Forecast of Energy Intensity Indicators for Polish Industries

Marek Kott
Institute of Electrical Power Engineering
Wroclaw University of Technology
Wroclaw, Poland
marek.kott@pwr.wroc.pl

Bogumila Wnukowska
Institute of Electrical Power Engineering
Wroclaw University of Technology
Wroclaw, Poland
bogumila.wnukowska@pwr.wroc.pl

Abstract. **The most important element in power engineering policy is assure safety delivery cheap energy produced with proecological sources of energy. One of the ways of improvement the energy safety of government is reduce energy-consuming industry, which is the biggest consumer electric energy Forecasts of energy-consuming factors for power industry and mining industry to allow to plan strategy of development all sector national economy which is industry and improvement the energy safety our country.**

In the paper presented the forecasts of energy-consuming factor for fundamental industry with software using to create econometric models.

Keywords- energy-consuming factor, industry, forecasting

I. INTRODUCTION

Energy has one of the most important roles in the life of society development. It is also essential and necessary factor in the implementation of any business. The most prized form of energy is electricity. The biggest of advantage of electricity is the ability to convert it to any other form of energy (eg mechanical, heat).

Constantly increasing energy needs of state economies, dwindling fossil fuel resources and environmental degradation caused by the extraction of raw materials and stimulate the production of electricity force us to pay special attention to problems of energy policy, and thus on energy security. The European Union is at the stage of implementation of wider regulation of the production, distribution and use of energy. This plan is based on documents called Energy and Climate Package for Europe (in short 3x20 2020). They assume 3 main demands: by 2020 achieve 20% reduction in CO2 emissions, increasing to 20% share of renewable sources (RES) in energy balance and a 20% increase in energy efficiency from the 1990 base year.

Poland has a modern law of energy (Energy Law - the Law of 10 April 1997 and subsequent amendments), corresponding to European standards and objectives of Polish energy policy are part of the priorities of the European Union energy policy. Unfortunately the issue of energy efficiency improvement, thereby reducing the energy consumption of economy in this Act are treated marginally, and are not supported by any record of a policy to allow efficient use of the Law for rational energy use. One of the most important documents in this field is the draft of Polish Energy Policy until 2030. It contains a statement that one of its objectives is to seek without-energy growth, or economic development without growth in energy demand and reduce energy consumption in polish economy by 2030 to the EU-15 level in 2005. In the Government Program for Electric Power was a record saying that an action is to "promote high-tech production and consumption of electricity in order to increase the efficiency of the equipment and reduce energy consumption by establishing appropriate standards and systems of informing the public about energy consumption devices" .[7]

One of the most important sectors of national economy is industry, where there is significant potential for energy savings, estimated at 30.5% (fuel) and 12.6% (electricity) according to the Energy Conservation Center [7]. To effectively implement the provisions of the state energy policy is necessary to define factors affecting energy consumption coefficients of major industries. Coefficient of energy consumption is meant as the electricity consumption for 100 PLN of production sold, allows a comparison between the industry or, looking more broadly, a comparison of the country economic level with other modern economies.

II. POLISH ENERGY SITUATION

From the viewpoint of the industrial branches structure of the industry's, the biggest impact on the energy situation is brought by the power industry which is seen as a manufacturer and distributor of electricity and coal industry coming out coal and lignite.

World coal production continues to increase, mainly due to Asian countries (China, India). However, the fate of coal mining in Western Europe may indicate that the material may be replaced by other energy carriers (renewable energy,

nuclear energy). Extractive industry in Poland is the second largest coal producer in Europe and seventh in the world. The annual production of brown coal in the country is at 60 million tones per year, which gives fourth place on the Old Continent and seventh in the world in terms of production volume. However, despite such a high position in the world, we export only about 14% of annual output of coal (11.9 million tones in 2007). Brown coal is consumed entirely for domestic needs for electricity and heat. It would seem, therefore, that by analogy, coal meets the needs of power stations heated with this fuel. However, in 2008 only nearly 60% of energy was burned raw from the national extractions, the rest came from imports. From a significant producer, Poland is becoming a country where others deposit (export) their carbon, and as the affect of that, the annual production of electricity from imported coal at more than 20%, which reduces the energy security of the country [4,6].

Despite numerous operations, including employment restructuring, capacity reduction by mines closing, procedures for un-debt the mining - debt reduction, organizational and legal changes to create new structure, the profitability of the mining remains consistently low. The energy consumption of production sold in 2007 was 27 kWh per 100 PLN production sold. The main reasons for reducing the demand for coal is a relatively high price of Polish coal, because of, inter alia, difficult mining conditions, elimination of the capacity of old plants with high production costs and very high pro-ecological installation costs and high environmental costs of rail transport.

Power industry is highly dependent on coal as the main energy source. In 2008, nearly 92% of the electricity produced in the country was in power plants fired by coal or lignite. This structure does not change over the last decade, which leads to detriment of the country's energy security in the absence of diversification of energy sources.

Increasing limitation is happening because of outdated technology and specifications of power blocks in Poland. The installed capacity of domestic power is 35 000 MW, for comparison, in Spain more than 63 000 MW, although both countries are characterized by a similar number of inhabitants. Unavailability of generating units in 2008 was at around 15%. The reason for this high rate include failures, current repairs and upgrades. Over 80% of power plants in Poland were built before the year 1987. In order to improve the electric safety there is a necessity for investments in new electricity generation capacity and modernization of power plants. The national electricity industry also faces the problem of insufficient quantity, quality and age lines. Over 80% of the 400 kV transmission lines and 99% of the 220 kV line was built over 20 years ago. Poland is a kind of "energy island". Cross-border mergers do not allow for larger power flows, or on a larger scale exchange. It is necessary to invest in transmission networks and their modernization. Power losses estimated at about 12-15% of power, around 5 000 MW per year. Bad law, lack of funding, many protected areas, such as the European Nature Program 2000, sites and public protests effectively restrict the extension and modernization of power system [4,5,6].

III. ECONOMETRIC MODELING

The process of reducing energy consumption indicators (improvement of energy efficiency) is very complex and multifaceted phenomenon. Econometric modeling makes possible to, inter alia: identify the key factors influencing the energy consumption industries, assess the trends and factors identifiers to improve energy efficiency, provide energy consumption indicators forecasting.

For the purpose of constructing econometric models of factors affecting the energy consumption of industrial production has been divided into three groups:

- the energy-technical factors,
- financial and economic factors,
- social factors.

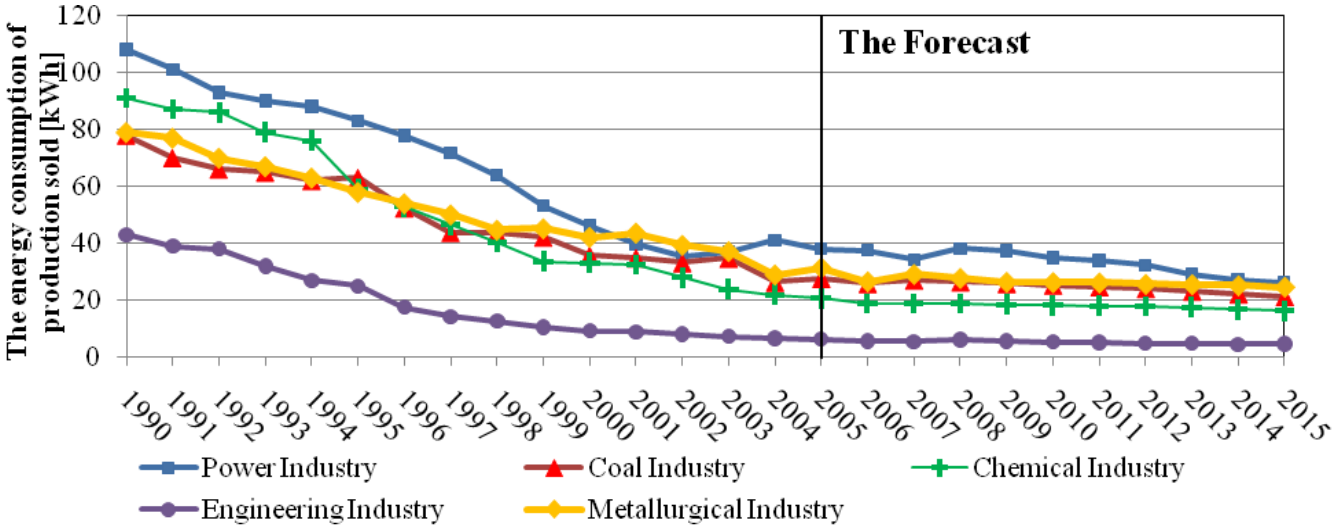

Figure 1. The energy consumption of production sold in chossen branches

The energy-technical factors include, among others, energy balance of production and distribution division of power or balance of power in terms of the whole economy. In recent years, the impact of financial and economic factors is growing. Factors such as the electricity price, capital expenditures and return on turnover have a decisive impact on the finances of every industry. The last group are the social factors such as number of employees, salary or outlays on research and development activities. The European Union has paid increasing attention to the protection of the environment which led to inclusion of the following factors: reduction of pollution, investment in fixed assets for environmental protection. Factors should meet the substantive criteria: ownership of the most recognized phenomena, be precisely defined and allow control through a mutual knowledge of statistical and substantive relationship existing between them and characterized by a compatibility ratio between the number of variables representing a given aspect of the phenomenon and its importance merits [1,2].

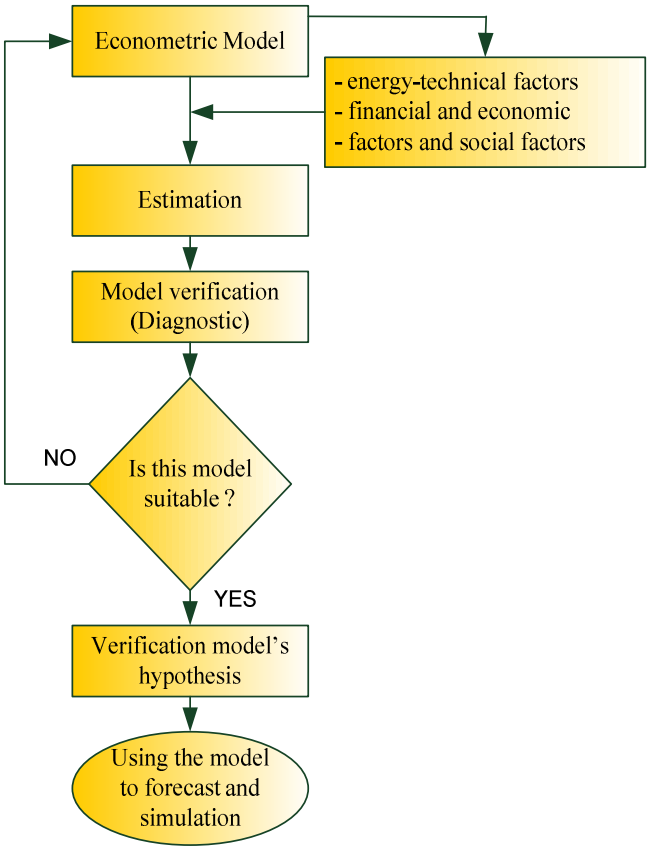

Figure 2. The Diagram of Econometric analysis.

Factors meet the above criteria can be used as explanatory variables in the econometric model. Linear econometric model with many explanatory variables is:

$$Y = a_0 + \sum_{k=1}^{K} (a_k X_k) + \varepsilon \qquad (1)$$

where:
Y – dependent variable,
X_k – k explanatory variable for k = 1, 2 …*K*,
a_0, a_k – structural parameters of the model for k = 1, 2 …*K*,
ε – random component.

To determine the various parameters of the econometric model uses the classical method of least squares. The next steps in the econometric analysis are presented in Figure 2.

To verify the econometric model it was the need to use a number of statistical tests, which was provide by GRETL software, developed at Wake Forest University in North Carolina. Diagnostics consisted of: assessing the coefficient of variation, evaluated the structural parameters of significance (t-Student test, F-Snedecora test), assessing the degree of fit of the model (R^2 determining factor), assessing the normal distribution (Jarque-Bery test), evaluated the linearity of the analytical form model (White test) and assessing the collinearity of dependent variables [3].

Models were constructed for industries that are characterized by at least 6% share in electricity consumption in the entire industrial sector. In 2007, electricity consumption in industry amounted to 81,766 GWh (Fig. 3).

The next stage of analysis was to develop forecasts of energy consumption ratios for selected industries, which has been described in detail and based on the assumptions of balanced growth and trends of the main factors (Fig. 1).

The study shows that the rate of limiting energy consumption factor in in key industries has declined significantly in recent years and forecasts show a fall within the limits of 0,3-1,2% annually over the next five years.

Lack of dynamic changes in energy consumption indicators may adversely affect the objectives of energy policy, which implies without-energy growth.

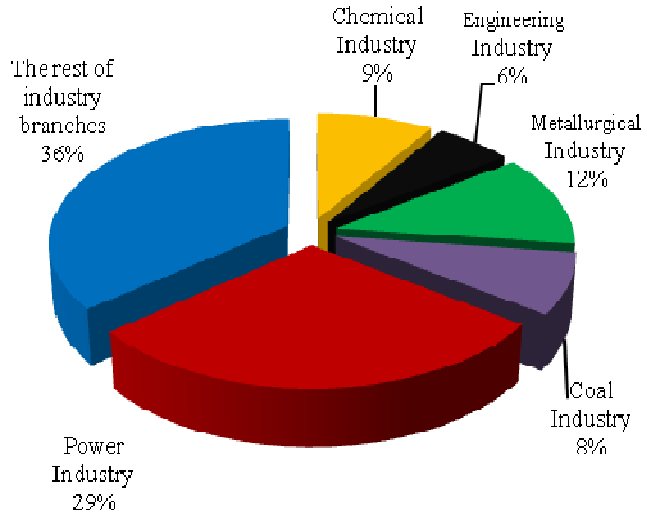

Figure 3. The structure of electric energy consumption in polish industry [6].

TABLE I. THE PARAMETERS OF ECONOMETRIC MODELS

Power Industry			
Symbol	Value	Description	Unit
a_0	146,3	constant	-
a_1	-10,9	Production of electric energy	TWh
a_2	0,58	Electric energy consumption on 1 employer	MWh/person
a_3	-1,87	Gross national product	year 1990=100%
a_4	1,15	Price of electric energy	previous year =100%
a_{5-2}	0,56	Investment means on environment protection	mln PLN
Coal Industry			
a_0	86,7	constant	-
a_1	-0,8	Investment expenditure	previous year =100%
a_2	0,14	Total employment	Thousand of people
a_3	-0,45	Number of centerprises	Year 1990=100%
a_4	1,11	Hard coal production	mln t
Metallurgical Industry			
a_0	46,681	constant	-
a_1	-4,15	Investment expenditure	previous year =100%
a_2	0,58	Sold production	previous year =100%
a_3	-0,28	Participation of export	%
a_4	0,45	Price of electric energy	previous year =100%
Chemical Industry			
a_0	10,32	constant	-
a_1	0,58	Sold production	previous year =100%
a_2	0,56	Investment means on environment protection	mln PLN
a_3	-1,87	Economic value added	year 1990=100%
a_4	-0,8	Investment expenditure	previous year =100%
Engineering Industry			
a_0	3,56	constant	-
a_1	-1.03	Volume of new car production	unit
a_2	1,42	Investment expenditure	previous year =100%
a_3	0,58	Electric energy consumption on 1 employer	MWh/person
a_4	-0,28	Participation of export	%

IV. SUMMARY

The analysis shows that the most energy-intensive industries and the price of electricity have the greatest impact on the electricity consumption in the industry. Restructuring and modernization of key industries will allow conducting a country energy policy in accordance with its objectives.

In recent years, one can notice the fall of energy consuming industrial production factor. It is most clearly visible in the private sector. Polish economy is an excessive contributor to the energy-consuming factor. To limit the energy-consuming factors of Polish industry, one should:

- exchange energy-consuming and material-consuming technologies to modern and energy-saving technologies, especially in heavy industry,
- magnify work productivity with a better organization of production and exploitation,
- introduce a suitable legal-economic settlement, which will promote energy-saving and ecology technologies,
- allow the Polish government to promote, by suitable legal means, saving energy.

One effective way of providing opportunities to improve energy efficiency is known as “Voluntary long-term liabilities”/ It is a mechanism, which is to conclude by the government or local government contracts with industry stakeholders to undertake by them the project implementation resulting in increased efficiency of energy consumed by them. In return, they receive grants, subsidies or financial support, and expert audit, or the reduction of fees for use of the environment.

REFERENCES

[1] Gładysz B., Mercik J.: Modelowanie ekonometryczne. Studium przypadku, (ang. Econometric modeling. Case Study.) Oficyna Wydawnicza PWr, Wrocław, 2007.

[2] Guzik B.: Podstawy ekonometrii, (ang. The Base of econometric) Wydawnictwo Akademii Ekonomicznej w Poznaniu, Poznań, 2008.

[3] Kufel T.: Ekonometria. Rozwiązywanie problemów z wykorzystaniem programu GRETL. (ang. Econometric. Resolve problems with GRETL Software) Wydawnictwo Naukowe PWN, Warszawa 2007.

[4] Janasz W.: Zarys Strategii Rozwoju Przemysłu. (ang. Outline of development strategy In industry) Difin, Warszawa 2006.

[5] Pyk J.: Szanse i zagrożenia rozwoju rynku energetycznego w Europie i Polsce, (ang. The chances and hazard of development energy market in The Europe and Poland) Wydawnictwo Akademii Ekonomicznej w Katowicach, Katowice, 2007.

[6] Rocznik statystyczny przemysłu, (ang. The Industry yearbook) GUS, Warszawa 1996-2008

[7] The Master Plan Study for Energy Conservation in the Republic of Poland, ECCJ, Japan 1999