The Future for Conventional Resources of Romania Used in Energy Production

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Abstract. Humanity, as we know it, has always had a growing need for energy. The industrial revolution generated an excess in the exploitation of the Earth's natural resources. As a result, global warming, climate change and CO2 emissions have become topics frequently addressed in various political, economic and in today's press debates. Romania is no exception to this trend. Although the industrial revolution began a few decades later than in the developed countries such as England, France and the USA, environmental consequences follow the same path. Therefore, it is necessary to raise awareness of the direction and implications of using the so-called conventional resources in energy production. Energy resources are the material bases of a country's energy policy, the premise of energy development studies. It is advisable to promote all energy sources and practices that are positive for the environment and to intensify efforts to manage the pollutant emissions generated by energy production. Even though some renewable energy sources have been exploited for a long time (for example, hydropower), it is essential to draw the attention of producers, consumers, governors and investors and other unconventional energy sources so that the electricity produced from renewable sources can grow in the near future. Governments will need to take measures in the area of taxation, subsidies and regulations, which will not only help them achieve their energy security and environmental goals, but also contribute to promoting technical progress and economic development. What it intends to present is the real state and trends of the conventional resources used in energy production in Romania

1. Introduction

Energy use in our days is a must. We use it in every aspect of our daily life and it helps improve our living by making it lighter, warmer and more comfortable. Energy is the one that moves the economy by its contribution in each and every one of its sectors –from education to research, from agriculture to industry and services. It brings closer accessibility to information, transportation, services, science, research, progress. Unfortunately, besides its usefulness, energy use also generates a harmful effect on the environment – it pollutes air, water and soil.

This paper is an evaluation study for the so called “conventional resources” used in energy production in Romania. It presents the actual status, tendencies and perspectives for fossil and nuclear resources in the context of European Directives and legislation about environment protection and energy security. As an energy crisis emerges worldwide, the purpose of this paper, beyond its informative character, is to increase the awareness for the Romania’s status and for its need for durability, sustainability, energy savings and efficiency in its future energy projects and strategy.
2. International context

Starting with Directives 2001/77/EC and 2003/30/EC of the European Parliament and of the Council and, after those, with Directives 2009/28/EC and 2012/27/UE, Europe establishes a common frame for the use of energy generated by renewable resources in order to limit and to decrease greenhouse gas emission and to promote cleaner transport. In order to meet these objectives, national plans are to be defined [1]. The energy sector is a strategic one and Europe depends on imports for different types of fossil fuels in order to meet its needs. Since 1990 the import dependency in the European Union is increasing [2], [3]. Its maximum value was in 2008 - 54.7%. The only country with negative values is Denmark but its imported energy dependency rate decreased from 31.4% in 2003 to 3.4% in 2012. In the EU-28 there is a decreasing trend in primary energy consumption. Lithuania has decreased its consumption from 15 Mtoe to 6 Mtoe in 2012 while Germany, Hungary, Poland, Slovakia, the United Kingdom and Romania have also noted a significant decrease and have reached levels values the reference ones from 1990. In Austria, Cyprus, Greece, Finland, France, Italy, the Netherlands, Spain, and Sweden the consumption levels are higher compared to 1990.

3. Romania

In order to fully understand the macroeconomic environment in Romania and its impact in the energy industry, in Table 1 is presented a comparative analysis of the main macroeconomic indicators that influence the energy sector, the main indicators in the energy industry. As it can be seen in Table 1, the Gross National Production (GNP) registered a 20.07% increase in 2014 – 2018 period while the primary energy consumption registered a decrease by 7.85%. This and the comparative analysis of the indicators shown above reflects the rupture between GNP evolution and the energy consumption rate which is a major fact in dimensioning the evolution of the energy industry in Romania for the next periods of time: 2015 – 2035 and 2035 – 2050.

| Social, economic or energy sector indicator | Measurement unit | 2014       | 2015       | 2016       | 2017       | 2018       | % 2014-2018 |
|--------------------------------------------|------------------|------------|------------|------------|------------|------------|-------------|
| **Resident population**                    | mio pers.        | 20,44      | 20,29      | 20,20      | 20,10      | 20,02      | (-2,05)     |
| Annual evolution                           | %                | (0,97)     | (-0,73)    | (-0,44)    | (-0,50)    | (-0,40)    |             |
| **Unemployment rate**                      | %                | 6,90       | 7,30       | 7,40       | 7,00       | 7,30       | 5,80        |
| Annual evolution                           | %                | 18,97      | 5,80       | 1,37       | (-5,41)    | 4,29       |             |
| **Gross National Production (GNP)**        | billion EUR      | 120,48     | 126,82     | 133,34     | 133,91     | 144,66     | 20,07       |
| Increasing rate                            | %                | (-7,07)    | -0,80      | 1,06       | 0,64       | 3,49       |             |
| **Gross Domestic Production (GDP) per capita** | mio EUR per capita | 5,92       | 6,26       | 6,62       | 6,68       | 7,24       | 22,30       |
| Increasing rate                            | %                | (-6,29)    | -0,21      | 1,55       | 1,08       | 3,89       |             |
| **Consumers Index Price (CIP)**            | %                | 127,43     | 135,17     | 143,04     | 147,88     | 152,61     | 19,75       |
| Annual evolution                           | %                | 5,58       | 6,07       | 5,82       | 3,38       | 3,20       |             |
| **Exchange rate**                          | RON/EUR          | 4,24       | 4,21       | 4,24       | 4,46       | 4,42       | 4,29        |
| Annual evolution                           | %                | 15,06      | (-0,65)    | 0,67       | 5,15       | (-0,83)    |             |
| **Energy Intensity**                       | toe/mio EUR      | 387,40     | 394,60     | 393,70     | 378,80     | -          | (-2,22)     |
| Annual evolution                           | %                | (-5,49)    | 1,86       | (-0,23)    | (-3,78)    | (-4,6)     |             |
| **Internal production of primary energy**  | ktoe             | 28,034     | 27,428     | 27,468     | 27,112     | 25,853     | (-7,78)     |
| Annual evolution                           | %                | (-2,9)     | (-2,2)     | 0,1        | (-1,3)     | (-4,6)     |             |
| **Gross national primary energy consumption** |                |            |            |            |            |            |             |
3.1 Oil: The national reserves could be over in 23 years
Romania is the fourth oil producer in European Union with 6% of the total and the fifth in entire Europe, with 2% of the entire oil production. Most of the geological reserves and of the sure reserves in Romania are located onshore – 96% and only 4% is located on the continental platform of The Black Sea. Considering the reported values for 2008-2018 (4.2ktoe as medium production for the recent years, the 5% for constant annual decrease rate and 5% as replacement rate) we can say that the national oil reserves could be consumed in 23 years.

In the short term, as well as, in the medium term, an increase in oil reserves could be done by implementing new technology for increasing the recovery rate of the known deposits.In the long term, implementing new projects for exploring offshore – under 1.000m deep areas of The Black Sea and exploring under 3.000m deep in complicated geology onshore areas could be the answer for increasing the national reserves.Unfortunately, most of the known oil fields are mature and already have an over 25-30 years period of exploitation. This is why, in Romania, are currently in exploration 36 areas in order to find new oil and gas deposits.

3.2 Natural Gas: The known reserves could last for 13 years
Romania owns the largest natural gas reserves in Central and Eastern Europe. Its reserves of 1.600 TWh are mainly onshore [4]. If we take into consideration for the sure reserves of natural gas in Romania a medium annual production rate of 11 mil. mc, a constant annual decline of 5% and a replacement rate of 80%, we can see that the national reserves could be over in about 14 years. In the short and medium term, implementing new technology meant to increase the recovery rate of the deposits could bring an increase in the sure national reserves. In the medium to large term, implementing projects for exploring in over 3,000m deep and in complicated geology onshore areas as well as the offshore areas in The Black Sea – especially over 1,000m deep. Like the oil, a big part of natural gasses in Romania are in an advanced state of exploitation so, they now function at less than 10 bar pressure.

3.3 Coal: The lignite leased reserves could ensure exploitation for about 15 years
**Lignite** is the main raw material in producing electrical and thermal energy in most thermal power stations in Romania. Having a calorific efficiency between 1,650 and 1,950 and a medium calorific efficiency of 1,800 kcal/kg, lignite used in thermoelectric power stations in 2016 produced 30% of the electrical energy produced in Romania. Most of the 400 Mt of sure lignite reserves – 95% - are in Oltenia Coal Basin. At a production rate of 30 Mt per year, they could last for about 15 years [5].

**Pit-coal** produced in Romania comes mainly from Valea Jiului. Coal Basin and it has a 3,650 kcal/kg calorific efficiency which place it on low quality category. Because the main pit-coal producer in Romania – Targu-Jiu Mining Division, belonging to Power Complex Oltenia SA who delivers for the other thermoelectric power producers, covers 98.66% of the national production of 2016, its production, sales and stocks dynamics reflect the specific market. In 2016 there was a 24% decrease in pit coal production and an increase in the stock of 46% caused by the low demand for energy, especially for the one produced by the use of pit-coal.In the European Union, the production of superior coal registered a decreasing tendency (12% difference between 2015 and 2016 production - from 128.5 Mt to 113.7 Mt) and Romania makes no exception from this trend. Although in recent years, it registered a decrease in production, Romania is the seventh pit-coal producer in European Union. Currently, the demand for pi-coal is higher then the production. If we consider a production rate of 1.5 Mt per year, the national reserves could last for another 36 years.
3.4 Uranium – Crucea-Botușana deposit is almost depleted

Romania has one nuclear power plant – in Cernavoda – and it provides 1,400MWh which means 18% of the total energy production. The initial plan was to build five reactors, but now only two of them are fully operational. By 2019 Unit 3 and Unit 4 is planned to begin their energy production and they should provide another 1,500MWh on the electricity internal market. In Romania there is a single uranium exploration site located in the North – at Crucea and Botusana – in Suceava County. This deposit has been explored for 27 years and is running out. This is why The National Uranium Company who administrates all the uranium resources in Romania is about to open for the economic circuit a new exploration site located in Eastern Carpathians – at Tulgheș-Grințieș from Harghita County and Neamț County.

Currently, the national uranium reserves and the stocks of technical uranium concentrate in different stages of refining are deposited on Feldioara Platform which ensures the raw material for Reactor Number 1 and for Reactor Number 2 in Cernavoda Uranium Pile Power Station.

The nuclear fuel is ensured for the entire technical life of these two reactors. In order to ensure the continuity in function for Units 1 and 2, the opening of Tulghes-Grințieș deposit is imposed. In the context of closing the uranium exploration sites in Caraș-Severin County and Bihor County and the perspective of soon depletion of the one in Suceava County, the delay of opening for the economic circuit of Tulghes-Grințieș deposit, the decrease in technical uranium concentrates stocks and the perspective of completion, commissioning and operation of Units 3 and 4 in Cernavoda Uranium Pile Power Station, there is a need of measures meant to insure a long term policy and security in nuclear energy production in Romania. Opening the new uranium deposit for exploration and exploitation is useful but it cannot ensure the fuel for all four Units in Cernavoda Nuclear Power Plant. It has to be corroborated with uranium acquisitions from the international market and with building new refining and processing facilities based on new advanced technology for the high uranium recovery rate and low production costs.

Because the power station works on CANDU 6 fuel and Romania has the technology for producing it, the imports could be oriented either to buying technical uranium concentrated either to sinterable uranium dioxide powder. There should be considered that these are products commercialized on long term contracts and it takes 5 years from signing the contract to the first delivery.

4. Results and discussions

4.1 Primary energy production

Primary energy production dropped in Romania by 20.5% - from 28 861ktoe in 2013 to 25,853ktoe in 2018. The largest share in the total is being held – for each ear – by natural gases, oil and coal. Compared to 2017, in 2018 the internal primary energy production went down by 4.6% and the internal primary energy consumption went down by 9.2%.

In 2018 the natural gas production had the biggest contribution in primary energy production – 33.6%, followed by coal with 18%, oil with 15.6%, firewood and agricultural waste with 14.1%. The largest share in primary energy consumption was being held in 2018 by natural gas also – 31.3%, followed by oil with 24.4%, coal with 18.1%, firewood and agricultural waste with 11.4% [6].

The reported values for primary energy production and primary energy consumption in Romania are illustrated in Table 2.
Table 2. Values for primary energy production and for primary energy consumption in Romania

| Period of time | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  |
|---------------|-------|-------|-------|-------|-------|-------|
| Measurement unit | ktoe  | ktoe  | ktoe  | ktoe  | ktoe  | ktoe  |
| **Values for primary energy production** |       |       |       |       |       |       |
| Coal          | 7 011 | 6 447 | 6 795 | 6 663 | 6 346 | 4 656 |
| Oil & oil derivate | 4 619 | 4 390 | 4 186 | 4 129 | 3 891 | 4 028 |
| Natural gas   | 8 982 | 8 964 | 8 705 | 8 724 | 8 770 | 8 687 |
| Firewood and agricultural waste | 3 750 | 3 838 | 3 900 | 3 476 | 3 795 | 3 657 |
| Other fuels   | 240   | 98    | 88    | 152   | 159   | 188   |
| Electric energy | 1 481 | 1 361 | 1 769 | 1 407 | 1 290 | 1 743 |
| Thermal energy | 2 752 | 2 881 | 2 841 | 2 880 | 2 811 | 2 848 |
| Unconventional energy | 26    | 25    | 26    | 37    | 50    | 46    |
| **Values for primary energy consumption** |       |       |       |       |       |       |
| Coal          | 9 649 | 7 436 | 6 911 | 8 147 | 7 552 | 5 725 |
| Oil & oil derivate | 9 719 | 8 331 | 7 855 | 8 172 | 8 303 | 7 705 |
| Natural gas   | 12476 | 10642 | 1 897 | 1 187 | 10924 | 9 892 |
| Firewood and agricultural waste | 3 710 | 3 742 | 3 982 | 3 458 | 3 654 | 3 591 |
| Other fuels   | 352   | 107   | 723   | 225   | 244   | 257   |
| Electric energy | 1 115 | 1 164 | 1 573 | 1 242 | 1 312 | 1 569 |
| Thermal energy | 2 752 | 2 881 | 2 850 | 2 880 | 2 811 | 2 848 |
| Unconventional energy | 26    | 25    | 26    | 37    | 51    | 46    |

Source: National Institute of Statistics, Energy Balance of Romania - collections

4.2 Final energy consumption

Due to the economic crisis in recent years the final energy consumption has dropped by 12.5% from 2013 to 2018. As a result of reducing industrial activity in Romania the industrial energy use has dropped by 26% and the residential sector has become the main final energy consumer in Romania [7].

Compared to 2017, in 2018 the final energy consumption decreased by 4% from 22 766ktoe to 21 885ktoe out of which 35.4% for residential sector consumption and 28.8% for the industrial sector. The structure of final energy consumption is presented in Table 3.
Table 3. Final energy consumption in Romania

| Period of time | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  |
|---------------|-------|-------|-------|-------|-------|-------|
| Measurement unit | ktoe  | ktoe  | ktoe  | ktoe  | ktoe  | ktoe  |
| **Final energy consumption** | 25002 | 22387 | 22739 | 22750 | 22766 | 21885 |
| Industrial sector | 8 544 | 6 202 | 6 613 | 6 618 | 6 346 | 6 307 |
| Construction sector | 571 | 410 | 407 | 474 | 450 | 395 |
| Transportation sector | 5 399 | 5 377 | 5 107 | 5 313 | 5 351 | 5 364 |
| Residential sector | 8 089 | 8 037 | 8 124 | 7 883 | 8 095 | 7 748 |
| Agriculture | 293 | 385 | 391 | 433 | 499 | 472 |
| Services sector | 2 106 | 1 976 | 2 097 | 2 029 | 2 025 | 1 599 |

Source: National Institute of Statistics, Energy Balance of Romania - collections

4.3 Import dependency
The trend from 2013 to 2018 is toward decreased import dependency. For the 2013-2018 period of time it registered a 33.6% decrease in the context of a 38.8% lower rate for primary energy importation and a 24.5% lower rate for primary energy exportation.

Compared to 2017, in 2013 there was an 18.3% decreased rate for import dependency in Romania in the context of a 14% lower rate for primary energy importation and a 16.1% upper rate for primary energy exportation. The import rate had been influenced mainly by natural gas import diminution by 49.3% which represented 71% of the total.

The export rate, on the other hand, had been influenced mainly by oil import increase by 13.8% which represented 88% of the total. The evolution of import dependency is presented in Table 4.

Table 4. Evolution of import dependency in Romania

| Period of time | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  |
|---------------|-------|-------|-------|-------|-------|-------|
| Measurement unit | ktoe  | ktoe  | ktoe  | ktoe  | ktoe  | ktoe  |
| **Primary energy import:** | 16324 | 11 35 | 11239 | 11570 | 11615 | 9 993 |
| Coal import | 2 550 | 1 013 | 1 221 | 1 101 | 1 233 | 1 045 |
| Oil import | 10073 | 8 471 | 7 955 | 7 769 | 7 766 | 7 523 |
| Natural gas import | 3 567 | 1 614 | 1 834 | 2 489 | 2 321 | 1 177 |
| Electric energy import | 79 | 56 | 66 | 89 | 121 | 39 |
| **Primary energy export:** | 5 565 | 4 600 | 3 992 | 4 124 | 3 620 | 4 203 |
| Coal export | 17 | 14 | 50 | 24 | 13 | 4 |
| Oil export | 5 103 | 4 332 | 3 654 | 3 811 | 32 64 | 3 714 |
| Electric energy export | 445 | 254 | 262 | 253 | 99 | 212 |
| Import/export balance | 10759 | 6 635 | 7 247 | 7 446 | 7 995 | 5 790 |
| Internal consumption | 39799 | 34328 | 34817 | 35648 | 34851 | 31634 |
| Import dependency rate | 27% | 19.3% | 20.8% | 20.9% | 22.9% | 18.3% |

Source: National Institute of Statistics, Energy Balance of Romania - collections
Energy savings, efficiency and intensity

Energy savings, efficiency and intensity represents one of the main objectives in European Union energy strategy for 2020, 2035 and 2050. For establishing how efficient the use of energy in a country is we use the energy intensity indicator which shows how much energy is needed for producing every unit of GDP.

Between 1990 and 2016, the EU's energy intensity, i.e. the ratio between its gross inland energy consumption and its gross domestic product (GDP), decreased by 36%.

This decrease was continuous during the entire period, with an average annual decrease of 1.7% per year. The 1990-2005 period is characterised by relatively high economic growth and more moderate growth in gross inland energy consumption.

In contrast, the 2005-2014 period is characterised by lower economic growth and decreasing gross inland energy consumption. Gross inland consumption of energy started to increase again after 2014, marking a slow-down in energy intensity improvements.

In all member countries of the European Environment Agency (EEA), energy intensity decreased between 2005 and 2016. The largest decreases were observed in central and eastern European countries (e.g. Lithuania, Romania and Slovakia) because of changes in their economic structure, and in Malta.

As shown in Table 5 in Romania the economic crisis and the measures determined by it, as well as the steps taken towards a higher energy efficiency generated a decrease by 42% in energy intensity in 2007-2012 period of time.

| Period of time | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---------------|------|------|------|------|------|------|
| Measurement unit | toe / 1 000EUR |     |      |      |      |      |
| Primary energy intensity | 0.428 | 0.404 | 0.347 | 0.384 | 0.384 | 0.373 |
| Final energy intensity | 0.269 | 0.254 | 0.244 | 0.251 | 0.245 | 0.244 |
| Industry energy intensity | 0.361 | 0.336 | 0.252 | 0.230 | 0.216 | 0.210 |

Source: National Institute of Statistics, Energy Balance of Romania - collections

In Romania energy intensity also decreased but the registered values are much higher than the medium values in UE-28. The estimated potential in energy savings is around 30% of the final energy with the highest contribution in constructions – 42%, followed by transportation with 32% and by services and industry.

In order to ensure energy security, durability, competitiveness and savings in consumption of primary energy resources and in order to protect our environment, Europe – Romania included – needs to take the next step towards a cleaner world by starting a technological revolution.

5. Conclusions

Since 1990, Europe’s needs for energy have increased year after year but its fossil fuel deposits, are heading to depletion. Energy demand, on the other hand, is constantly growing. As a result, the import dependency has increased over the years and the trend for energy dependency is towards higher levels while the energy price is getting higher.

Until now, Europe’s advantage was the diversity in the so-called “energy mix”: oil platforms, natural gas deposits, coal mines, nuclear power plants and lots of water barrages. Unfortunately,
burning of fossil fuels used in energy production generates most of the greenhouse gas emissions with a high impact on the environment.

Energy independence and a safe environment are the main objectives for the energy strategy in all Europe’s states, Romania included. This is not an easy target but it is achievable by increasing energy efficiency, by lowering the use of fossil fuels and by expanding the use of “green technology” that generate low CO₂ emission.

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