Energy efficiency and performance indicators of European electricity market

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Abstract: *The electric power system plays a vital role in the development of every country, ensuring the "fuel" which feeds its economic motor. The efficient functioning of this motor is essential for economy. The efficiency and the performances of electric power systems are reflected on the living level of population, through the money spent and the satisfaction level of their needs. The continuity of power distribution process, the good communication between the suppliers and consumers, the promptitude of interventions, the environment protection - all these are aspects characterizing the performance level of power distribution systems. The paper analyzes the evolution of quality indicators of power distribution systems both for countries' level and for population on European market of electricity.*

Key-words: *power system, environment, efficiency, market performance indicators.*

1. Introduction

The Europe 2020 Strategy has as main purpose to attain a smart, sustainable and inclusive growth, and the transition to a resource efficient economy.

Having the same level of economic activity based on less energy inputs, means a technical way to obtain energy efficiency. Saving energy through efficiency, also addresses the reduction of consumption through a behaviour changing, in the spirit of avoiding its waste.

The only way for the security of energy supply is ensuring the energy efficiency. In this way the energy efficiency is considered to be in itself, a big source of generating energy. The energy efficiency can contribute to the reduction of emissions of greenhouse gases and of other pollutants.

The EU legislation for liberalization of energy markets constitutes the legal frame for the action of energy efficiency. The third legislative package in 2007, completed in 2009 with the 20-20-20 targets, has been transposed into national laws starting with 2011. The targets of Europe 2020 Strategy are: to reduce EU

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greenhouse gas emissions of at least 20% below 1990 levels, at least 20% of EU gross final energy consumption and at least 10% of transport final energy consumption to come from renewable energy sources, and a 20% reduction in primary energy use compared to projected levels, to be achieved by improving *energy efficiency*.

2. Objectives

The main objectives of the paper are to present:
– the indicators of energy efficiency of national power systems, as: energy intensity and energy productivity, but also
– the way of considering the consumers' satisfaction as a measure of performance of the electricity on European market.

The analysis of these indicators shows the status of fact in European Union using data until 2012, in correlation with the targets of EU Strategies for future development.

3. Material and Methods

Using the data from Eurostat, the study is divided into two parts: the analysis of efficiency indicators of power systems and the analysis of indicators of energy market performance.

The first part contains the evolutions of efficiency indicators of power systems at European Union level, during the period 2001-2012.

The analyses of the efficiency indicators of power systems are also presented and commented at EU countries level, for the period 2001-2012.

The analysis of share of electricity from renewable sources in gross electricity consumption, of the share of renewable energy in the final energy consumption, and of the share of electricity consumption of households in the electrical energy consumption – all these aspects emphasize the efficiency of energy production.

The second part of the study analyzes the evolution of electricity consumption in households, at EU level, during 1990-2012, and at EU countries level, in 2012.

Monitoring the performance markets indicators includes also the electricity market at national level and at European Union level.

Modelling the perceptions of customers for the electricity market of EU, conduct to few models of consumers' satisfaction about electricity market, in 2012, at European Union level.

4. Results and Discussions

4.1. Energy efficiency indicators in European Union during 2001-2012

An indicator for measuring the energy efficiency is the *energy intensity*. It is obtained dividing the gross inland consumption of energy in kilograms of oil equivalent (kgoe) to GDP in constant prices of year 2000. The unit measure of energy intensity is kgoe per EUR 1000. This indicator should decrease if the economy has performance.

Using the data from Eurostat, the calculated average changing rate of energy intensity is negative for all the European countries, for the period 2001-2012.

The chart in Figure 1 shows the level of energy intensity in 2012 and the countries positions in 2012, depending on their potential of decreasing, during the period 2001-2012.
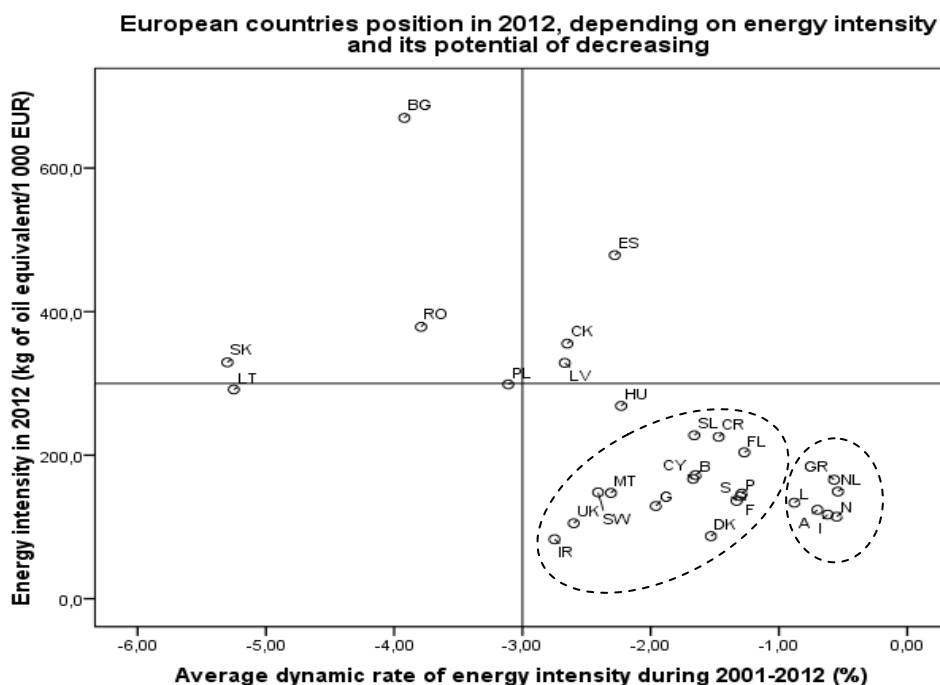

Fig. 1. *Energy intensity in European Union and Norway, in 2012*

The countries' position shows their effort in reducing the energy intensity, saving energy for each 1,000 Euro of GDP.

The countries from the fourth frame have low levels of energy intensity in 2012. Ireland, Denmark, United Kingdom, Germany, Malta and other countries form a group with low energy intensity. Here is another group formed by Austria, Italy, Norway, Netherlands, Greece and Luxembourg also with low levels of energy intensity, but without making efforts to decrease it.

But it is important to mention that the structure of economy is very important. There are economies with low energy intensity due to the lack of industries, which are highly energetic consumers.

The intersection of axes meets the means of both variables: energy intensity on OY axis and the annual average rate of changing on OX axis.

The countries from the first and the second frame are placed over the mean level of energy intensity for the analyzed countries in 2012. These countries are later entered in EU: Estonia, Czech Republic, Latvia and Poland, Romania, Bulgaria and especially Slovakia and Lithuania – the last two countries have made huge efforts to reduce the energy intensity during 2001-2012.

In Figure 2, it is presented the evolution of energy intensity for the EU 28 countries, including Croatia, during 2001-2012.
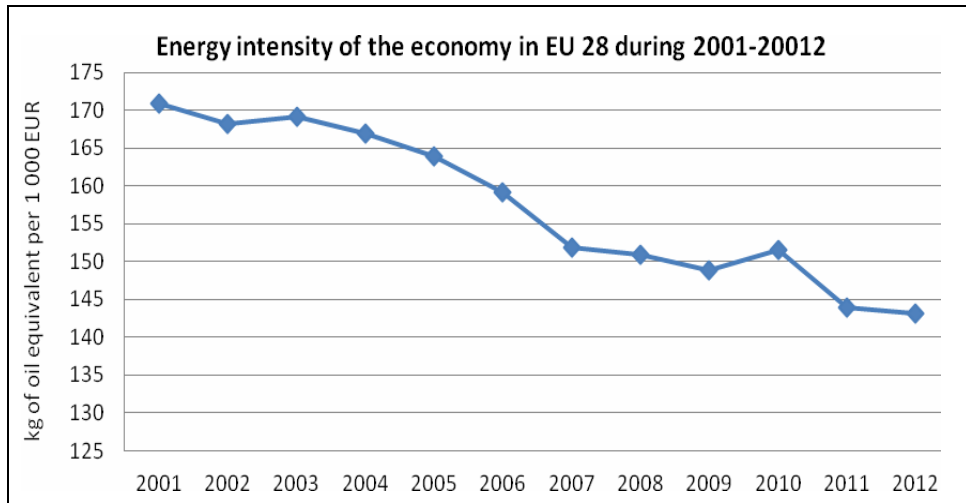

Fig. 2. *The decreasing evolution of energy intensity at EU level, during 2001-2012*

The effect of economic crisis can be seen on the chart in 2010, when the level of energy intensity increased, and then in 2011, when its decreasing tendency continued.

Energy productivity is an indicator of energy efficiency which is the inverse of energy intensity; dividing the GDP in million EUR or million Purchasing Power Standard (PPS) by gross inland consumption of energy in thousand tonnes of oil

equivalent. The unit measure can be either EUR per kg of oil equivalent or PPS per kg of oil equivalent.

The inverse correlation between the two indicators will show the increasing of energy productivity during 2001-2012, in Figure 3.
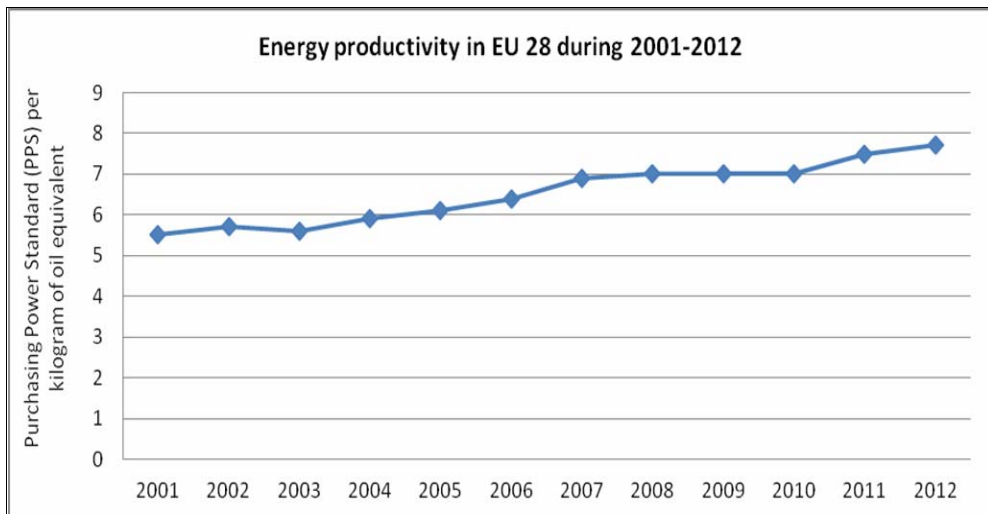

Fig. 3. *The evolution of energy productivity at EU level, during 2001-2012*

The energy efficiency supposes the efficiency use of natural resource and the environmental protection.

Energy saving ways are: renovation of public and private buildings, development of heat products with energy performance of the components. Introducing an energy efficiency criteria in public spending and for utilities is an effective way of saving energy. The transport and industry have energy efficiency requirements for industrial equipment. Introducing the energy audits and energy management systems for SMEs may improve the efficiency of power and heat generation.

The economic performance of each country must be considered for the target of renewable energy, because the development of energetic sector starts from different levels.

Figure 4 presents the share of renewable energy in the gross final energy consumption, the share of electricity from renewable sources in gross electricity consumption and the share of electricity consumption by households in electrical energy consumption.
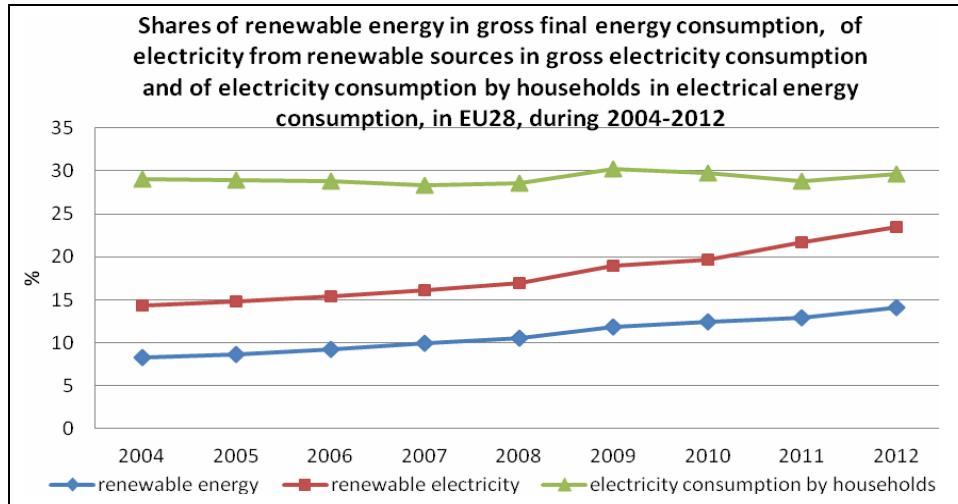
Fig. 4. *Shares of renewable energy and electricity, in EU during 2004-2012*

Share of electricity from renewable sources in gross electricity consumption are greater than the share of renewable energy in the final energy consumption, but the share of electricity consumption of households represents around 30% from the electrical energy consumption.

4.2. Electricity consumption in households of EU countries, during 1990-2012

The households consumption can vary as result of a range of factors, which can be clasified in:
- personal factors: monthly income, number of family members, habits, education level;
- national level factors: culture, structure of economic activities, labour productivity, degree of technologisation of industries, degree of dependence on imports, urbanisation degree, proportion of rural/urban, weather, geographical position;
- other factors of conjectural nature: economic international competition, liberalization of energy market at European Union level, globalization process.

A proportion of 20-31% of total household consumption expenditure is spent for housing, water, electricity, gas and other housing fuels. The evolution of electricity consumption of households in the countries of EU, during 1990-2012, is presented in Figure 5.
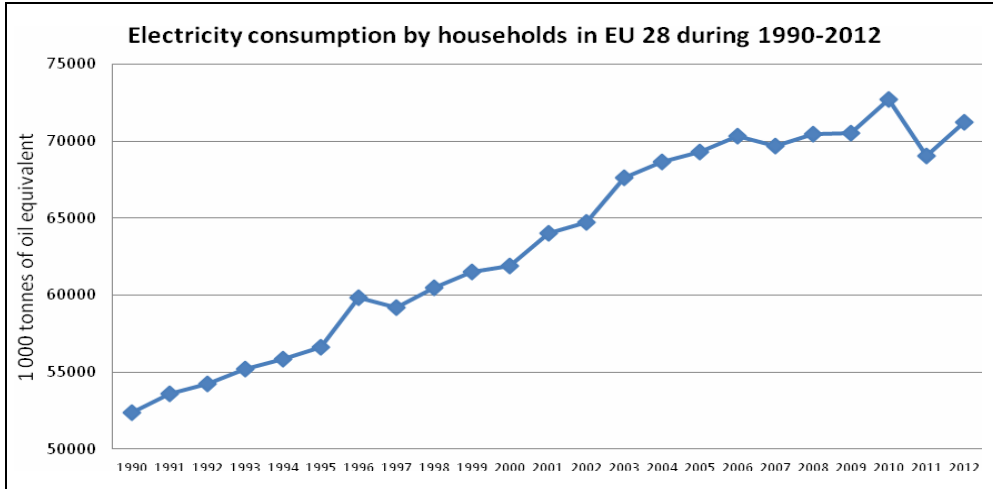
Electricity consumption by households in EU 28 during 1990-2012

Fig. 5. *Electricity consumption of households in EU28, during 1990-2012*

Analyzing the level of electricity consumption of households for the countries of European Union, Norway and Iceland, in 2012 and the potential of development during 2004-2012, it results the chart from Figure 6.
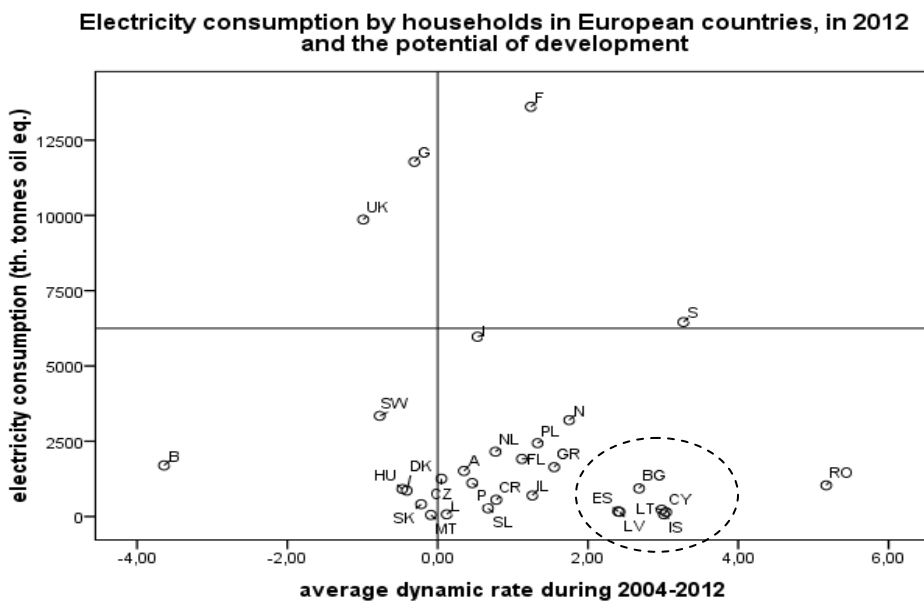
Electricity consumption by households in European countries, in 2012 and the potential of development

Fig. 6. *Level and potential of EU electricity consumption of households*

There are well developed countries with higher numbers of population, such as France, Germany, United Kingdom, Spain, which have high levels of households' electricity consumption. The average rate of changing the households' electricity consumption in Spain is more than 3% per year. In Germany and United Kingdom, the annual decreasing rate shows that the population is making efforts for saving electricity.

Belgium, which is a small country, also has saved electrical energy of households. At the other end, it seems that the households in Romania are not preoccupied by the electricity saving. But the truth is of other nature. Romania is placed at the same level of electricity consumption with the group of small countries: Bulgaria, Estonia, Cyprus, Lithuania, Latvia and Iceland, which have dynamic rates between 2% and 4%. But in Romania the living standard of households is still undeveloped as compared to the other countries.

A deeper analysis can show that some countries are great producers of electrical energy. Also, the patterns of obtaining electricity from nuclear energy plants, power stations using combustible fuels (natural gas, coal and oil), and electricity generated from solar and wind turbines - can offer interesting conclusions.

4.3. Analyzing the consumers' satisfaction about electricity market, in 2012

Starting with 2010, EU assesses the performance of goods and services' markets. There were organized monitoring surveys of consumer markets to ask the opinion of consumers from EU, Iceland and Norway about the 51 markets' performances.

The assessments are very different between countries, not only because of market performance but also because of cultural and economic differences of consumers. Their expectations are influenced by the education, age, gender, the confidence in national policies of government, movements of prices, unemployment etc. The purpose of monitoring surveys is to find the functioning ways of markets for ensuring the outcomes desired by consumers.

The questionnaires for each market have contained mostly the same eight questions respecting the following aspects:

- comparability - refers to the ability of consumers to compare the outcomes of the different suppliers on the market; it comprises comparisons of price and quality;

- trust – refers to the confidence accorded to suppliers, existing rules, regulations and organization actions for the consumers' protection;

- consumer problems and complaints – they count the occurrences of problems and their severity, the possibility of complaining and the results of the complains;

- expectations – refers to the satisfied desires of customers;

- choice - means that the customers can choose the providers in a certain market;

- switching – refers to the situation when customers have an on-going contract and how they make a choice for other suppliers.

Last two characteristics: "choice" and "switching" cannot be applied on all the markets. For electricity market even there exists the possibility to choose from more providers, sometimes is difficult because of geographical distribution of electricity companies which have monopoly status for their origin regions. In Romania, for electricity market also "switching" seems to be very difficult.

The answers are receiving marks between 0 and 10; then there are calculated average levels for all respondents, for a certain market. The results are presented as scores in a normalised way, for ensuring the comparability and to eliminate other influences over the Market Performance Indicators, MPI.

The MPI scores are normalised to the average score of the analyzed market, whereby the average score equals 100 and it is named nMPI. Some markets may have a better performance than the average of all markets in their respective group and so they can receive more than 100. The markets under the average level, receive a score below 100.

The base of comparison is important to be considered. When analyzing all the markets in a certain country, the normalization operation will be to the average of all markets within that country and when there is analyzed a single market at EU level, the average will be for all the countries having that market. In different points of view the MPI scores of a market can be different depending on the areal criterion.

The MPI is a measure of the extent to which the market responds to the desires of its customers. It is calculated as a composite index including the four key components: "comparability", "trust", "problems and complaints", and "expectations". The weight for each component is equal with 1/4. The mean of the answers of all respondents for the characteristics: "comparability", "trust" and "expectations" - is therefore always a number between 0 and 10. The component of "problems and complaints" is calculated based on the answers for problems experienced and for the complaint behaviour.

The nMPI is calculated using the formula: nMPI = MPI – Average MPI +100.

In the report on 2012, the market of electricity services is the 46th in descending order of nMPI scores of the 51 analyzed markets, having nMPI = 96.3.

The MPI for electricity market was obtained based on the nMPI of each EU country, Iceland and Norway. The MPI in descending order is presented in Figure 7.

Trying to modelling the perceptions of customers for the electricity market of EU, we considered the scores nMPI of analyzed countries depending on its influence factors.
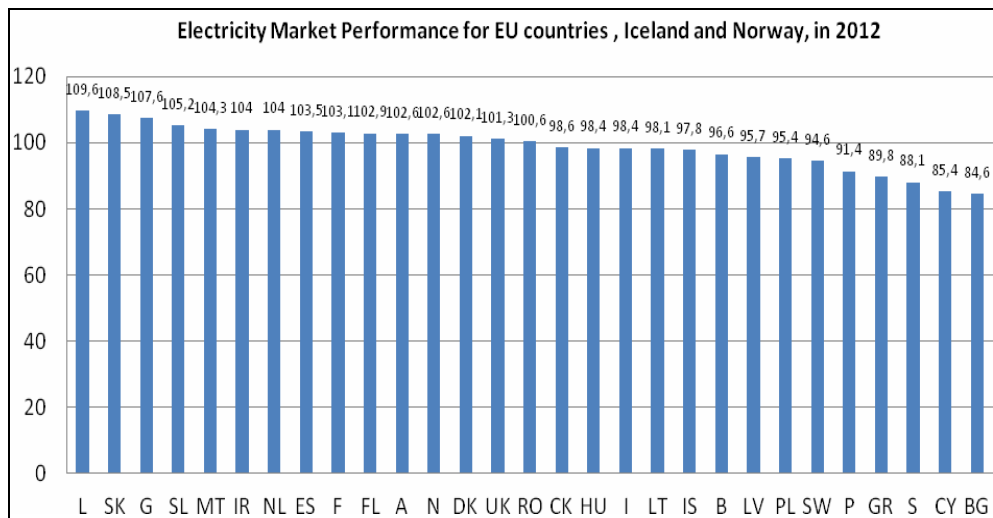
(Source data: ”Monitoring consumer markets in the European Union”, GfK EU3C, 2012)

Fig. 7. *The electricity market nMPI by EU country, Iceland and Norway, in 2012*

It has resulted only one important factor, Overall Life Satisfaction Index (OLSI). The regression equation has the determination coefficient R^2=21.7%:

$$nMPI_i = 79.78 + 3.06 \cdot OLSI_i \text{ , where } i = 1, 29$$
$$(11.16) \quad (2.74) \quad\quad (*) - t \text{ Student, P=95\%}$$

Considering the OLSI as a measure of customers' satisfaction, the obtained multiple linear models are the following:

- $$OLSI_i = 6.84 - 0.461 \cdot r\_cons\_HDI_i - 0.004 \cdot en\_int_i + 0.019 \cdot sh\_renew_i$$
$$(21.55)\ (-2.03) \quad\quad\quad (-3.39) \quad\quad\quad (1.99)$$

(*) – t Student ratio, $i = 1, 28$, R^2=54.03%, for probability P=90%, where:
- $r\_cons\_HDI_i$ = correlation coefficient between the electricity consumption of households and Human Development Index (HDI) during 2005-2012, for each country, *i*. It signifies the measure of correlation showing how electricity consumption contributes to HDI;
- en_int_i = the energy intensity for each country (kgoe per 1,000 EUR);
- sh_renew_i = share of renewable energy in gross final energy consumption (%), for each country.

- $$OLSI_i = 7.62 - 0.241 \cdot r\_avg\_cons_i - 0.46 \cdot r\_cons\_HDI_i - 0.005 \cdot en\_int_i$$
$$(27.23)\ (-2.96) \quad\quad\quad (-2.26) \quad\quad\quad (-4.52)$$

(*) – t Student , $i = 1, 29$, R^2=60.4%, for probability P=95%, where:

$r\_avg\_cons_i$ = the annual dynamic rate of electricity consumption of households during 2005-2012, for each country.

The econometric modelling has used also other indicators, as: the electricity prices in EUR per kWh, share of electricity generated from renewable sources expressed as % of gross electricity consumption, the energy productivity in PPS per kgoe and HDI. But the two models presented above were the only significant.

5. Conclusions

The analyses presented in this study can contribute to the evaluation process of the state of energy indicators, efficiency of energy consumption, sources of energy producing, environment protection, consumers' satisfaction and energy market performance.

The paper presented some statistical coordinates about the energy efficiency in the European Union, in the last decade. Statistical methods to analyze the electricity consumption in the households of EU countries, during the period 2004-2012 revealed aspects about the positions of countries depending on their development potential, the trends of renewable energy share and share of electricity generated from renewable sources.

The satisfaction of customers is subject to monitoring each year.

Modelling of the evolution of market performance indicators cannot be validated only with data of three years for the period 2010-2012.

Monitoring the satisfaction of customers on the electricity market can be a good estimation for the well-being of population.

All these aspects are the bases of attaining the EU targets, established by its strategies.

In January 2014 the European Commission established energy and climate objectives for 2030. The targets are: 40% cut in greenhouse gas emissions, compared to 1990 levels and at least a 27% share of renewable energy consumption. For energy efficiency it was not established any specific target.

In order to attain a low-carbon economy and energy system, EU prepares forecasts until 2050. These targets have strategic importance to ensure a competitive and sustainable economic growth in the future.

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