ANALYSIS OF ROMANIA'S ENERGY MANAGEMENT FROM 2000 UNTIL TODAY

Margit Csipkés, Sándor Nagy, Tímea Gál
University of Debrecen Faculty of Sectoral Economics and methodology Department of research methodology and Statistics Debrecen, Hungary
csipkes.margit@econ.unideb.hu
nagy.sandor@econ.unideb.hu
gal.timea@econ.unideb.hu

Abstract: *The aim of energy management is to provide good quality and proper quantity energy in an economic and continuous way for the energy consumers in different parts of the country with minimal energy costs. We did our calculations because many changes happened during the last 15 years in the energy management of Romania. Year by year the percent of the import energy is increasing. Most of the energy is produced by nuclear, hydro and thermal plants. Looking at the year 2016 in the energy production of Romania the most dominant is the coal and gas usage to produce electric energy in thermal plants. In this paper we wanted to look through the energy management of Romania both in the field of conventional and renewable energy sources based on different aspects. In our research we have made several forecasts considering the consumption and production. In this paper we have reviewed the Romanian energy management from 2000 until recently, since a continuous change can be seen in the energy management of Romania. In the analysis descriptive statistics, dynamic indices and polynomial trend values were used. At the calculations many databases were taken into consideration. For some of the analysis we used the data found on Transelectrica. Besides, we used the data of BP Statistical Review of World Energy and their descriptions. In case of Romania we also utilized the governmental strategies, professional political materials, action plans and different professional studies as well. In the course of our research we used long time series in which the component effect of the time series must be filtered out, so it had to be 'smoothened'. There are two methods for this: the method of moving averages and the analytical trend calculation. We chose the analytical trend calculations (polynomial trend function) based on the proper fitting.*

Keywords: *energy management; electricity; primary energy; energy production; energy consumption; Romania.*

JEL classification: *Q4.*

1. Introduction

In general, energy use can be interpreted on service and household levels where we can differentiate fuel usage, heat and electric energy usage. The heat and electricity has the highest significance in the households. Thermal energy is produced by de-allocating the materials' chemical energy which can happen depending on the technology at the place of usage or centrally in the thermal power plants. In contrary, electricity is the most popular energy form because of its favourable use and

transportation characteristics. Usually it is produced in electric power plants in industrial size.
Forms of energy can be separated into 6 groups according their everyday use: mechanical, heat, light, chemical, electric and nuclear energy. In the process of energy supply the energy is transmitted by the energy sources (primary and secondary energy sources). Primary energy sources are the coal, oil, gas and renewable energy sources (the most significant is the biomass, by-products of forestry and agriculture mainly). Among the renewable energy sources solar, wind, water and geothermal must also be mentioned, however, the amount of these compared to the total energy use is minimal. It can be stated that energy sources produced by the conversion of primary energy sources are called secondary energy sources.
In our research we examined Romania's energy management which analyses the rate of the produced energy, the imported energy, the exported energy and the used energy compared to each other. Energy management on the level of companies and national economy shows how much and what kind of energy is used or with the given energy use how big is the production and the production value (Barótfi et al., 2007).
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2. Material and method

At the calculations many databases were taken into consideration. For some of the analysis we used the data found on Transelectrica. Besides, we used the data of BP Statistical Review of World Energy and their descriptions. In case of Romania we also utilized the governmental strategies, professional political materials, action plans and different professional studies as well.
In the course of our research we used long time series in which the component effect of the time series must be filtered out, so it had to be 'smoothened'. There are two methods for this: the method of moving averages and the analytical trend calculation. We chose the analytical trend calculations (polynomial trend function) based on the proper fitting.
In the basic case, it is supposed in the analytical trend calculations that the permanent trend (increase/decrease) can be plotted by some analytically descriptive function (linear/non-linear).
The applied polynomial trend curve can be used in case of fluctuating data. The polynomial trend curve is determined by the number of data fluctuations and the arcs on the curve (hills and valleys). If a curve has one hill or valley, the quadratic polynomial trend line must be applied. Among the p-polynoms we know and use the parabola most.
If there are one or two valleys/hills on the curve, cubic, if there are three valleys/hills, cyclic polynomial trend curve must be applied. The general formula of polynomial trend line (based on the method of least squares) is the following: $y = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + ... + \beta_p t^p + \varepsilon_t$ where β can be considered as constant.

The reliability (and the strength of the statistical relation) of the trend line can be assessed by the value of R^2 (discrimination equivalence). The value of R^2 can be between 0 and 1 which shows how close the estimated values are to the real data of the trend line. The trend line is the most reliable when the value of R^2 is 1 or very close to it. If the value of R^2 is above 0.7, it shows strong statistical relation between two variables. If the R^2 value is between 0.5-0.7, it is mid-strong, between 0.3 and 0.5 the relationship is weak. If the value of R^2 is under 0.3, it is not worth talking about statistical relations at all.

2.1 Energy management of Romania

The most important raw materials of energy production are the primary (fossil) energy sources. Primary energy sources are those energy sources which contain chemically, physically or nuclear, renewable or non-renewable energy (Energy, 2017).

According to another definition, the fossil (petrified) energy sources were created by vegetal and animal remains under airless conditions during millions of years (I1). Their advantage is that their energy density is high and they contain mostly coal and hydrogen compounds. These can be solid (coal, lignite), liquid (oil), or gaseous (field gas).

Whatever definition is followed, the most significant fossil energy source is the coal in the world now.

Considering the energy production of Romania, there are fossil and nuclear fuels (coal, oil, gas and fissile materials) and the renewable energy sources and waste are also present in the energy production. In the examined period (and also before that) gas and oil have the highest significance. These two materials come out at almost 50% of the total energy production every year.

It is interesting that compared to other European Union member states data are expressed in oil equivalence in Romania (10000 kcal/kg). Oil equivalence is the measurement for energy which gives the quantity of raw oil to be burnt for producing a given amount of energy.

2.2 Energy production of Romania

If we take a look at the rate of primary energy sources, it can be stated that the highest rate had the gas (25-30%) in Romania which only slightly overcame the oil in the second place. Considering the time series data, we can say that while in 2002 the rate of fossil energy sources was more than 80%, it decreased to 68% in 2015. From 2000 to 2015 it means 6.44% decrease.

It is important to notice that the renewable energy sources have higher and higher significance in the energy production. Renewable energy sources are those sources which do not run out but reproduce during their use (solar, wind, geothermal energy, wave, tide or water energy, biomass, energy produced directly or indirectly from biomass, furthermore, gas from landfill and sewage treatment plants, and biogas). With their use the environment is not polluted and the energy stocks of the Earth is not decreasing. Alternative plants are those which produce energy from alternative energy sources. Nowadays, the most widely used renewable energy source is the water in Romania, and then the wind energy.

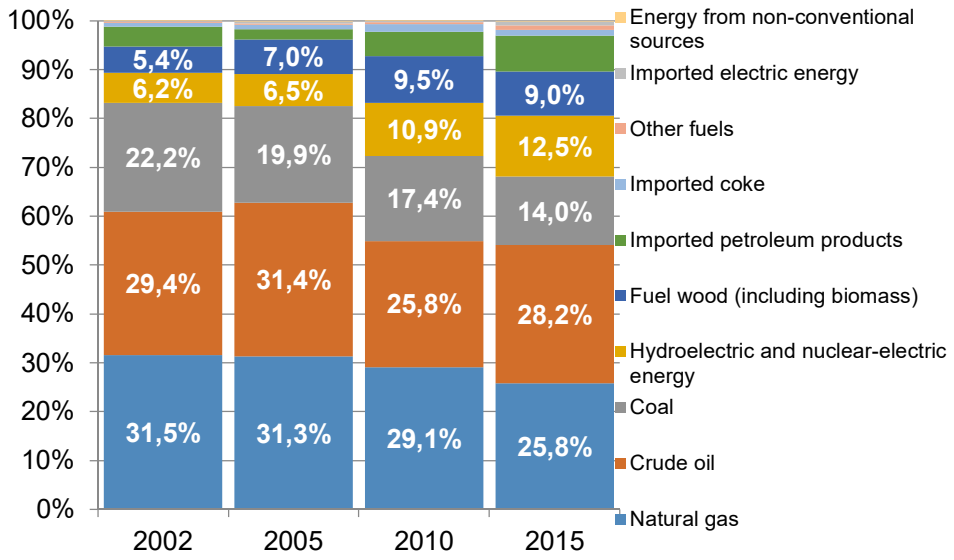

Figure 1. Primary energy sources in Romania from 2000
Source: Own calculation based on NIS data

The examined period can be separated into two periods concerning the total energy production (Phase 1 and 2) (Figure 2). The first phase is the period of 2002-2008 when there was 9.5% increase compared to the base year. The second phase is from 2008 until today when there is a decreasing tendency. There is 15.3% decrease compared to 2008. According to our forecast, this tendency will continue slightly in the future. This is due to the more mature energy production, and also the energy saving also plays a role in decreasing the quantities.

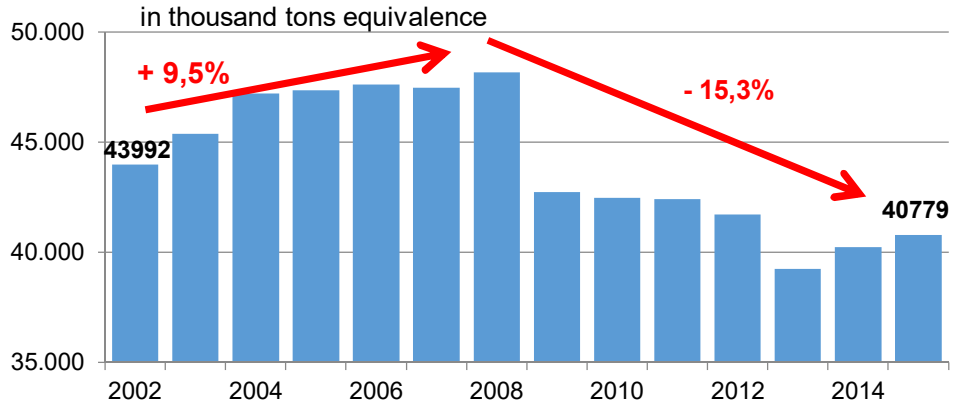

Figure 2. Quantity of primary energy sources in Romania
Source: Own calculation based on NIS data

60-65% of the total energy comes from own production, 35-40% is imported in Romania in the examined years. Considering the rate of produced and imported

energy, it can be stated that the produced quantity always exceeded the imported quantity (Figure 3).
From 2009 due to the Romanian regulations (and EU directives) the production has increased, so the dependence on import energy has decreased a bit.

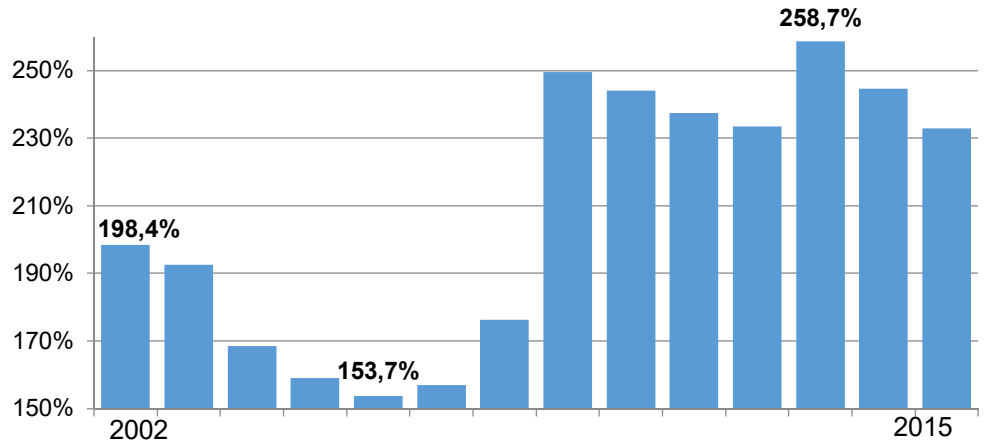

Figure 3. Production of Romania between 2002-2015
Source: Own calculation based on NIS data

In each of the examined years the production was almost the same (27 million oil equivalence), but in parallel with it the quantity of import decreased from 14 to 11 million tons equivalence.
In case of raw materials in Romania raw oil, gas and electricity (nuclear, wind, water plants and solar energy) were used for energy production. In the last 15 years the rate of coal, raw oil and gas has slightly decreased with the higher rate of electricity. The electricity rate increased from 10.3% in 2000 to 22.6% in 2015 (Figure 4).

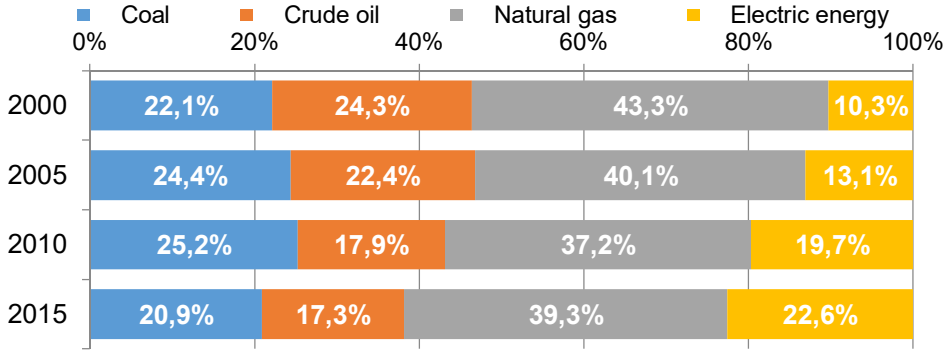

Figure 4. Materials of energy production in Romania between 2002-2015
Source: Own calculation based on NIS data

Recently in Romania electricity is produced in power plants by converting primary energy sources. The produced electricity is transported to the consumers by devices through a network.

Electricity is produced in thermal, water and nuclear power plants. In Romania the most important plants are the nuclear ones. Nuclear plants produce great amount, cheap electricity by using small amount of fissile materials (in a safe way). During the production it is aimed to avoid climate depletion. Its advantage is that the fissile materials can be stockpiled for years, so the unit cost of electricity production can be planned more or less on a long term.
In Romania (as in all of the EU member states) the most important task of the following years is to lengthen the existing blocks' running time in a way to be suitable from security, technical and economic points of view.
At the electricity production it will be aimed to use more renewable energy sources (primarily biomass and water), because they can be good supplements to the recently used materials. Renewable energy sources will never be competitors to the conventional raw materials because of the quantity, but by using renewables the dependence of Romania can be decreased.
Comparing Romania's with the neighbouring Hungarian power plants' net built-in capacities, we can state that both in Hungary (73.4%) and in Romania (42.6%) the thermal plants have the greatest significance based on the official statistic data (Figure 5).
In Romania thermal plants are followed by hydro power plants (31.6%) and the wind power plants. The significance of other power plants is negligible. In contrary, in Hungary thermal plants (the most significant is the Mátrai and Dunamenti thermal plants) are followed by nuclear power plants (in Paks) with 22% rate. The significance of other power plants is not major.

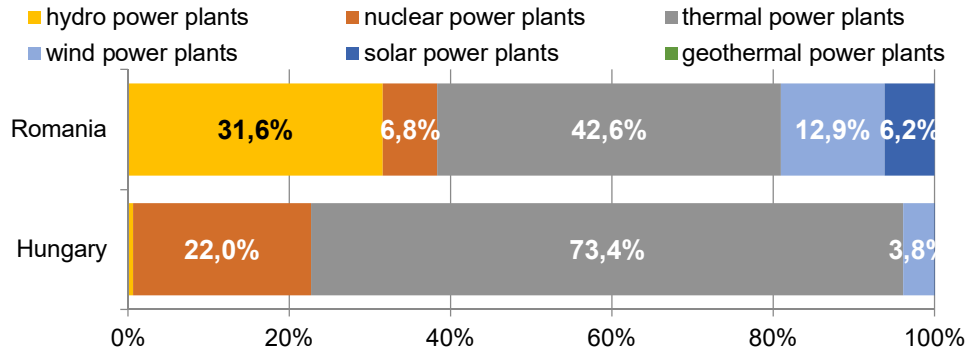

Figure 5. Net built-in capacities of Romanian and Hungarian power plants in 2015
Source: Own calculation based on NIS data

2.3 Energy consumption of Romania

Within energy consumption we can differentiate gross Romanian energy consumption, final energy consumption and energy consumption per capita.
Gross energy consumption decreased from 32 million tons equivalence in 2000 to 25 million in 2015. Based on the polynomial function, we can state (with 80% reliability) that in the next year the gross energy consumption will increase by 851 thousand tons equivalence.

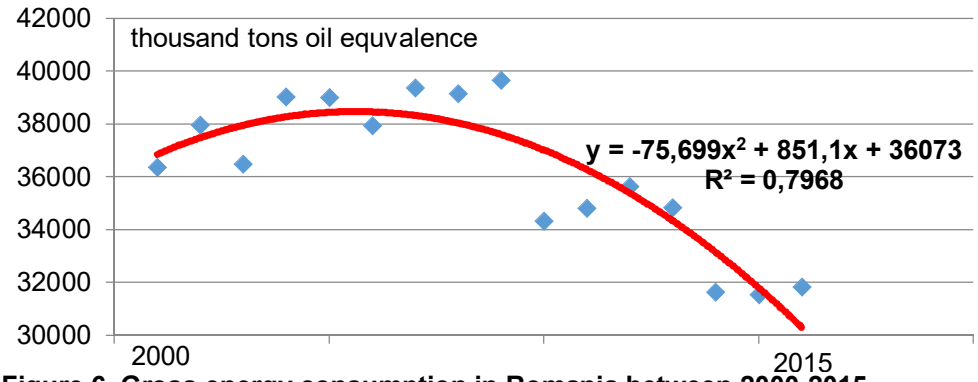

Figure 6. Gross energy consumption in Romania between 2000-2015
Source: Own calculation based on NIS data

Within the gross energy consumption, the gas has the highest rate in all of the examined years, but this value is continuously decreasing (Figure 7). Based on our forecasts, in some years the rate of raw oil and oil products will exceed the gas according to the official statistical data.

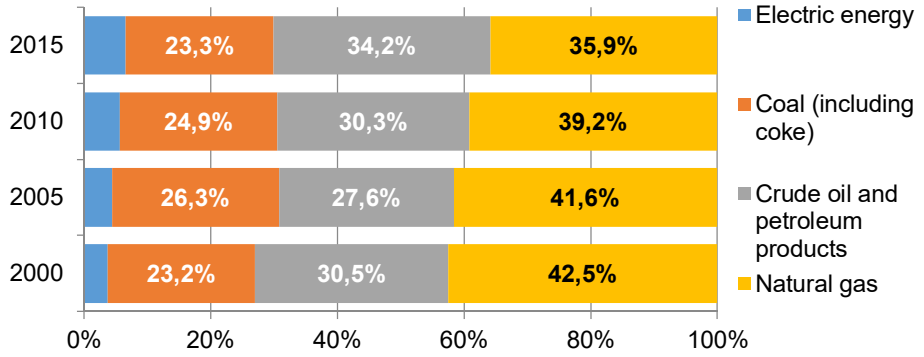

Figure 7. Subgroups of the Romanian gross energy consumption between 2000-2015
Source: Own calculation based on NIS data

Two users of energy are the population (household consumers) and the industrial users. Their significance has decreased in the last 15 years (5% in the population, 10% in the industry) compared to the transportation and broadcast, which value has increased in the last 15 years by 10%. The significance of agriculture and other activities is not major.
At last we would like to present the analysis of energy consumption per capita. With 90% reliability we calculated that based on the last 15 years' data this index will increase by 28.8 tons oil equivalence per capita. This means positive advance for Romania.

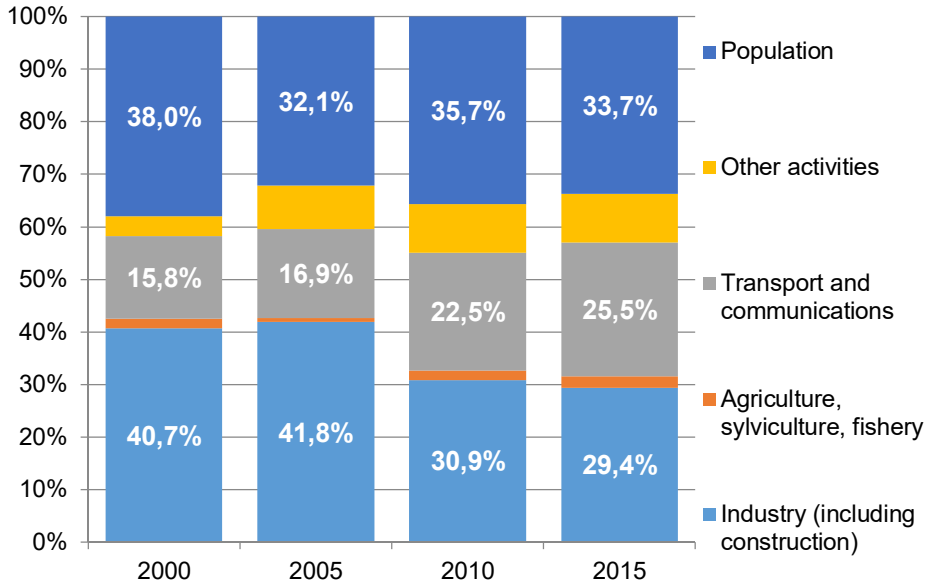

Figure 8. Subgroups of final energy consumption in Romania between 2000-2015
Source: Own calculation based on NIS data

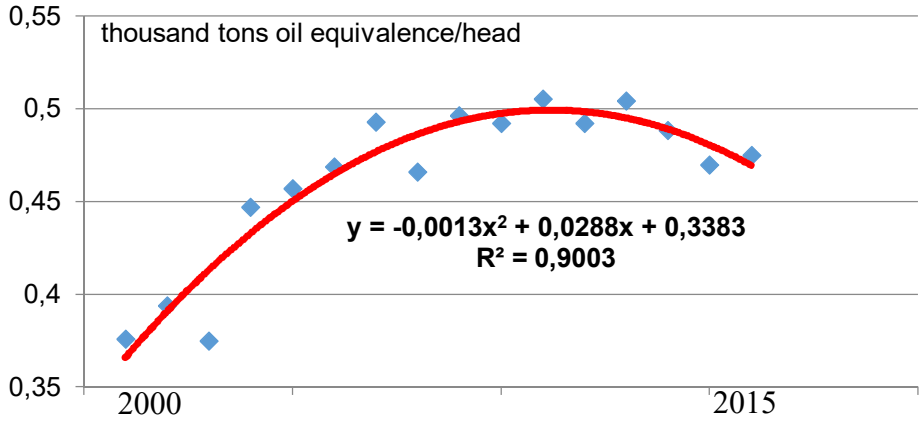

Figure 9. Energy consumption per capita in Romania between 2000-2015
Source: Own calculation based on NIS data

Summary
In this article we examined Romania's energy management from 2000 until now. In our opinion this topic is relevant, since by the accession to the European Union Romania has undertaken that it will use more and more renewable energy sources in the energy production beside the conventional energy production. Of course, renewable energy sources cannot substitute but supplement the conventional sources.
In this paper we have taken a look at the energy production and consumption in the last 15 years, and we have made forecasts on a short term.

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