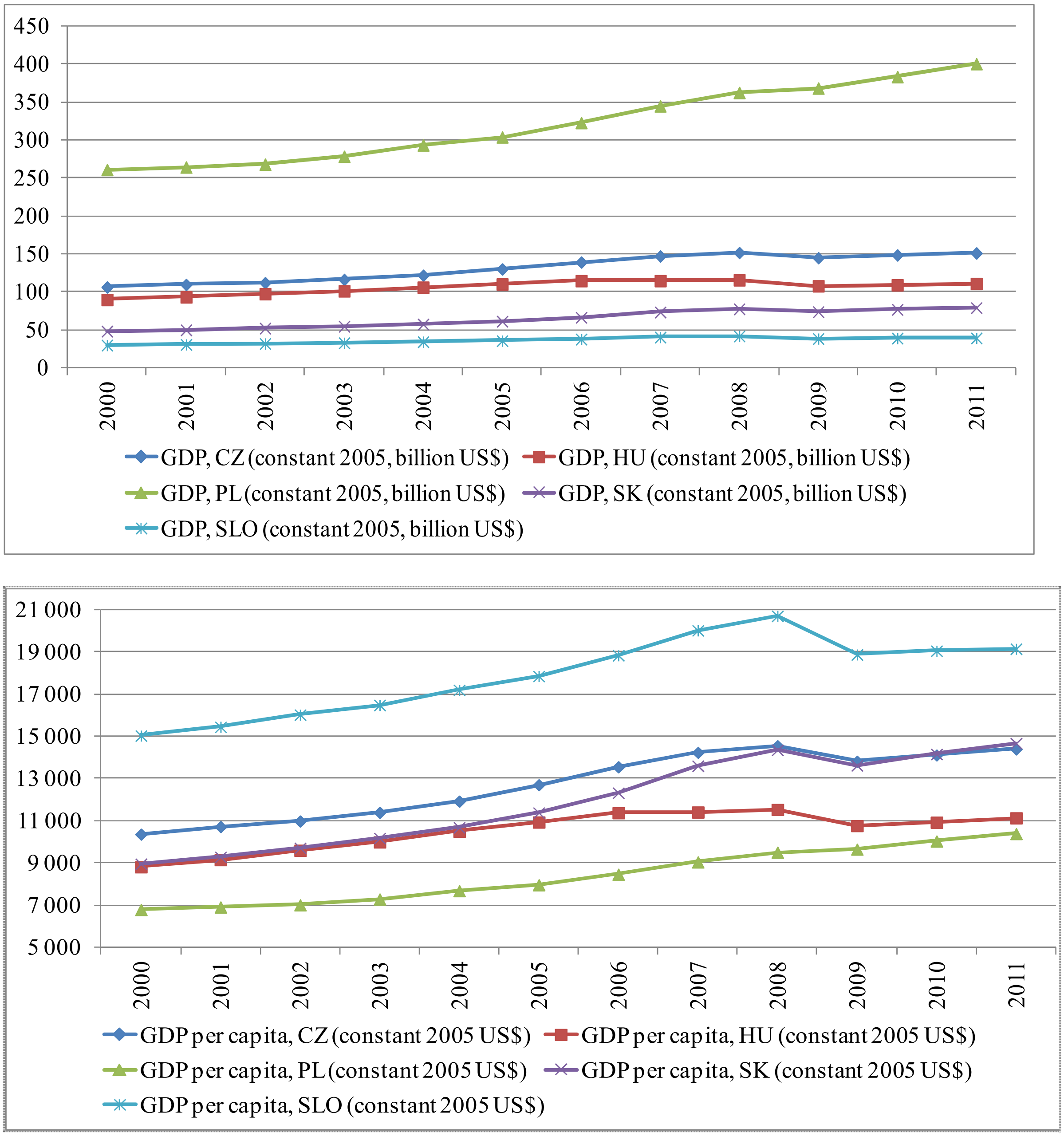

Figure 10 GDP growth in East-Central Europe, 2000–2011 (constant 2005 US$)

Source: Worldbank database

time period is 2000–2011, and the geographical field the region of East-Central Europe (it includes Hungary, Poland, the Czech Republic, Slovakia, and Slovenia).

The countries in the region of East-Central Europe are characterized by high energy dependency. These are not independent and they should import energy to cover their needs. With exception of Poland these nations stagnated: significant shift can be observed just in Slovenia and in Hungary in 2008 but the recession has not influenced the energy systems (in comparison to other economic indicators) which can be explained with 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, p. 2).

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

	coefficient	*std. error*	*t-ratio*	*p-value*
constant	-30,3157	4,73512	-6,402	0,000 ***
ln(GDP)	1,31878	0,186957	7,054	0,000 ***
Number of observations	60	**Mean dependent var**	3,084976	
Number of cross-sectional units	5	**S.D. dependent var**	0,456721	
Time-series length	12	**Sum squared resid**	1,997729	
R-squared	0,837676	**Durbin-Watson**	0,361012	
Adjusted R-squared	0,822646	**S.E. of regression**	0,192341	
F(5, 54)	55,73365	**P-value(F)**	0,000	

Source: own compilation

On average the countries of the examined region have undertaken 16.43 percent: Slovenia has highest one (25 percent to 2020), Poland 15.48 percent, Hungary 14.65 percent, Slovakia 14 percent, the Czech Republic 13 percent. Now (in January 2014) we are in half time and some countries have reached a high growth in the past decade, the 2008–2009 recession has caused a minor setback just in Slovenia and Slovakia (Figure 6).

The energy production per capita slowly increased in the prosperity period of the 2000s, but this tendency was stopped by the recession (Figure 7).

The energy consumption per capita strongly improved in Slovenia 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 can be explained by the heterogeneous geographical and climatic conditions and the different economic structure (Figure 8).

4 Empirical results

Diversity and different units of the examined indicator raise some questions and problems. To avoid them (the problems that is 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 former mentioned indicators have been put on scale based on the maximum value (it has got value of 1) and Table 2 shows a template for a year of 2000. With regard to these results the effectiveness of energetic policy implementation, so the EEP indicator in the Czech Republic is calculated in this way:

$$EEP_{CZ,\ 2000}=32,5*0,84 + 22,5*0,17 + 17,5*1 - 27,5*1 = 21,07.$$

With regard to this calculation method all of the results are shown in Figure 9. With the exception of Poland the indicator of the effectiveness of energetic policy implementation improved in the region, the most significant growth can be observed in Slovakia.

The question arises as how the GDP changes and the economic development affect the 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) marked with the names of Daly H. E., Cobb J. and Cobb C. A slightly modified version of the ISEW is the *Genuine Progress Indicator* (GPI), and the *Sustainable Net Benefit Index* (SNBI). To calculate the social development the *Human Development Index* (HDI) is the suitable one which assesses the countries into their 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 unify the advantages of that.

IEA has 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. So it applies the principle that the energy use is not the consequence but it is the cause of the economic development. According to its result in the developing nations the Gulf States have the highest EDI values, the lowest one 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 be far from the value of OECD countries. (IEA, 2004, pp. 344–350).

But these indicators have not only advantages but disadvantages as well. A frequently mentioned disadvantage is that the theoretical foundations are really soft and these indicators approach the welfare and the development from monetary perspective (such as Niemi and McDonald, 2004.). Another negative feature is that by the calculation the costs and benefits are chosen with regard to the personal preferences of the analyzer so the subjective part of that is really high (Clarke, 2008). It is also problematic that these indicators are only available for few countries (such as United States of America), most of data are only cross-sectional, and the time series are rare. The lack of data is increasing in parallel with aggregation level: in regional or subregional level just in few cases was the indicators calculated (such as in Victoria state – Australia, Alberta province – Canada). In our cases – 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 are 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). A detailed overview of that is given by Sebestyén Szép (2012). In our former analysis we concluded in East-Central Europe (Czech Republic, Hungary, Poland, Slovakia, and Slovenia) there is a significant relationship between energy consumption and economic growth. In this light energy consumption Granger causes the GDP in the long run, so the energy consumption can induce economic growth.

Hereinafter we examine how the GDP changes affected the EEP indicator. We assume if the GDP increases, it affects the energy sustainability positively. Figure 10 presents the GDP growth (constant 2005 US$) between 2000 and 2011 in East-Central Europe.

To examine the relationship of the EEP and the GDP firstly a Pooled OLS (pooled least squares) method has been estimated. Using the Breusch-Pagan test statistic (LM = 145,917 with p-value = prob (chi-square (1) > 145,917) = 1,35371e-033) 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 have calculated a random effects model. Testing the Hausman test statistic (H = 12,0859 with p-value = prob (chi-square (1) > 12,0859) = 0,000508049) 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 energetic policy implementation) the Fixed Effects Model has been estimated, obtaining the following equation:

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

All of the indicators are in logarithmic form. Estimates on Table 3 are considered as valid, all of the tests are performed.

The GDP growth has a positive effect on the effectiveness of energetic policy implementation and it can contribute to the improvement of it. 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 the sustainable energy and positive changes can be observed in their energy use. In our view validity of the analysis based on one year is really restrained, founded conclusions need more years.

5 Conclusions

The main 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), which 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, the economy depends on the changes in energy consumption. Energy consumption, economic growth and sustainable development and the relationship of these variables were core topics as early as in the industrial revolution and continue to be relevant today. The recognition of global problems has forced nations to determine economical goals to reduce emissions by improving energy efficiency and increasing the share of renewable energy sources in final energy consumption. These are one of the main dimensions of the sustainable energy.

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

In our analysis we determined the main pillars of the sustainable energy and quantified the effectiveness of energetic policy implementation based on the methodology of Golusin et al. (2011). Our survey covered 5 countries in the region of East-Central-Europe using long time series (2000–2011). At that time the effectiveness of energetic policy implementation improved due to the 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 stage: the most developed nation is Slovenia with regard to the GDP per capita, the lowest ones are Hungary and Slovakia. After a panel data analysis (applying the Fixed Effects Model) it has been verified that bthe economic development (measuring here with the GDP) affects the energy systems and the implementations of sustainable energy significantly.

References

Barótfi, I., Schlich, E., Szabó, M. (2003) *Energy management*. (in Hungarian: Energiagazdálkodás) E.ON Hungária Rt., Budapest 79 p. Hiba! A hiperhivatkozás érvénytelen. Downloaded: 2012. Június.

Bindra, S.P., Hokoma, R. (2009) Meeting the energy challenges for sustainable development of developing countries. *Proceedings of International Conference on Energy and Environment*, pp. 716–721.

Blum, H., Legey, L.F.L (2012) The challenging economics of energy security: ensuring energy benefits in support to sustainable development. *Energy Economics,* 34, pp. 1982–1989.

Buday-Malik, A., Győrffy, I., Nyiri, A., Roncz, J., Sebestyénné, Szép T., Tóthné Szita K. (2012) *Energy management and sustainability – Environmental and economical aspects of the energy sector in the North-Hungarian region* (in Hungarian: Energiagazdálkodás és fenntarthatóság – Az energiaszektor környezeti és gazdasági vonatkozásai az Észak-Magyarországi régióban) University of Miskolc Publisher 147 p.

Chaturvedi, A., Samdarshi, S.K. (2011) Energy, economy and development (EED) triangle. Concerns for India. *Energy Policy*, 39, pp. 4651–4655.

Clarke, M., Lawn, P. (2008) A policy analysis of Victoria's Genuine Progress Indicator. The *Journal of Socio-Economics*, 37, pp. 864–879.

Clarke, M., Lawn, P. (2008) Is measuring genuine progress at the sub-national level useful? *Ecological Indicators*, 8, pp. 573–581.

Cleveland, C.J. (2003) Biophysical constraints to Economic growth. In D. Al Gobaisi. Editor-in-Chief. *Encyclopedia of Life Support Systems*, 28 p.

Csákberényi-Nagy, G. (2005) *Energetics, the core point of the development* (in Hungarian: Energetika, a fejlődés sarokköve) Budapest, Bolyai Műhely Foundation 9 p. URL: http://www.alter-energia.hu/docs/sarokko.pdf.

Dinya, L. (2010) *Biomass based energy production and sustainable energetic* (in Hungarian: Biomassza-alapú energiatermelés és fenntartható energiagazdálkodás) Magyar Tudomány 2010/8, pp. 912–919. URL: http://epa.oszk.hu/00600/00691/00080/pdf/mtud201008912-925.pdf.

Energiaklub – Ámon A., Kardos, P., Kazai, Zs., Perger, A., Tóth, N. (2006) *Sustainable energy strategy for Hungary* (in Hungarian: Magyarország fenntartható energiastratégiája) 73 p. URL: http://energiaklub.hu/dl/kiadvanyok/fes.pdf. Downloaded: December 2012.

Energy 2020 – A strategy for competitive, sustainable and secure energy. Brussels, 10.11.2010, COM(2010) 639 final, communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions,{sec(2010) 1346}. URL: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52010DC0639:EN:HTML:NOT.

Eurostat database 2014. Downloaded: January 2014. URL: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database.

Global Footprint Network (2014). URL: http://www.footprintnetwork.org/en/index.php/GFN/page/footprint_basics_overview.

Golusin, M., Ivanovic, O.M., Domazet, S., Dodic, S., Vucurovic, D. (2011) Assessment of the effectiveness of policy implementation for sustainable energy development in Southeast Europe. *Journal of Renewable and Sustainable Energy,* 3. 12 p.

Hertwich, E. G. (2005) Consumption and the rebound effect. *Journal of Industrial Ecology*, 9(1), pp. 85–98. URL: http://www.score-network.org/files//3333.pdf.

International Energy Agency (2004) World Energy Outlook 2004, 577 p. URL: http://www.worldenergyoutlook.org/media/weowebsite/2008-1994/weo2004.pdf.

International Energy Agency (2012) *Key world Energy Statistics*, 82 p. URL: http://www.iea.org/publications/freepublications/publication/kwes.pdfNiemi, G.J., McDonald, M.E. (2004) Application ecological indicators. Annu. *Rev. Ecol. Evol. Syst,* 35, pp. 89–111.

Nordhaus, W.D., Tobin, J. (1972) Is Growth Obsolete? *Economic Research: Retrospect and Prospect*, vol. 5. Economic Growth. 81 p. URL: http://www.nber.org/chapters/c7620.pdf.

Press, M., Arnould, E.J. (2009) Constraints on sustainable energy consumption: market system and public policy challenges and opportunities. *Journal of Public Policy and Marketing*, Vol. 28(1), pp. 102–113.

Róbel, G. (2006) *The black gold* (in Hungarian: A fekete arany). Köz-Gazdaság, 2006/2.

Rohonyi, P. (2007) *Energy(revolution) – The potentials of the sustainable energetic in Hungary in the 21st century* (in Hungarian: Energia(forradalom – A fenntartható energiagazdálkodás lehetőségei Magyarországon a 21. században) Greenpeace Central and Eastern Europe, Greenpeace Magyarország Egyesület, 56 p.

Sebestyénné, Szép T. (2012) *Econometric analysis of the causality directions of the energy consumption and economic growth* (in Hungarian: Az energiafogyasztás és a gazdasági növekedés okozati összefüggéseinek feltárása ökonometriai módszerekkel) Gazdaságtudományi Közlemények, Vol. 6, no. 1, pp. 121–139.

Smil, V. (2008) *Energy at the Crossroads* (in hungarian: Energia-válaszút előtt) KOVÁSZ, pp. 13–32.

United Nations (2004) World population to 2030. Department of Economic and Social Affairs, 254 p. URL: http://www.un.org/esa/population/publications/longrange2/WorldPop2300final.pdf.

Vajda, Gy. (2004) *Energy supply today and tomorrow* (in Hungarian: Energiaellátás ma és holnap). Budapest MTA Társadalomkutató Központ.

World Bank database (2014). URL: http://data.worldbank.org.

World Energy Council (2012) World Energy Trilemma 2012. Energy Sustainability Index 128 p. URL: http://www.worldenergy.org/documents/2012_energy_sustainability_index_vol_ii.pdf.

World Energy Council (2012) World Energy Insight 2012, 36 p. URL: http://www.worldenergy.org/documents/wei_2012_sm.pdf Downloaded: December 2012.

Zhang, N., Lior, N., Jin, H. (2011) The energy situation and its sustainable development strategy in China. *Energy,* 36, pp. 3639–3649.