

Electricity Consumption and Associated Risks in European Countries - Convergence Analysis

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Abstract. Demand for electricity increases with economic development. At the same time, it is expected to provide the cleanest energy. This paper attempts to analyze the convergence of electricity consumption in European countries, reduce transmission losses and reduce the pollution associated with it - CO₂. In the presented research European states were taken into account. All countries and individual European Union and non-EU unions were analyzed. The study used descriptive statistics and B-Convergence analysis. The aim of the study was to compare changes in these variables in the EU Member States and non-affiliated countries. The results indicate in general terms the convergence of both energy consumption and CO₂ emissions reduction. Specific studies indicate that non-EU countries have no convergence in terms of energy consumption and reduction in transmission losses. The only significant convergence of CO₂ emissions concerns. This may be due to financial constraints that inhibit the efficiency of the tested energy systems.

1. Introduction

Permanent economic development, which is observable and increasingly common [1] on the one hand triggers other actions, on the other hand is determined by certain limitations and emerging opportunities. Among the opportunities mentioned above are the innovations accompanying humanity from the dawn of history, improving the work and improving the quality of life. It should be noted that in the long term, improvement of quality of life, increase of wealth of societies, prolongation of life and increase of population are observed. There are also opportunities for cultural and social change in different groups, but they are secondary to innovation. Development constraints are usually resource-based. In the production process, capital, labor, land and scientific and technological progress are usually mentioned as resources. Contemporary labour is not only about people but also about their knowledge, skills, and experience. Obviously, in parallel, it is important to remember that performing work involves the use of existing solutions, technology and equipment. In turn, due to the commitment of adequate amount of capital and use of technical progress, they are continually modified and improved in the area of efficiency and / or optimization of the profit effect for entrepreneur. At the same time, wealth of societies is growing due to the increase in wages (in the ideal model) reflecting the payment for competences. Wealth also grows in less quantifiable dimensions, due to the ease of work and daily living resulting from the use of modern equipment, which also results in increased free time, consumption of which generates further demand shifts and development especially in the service sector. As a result of specialization, we have at every stage emergence of new industries and services



that in many cases bring people into their day-to-day operations. With this development, importance of using new devices is growing. These devices are powered by energy they consume. So it seems natural that increase in consumption of electricity - especially in highly developed countries is observed. These include among others European countries. Given their high level of integration and relatively similar development, it can be argued that the level of electricity consumption in these countries should be similar. This paper attempts to analyze the convergence of electricity consumption in European countries, reduction of transmission losses and reduction of pollution associated with it - CO₂. The data used in the analysis come from the World Bank [2].

2. Basic aspects of electricity management

The reduction of electricity resources is related to several issues. The first is access to electricity. The main sources today are: hard coal and lignite, gas, nuclear reactors, wind turbines and water turbines, photovoltaics. Especially in the last types of activity is seen the hope of engaging prosumer [3].

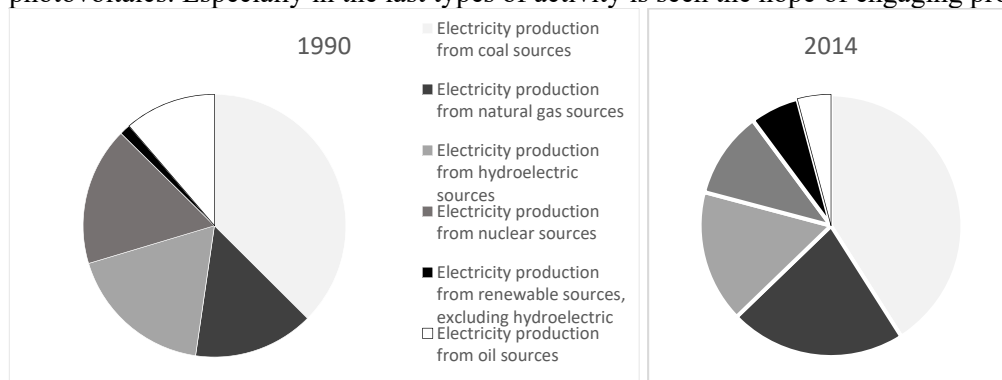


Figure 1. Electricity sources in Europe in 1990 and 2014 year.

In the case of lignite energy, one of the main constraints is the distance from power generating plants to sources of extraction - due to limited transport capacity. In the case of hard coal - increasing costs of getting out of ever deeper decks. In both cases we also face the problem of mining damage and environmental degradation. To make matters worse, the production of electricity from fossil fuels is associated with the combustion process, and thus the emission of many harmful substances into the atmosphere, among which are the following: sulphur dioxide SO₂, nitrogen dioxide NO₂, carbon oxide CO, benzene C₆H₆, ozone O₃, dust PM₁₀, lead Pb in PM₁₀, arsenic As in PM₁₀, cadmium Cd in PM₁₀, nickel Ni in PM₁₀, benzo(a)pyrene B(a)P in dust PM₁₀, dust PM_{2.5}[4]. In Europe, under the many regulations [5] [6] [7], the largest polluters pay higher energy production costs due to contaminated production. This results in a reversal of the carbon-based energy policy of the [8] in some countries. However, globally, the role of coal-based energy is growing steadily and its current share in total electricity production is as high as 40.7%. The second source is natural gas with a significant increase in share (by 46.5% between 1990 and 2014), which now accounts for 21.6% of electricity production. Another place is hydro energy - here we are dealing almost with supply saturation. Possible new investments and more efficient technologies are not able to keep pace with rising demand. In the case of nuclear energy, we are seeing a marked decrease in overall production from 16.9 in 1990 to 10.6% in 2014. Dangers of nuclear power failure can lead to increased concerns about this source of energy and virtually halting the development of nuclear power in Europe. The global economy is constantly looking for solutions that will help optimize the use of existing resources and more cost-effective technology. However, the steady increase in the use of electronics, the increase in the standard of living of societies and the population determines the increase in the consumption of electricity.

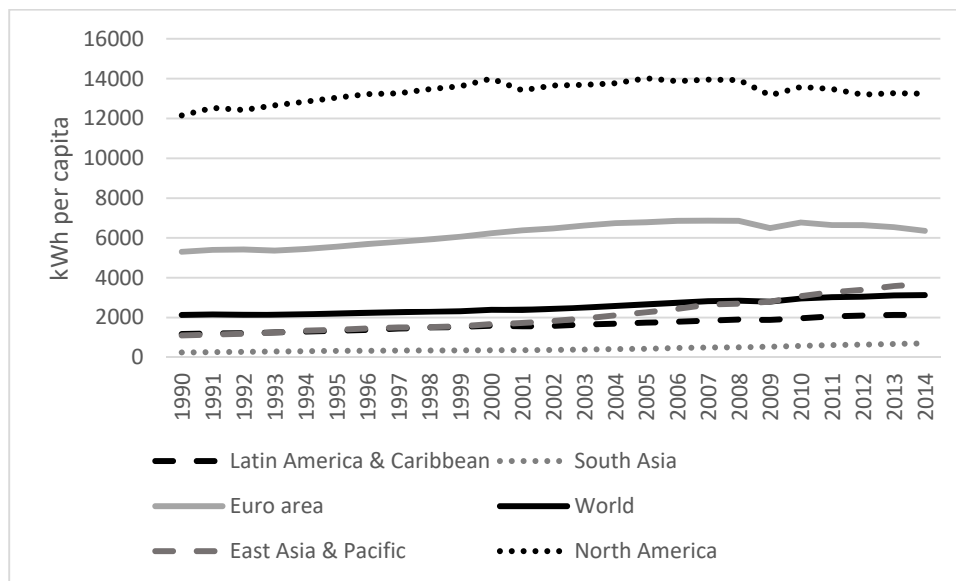


Figure 2. Change of electric power consumption (kWh per capita) in the years 2000-2010 in various parts of the world.

Electricity consumption varies in different parts of the world, but has a common feature (in the long run). Its consumption is constantly increasing. What is important, not only aggregated consumption but also per capita. The largest increase - 5.2% annually was observed in East Asia and Pacific. On average it is 0.4% globally and 0.8% in Europe. Unconsciously, using information technology, using the mass media, extending the working day and activity time, using entertainment, we increase the consumption of electricity. Importantly, current forecasts for the availability of existing liquid fuels resources commonly used to drive transport are not optimistic. Also, motor vehicles tend to use electricity. Therefore, attempts to anticipate the nearest demand for electricity carried out by various government agencies and private are justified.

3. Convergence analysis

By observing the European economy, it is easy to see some differences between their levels [9]. One would assume that economic leaders are treated as some sort of pattern for others. The weaker economies (most of which functioned at the end of the twentieth century in the Eastern Bloc) still stand out from the leaders, although the possibility of very rapid growth is evident - especially in the early stages of market economy implementation. In practice, we see three groups of states in Europe: economically developed (most of the "old" members of the EU and associated countries in the European Economic Area), developing continually - mainly new members of the European Union and countries where the road to development is open. In this respect, further analyzes were carried out taking into account the division of states.

Table 1. Convergence of electric power consumption (kWh per capita) in EU countries and broken down into groups of countries.

country grup measure	44 countries	EU 28	15 „old” EU + 3 EOG	EU „new” 13	others
θ	-3,232	-0,579	-0,760	-1,497	-5,042
β	0,012	0,002	0,004	0,012	0,048
p	0,002	0,567	0,458	0,163	0,000

With regard to consumption of electricity per capita, we see a clear convergence across Europe ($\beta = 0.012$, $p = 0.002$). However, when analyzing irrelevant convergence in the European Union countries with significant and very clear in other countries ($\beta = 0.048$, $p < 0.001$), it must be acknowledged that it is a result of catching up (in economic sense) of the Union countries on the part of other European countries. In 2014, the average electricity consumption per capita was 8397kWh in the European Union and EEA, but this was overstated by Sweden, Finland, Norway and Iceland for an average consumption of 26,391 kWh. Average for other EU Member States is 5731 kWh per person. Member States (old) are characterized by consumption at 6785 kWh with an average of 4597 for new members. Other countries are characterized by consumption at an average of 3849 kWh per person. Clearly higher consumption in northern states is due to the length of the day and the need for lighting and average daily temperatures, which also determine the consumption of electricity by both residents and industry. It should be noted here that especially the states located in the Scandinavian Peninsula are characterized by a high level of economic development, which at the same time results in an increased consumption of electricity from the economy. Consumption also affects the habits and wealth of the people, climate, geographical location, etc.

Convergence in the field of electricity management is more clearly seen in the factors that the energy producer directly affects. Such factors include electric power transmission and distribution losses.

Table 2. Convergence of electric power transmission and distribution losses in EU countries and broken down into groups of countries.

country grup measure	44 countries	EU 28	15 „old” EU + 3 EOG	EU „new” 13	others
θ	-2,268	-2,165	-2,209	-1,129	-2,155
β	0,016	0,024	0,027	0,025	0,029
p	0,029	0,039	0,042	0,283	0,054

In the case of electric power transmission and distribution losses, we see a clear convergence on almost all levels. The strongest is seen in the most developed countries ($\beta = 0.027$, $p = 0.042$). The convergence level recorded in the "new" 13 and non-member states was not considered statistically significant. Closer analysis shows, however, an ambiguous situation.

In the "old" EU Member States, the annual growth rate of the electric power transmission and distribution losses below 0.5% is observable among five countries, the highest observed in Netherlands +0.39%. In other countries we observe the electric power transmission and distribution losses decline, including three significant ones: Denmark -1.8, Luxembourg -3.4, Iceland -4.7. In the "new" 13 we observe quite large decreases in electric power transmission and distribution losses - in ten countries – of which 7 are higher than 1% annually, the strongest in Slovakia -4.6%. However, three countries break down here: Estonia - growth of 0.1%, Romania - growth of 0.7% and Lithuania - growth of as much as 6.0% a year. Hence the lack of convergence in this group. The situation in the group of non-member countries is even more diverse. We observe either the electric power transmission and distribution losses - 7 countries with the strongest decrease in Montenegro -4.7% and countries with significant growth - 6 countries with the strongest growth in Moldova + 4.5%. This is largely due to the way the system is managed. These countries mostly use old transmission lines and older technologies. In the case of those that have already implemented changes in the system, we are seeing an improvement, while the rest of the older infrastructure is generating more and more losses. Older infrastructure is also often accompanied by higher emissions of harmful substances.

Table 3. Convergence of CO2 emissions (kg per 2011 PPP \$ of GDP) in EU countries and broken down into groups of countries.

country grup measure	44 countries	EU 28	15 „old” EU + 3 EOG	EU „new” 13	others
θ	-5.156	-4.468	-1.652	-1.854	-4.382
β	0.021	0.021	0.013	0.019	0.041
p	0.000	0.000	0.118	0.091	0.002

In terms of CO₂ emissions, there is a clear convergence in the European countries ($\beta = 0.021$, $p < 0.001$), in the European Union ($\beta = 0.0217$, $p < 0.001$) and non-associated countries ($\beta = 0.041$; $p = 0.002$). It is the result of general care to reduce the amount of emitted pollutants, mainly due to regulations. EU directives impose penalties on Member States if certain levels of emissions are exceeded and international standards (not just EU ones) are aimed at limiting global pollution. Of the 44 countries surveyed, only Bosnia and Herzegovina saw an increase in emissions in the years 1990-2014 by 0.3% per year. In all others we observe a decrease in emissions, and in 32 countries higher than 1%, of which 16 is more than 3% annually. Current CO₂ emissions (kg per 2011 PPP \$ of GDP) are 0,200 on average for the European Union, 0,165 for the old 15 + EEA countries and 0,250 for the new 13. The level of pollutant emissions for the other states is significantly higher and in 2014 was on average 0.391 (kg per 2011 PPP \$ of GDP). In this aspect, we are dealing with a very unfavorable situation. By assuming higher electricity consumption with the development of these countries, we can also expect higher emissions. So nowadays, the authorities of these countries should endeavor to introduce appropriate environmental standards and emission reduction technologies, including CO₂. However, it should be noted that such activities are undertaken. Average emissions in 2000 for the old Member States were 0.232, for the new 13 0.397 and for the remaining 0.637. It is therefore clear that emissions from all groups of countries are reduced. This is all the more important in the case of the old 13 states, a decrease in CO₂ emissions of 29% was accompanied by an increase in energy consumption by 12%, for new 12 countries, a 37% decrease in new CO₂ emissions was accompanied by increase of 24% of energy consumption, and for non-associated countries a decrease in CO₂ by 39% was accompanied by an increase in consumption of electricity by 38%. This is a very clear indication of the policy pursued in almost all countries aimed at reducing the nuisance of electricity production processes.

4. Conclusions

When analyzing data on electricity consumption in European countries, apart from the noticeable increase in consumption, environmental care is also recognized. Despite the ever-increasing consumption, the fastest rate in the countries undergoing structural changes, the level of emissions of harmful substances - especially CO₂ - is constantly decreasing. Convergence is generally observed in terms of electricity consumption, CO₂ emissions (in a positive sense) and ECDTL minimization. However, in detail, it turns out to be the largest, permanently unresolved problem, especially for less developed countries. This is likely not only due to the shortage of funds, but also to the problems of repair or replacement of existing infrastructure during its use.

5. References

- [1] Piłatowska M Włodarczyk A Zawada M 2015 CO₂ Emissions, Energy Consumption and Economic Growth in the EU Countries: Evidence from Threshold Cointegration Analysis (2015 12th International Conference on the European Energy Market (EEM), Lisbon) pp 1-5
- [2] <https://data.worldbank.org>
- [3] Kucęba R Bylok F Pabian A Zawada M 2014 Prosumer Energy Dimension in the Conditions of Sustainable Micro-region Development in the EU (ICSSAM, International Conference on Social Science and Management. ISEPSS. International Symposium on Education Psychology and Social Sciences May 2014 Kyoto Japan Conference Proceedings) pp 1040–1051
- [4] Zawada M and Szajt M 2016 Analysis and Evaluation of Air Pollution Level in Czestochowa in the Years 2012-2015 (Acta Oeconomica Cassoviensia Vol 9) pp 14-28

- [5] The Directive of the European Parliament and the Council 2004/107/WE of 15 December 2004 on arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in the air (O. J. EU L 23 of 26.01.2005) p 3
- [6] The Directive of the European Parliament and the Council 2008/50/WE of 21 May 2008 on air quality and cleaner air for Europe (O. J. EU L 152 of 11.06.2008) p 1
- [7] The Council Implementing Decision 2011/850/WE of 12 December 2011 setting the rules for the use of directives 2004/107/WE & 2008/50/WE of the European Parliament and the Council with regard to a system of information and reports exchange on the air quality (O. J. L 335 of 17.12.2011) pp 86 - 106
- [8] <http://www.bbc.com/news/uk-england-york-north-yorkshire-35803048>
- [9] Zawada M 2007 Economic Development and Electric Energy Consumption in the European Union Countries-Copmarative Analysis (Acta Universitatis Lodziensis Folia Oeconomica nr 212) pp 259-272