

ELECTRICITY GENERATION IN COAL-FIRED PLANTS IN ROMANIA

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Abstract Energy is essential for the development of the European Union according to the new European Union Energy Policy adopted in 2007. Romania is fully aligned to the overall European Union Policy and to its Energy Policy in particular. The paper aims to show the global evolution and challenges in the energetic field where coal plays an important part as primary fossil fuel both in developed and emerging economies in the EU. We present the energy resources situation, highlighting the use of coal for power generation. In this context, the expectations and challenges faced by the companies who work in the energy field in Romania are shown.

Keywords: coal, energy, policy, resources, reserves.

1. Global coal reserves and resources

It is known that coal reserves mean the portion of known coal resources that can be profitably mined and marketed with today's mining techniques. Coal resources are deposits that are either proven, but at present are not economically recoverable, or not proven, but expected to be present based on geological knowledge. Coal and lignite account for more than half of the total reserves and resources out of fossil fuels, as shown in Figure 1 [8].

Unlike oil and gas, coal is widely distributed around the world with particularly large reserves in the USA, Russia and China. The distribution of coal around the world is presented in Figure 2 [7].

For this reason, coal offers a much higher level of supply security: most coal produced is used in

the same country where it is extracted, which ensures the energy supply security for that country. Natural gas, oil and nuclear fuels make up the remainder of total non-renewable energy reserves and resources [1]. Although abundant and – in the case of wind, solar and geothermal – practically inexhaustible, renewable energy is much harder to quantify as a resource since converting it into useful energy can be inefficient and expensive.

Based on data provided by the International Energy Agency and the BP Statistical Review of World Energy, we can say that coal provides 30.1% of global primary energy needs and generates over 40% of the world's electricity. It is also used in the production of over 70% of the world's steel [18].

Total world coal production reached a record level of 7822.8 Mt in 2013, 0.4% more than in 2012 but 40.2% more than in 1990 [18].

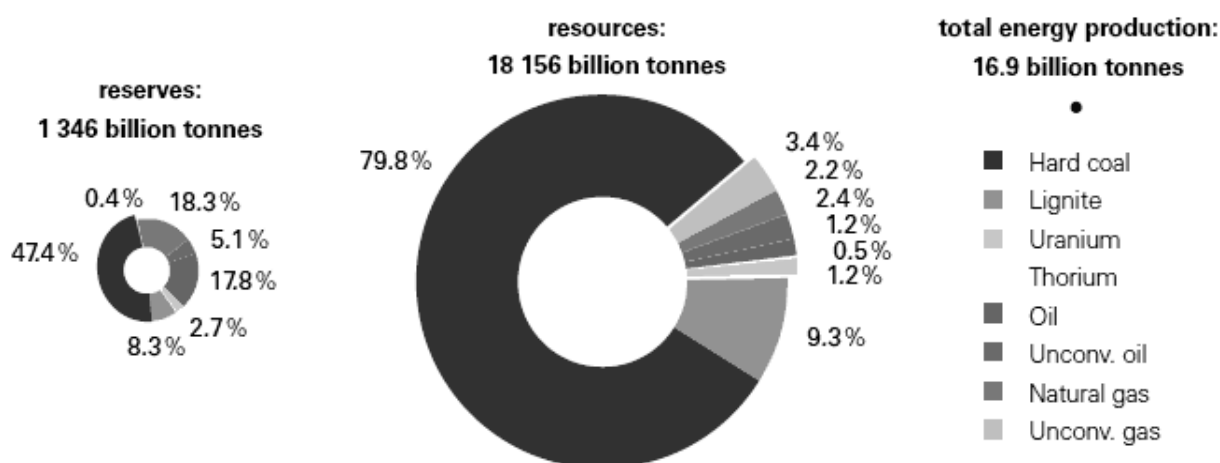


Fig. 1 Reserves and resources of non renewable fuels

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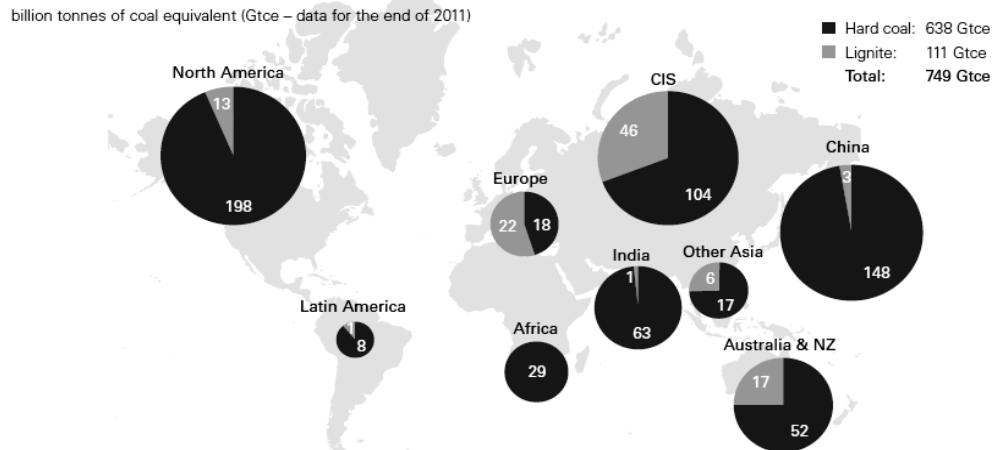


Fig. 2 Coal around the world [6]

The IEA reports that, according to the German Federal Institute for Geosciences and Natural Resources, there were 1052 billion tones of coal reserves remaining as of 2012 that are 14.6 billion tones more than in 2011. These proved reserves represent 134.5 years of production at current levels, up from 133.1 years calculated last year and 131.6 years in the preceding year.

However, other publications such as the BP Statistical Review of World Energy often refer to the World Energy Council estimates of global coal reserves. According to this source, there are 892 billion tones of coal reserves left, or 113 years of coal output.

2. Coal-based strategy of EU in power generation

The European Union holds only around 3% of the global energy reserves and resources (Table 1) [4]. As at the global level, reserves and resources of coal and lignite are most significant: together they account for 94 % of the EU's remaining potential [4].

Table 1. Fossil fuel reserves and resources in the EU

Gtce (billion tones of coal equivalent)	Reserves	Resources
Hard coal	16.6 43.0%	428.6 77.8%
Lignite	17.4 45.0%	93.1 16.9%
Oil	1.7 4.4%	3.6 0.7%
Natural Gas*	2.8 7.3%	20.5 3.7%
Uranium	0.1 0.3%	4.8 0.9%
Total	38.7 100.0%	550.7 100.0%

*Natural Gas includes conventional natural gas, tight gas, shale gas, coal bed methane, aquifer gas, gas hydrates.

The power generation sources in the EU are presented in figure 3.

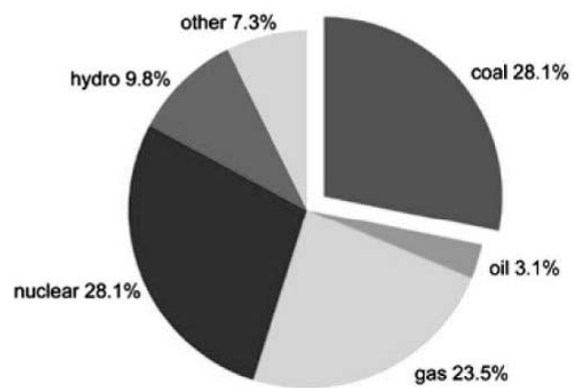


Fig. 3 Power generation in EU
(Source: <http://www.iea.org/>)

The five essential issues regarding a cleaner energy generation using coal are:

- Regulatory and policy dialogue;
- Sharing best practices in the field of Cleaner Electricity Production from Fossil Fuels in the United Nations Economic Commission for Europe region;
- Carbon Capture Utilization and Storage (CCUS);
- Enhanced oil recovery with CO₂;
- Advanced fossil fuels technologies for power generation.

These objectives are mentioned in the report of the *Ad Hoc Group of Experts on Cleaner Electricity Production from Coal and Other Fossil Fuels*, part of UNECE, ECE/ENERGY/GE.5/2013/23, and reassessed in 2014.

Some coal deposits lie near consumers and can be exploited under very favorable conditions. Some lignite opencast like the ones in Bulgaria, the Czech Republic, Germany, Greece, Hungary, Poland and Romania lie near consumers, mainly power plants,

which makes the transport to be on short-distance which in turn leads to the lowest cost electricity production in Europe.

The EU's share of global energy resources—about 3%—is relatively small. Out of the EU's total resources, supplies of coal and lignite are the largest component, comprising 88% of energy reserves and 95% of resources (Figure 4). Accordingly, the EU's endowment of coal is orders of magnitude larger than that of oil and gas combined. In fact, the EU has a 97-year supply of coal, but just a 12-year supply of oil and gas. Initiatives that increase the use of coal will thus diversify Europe's energy sources and enhance its energy security.

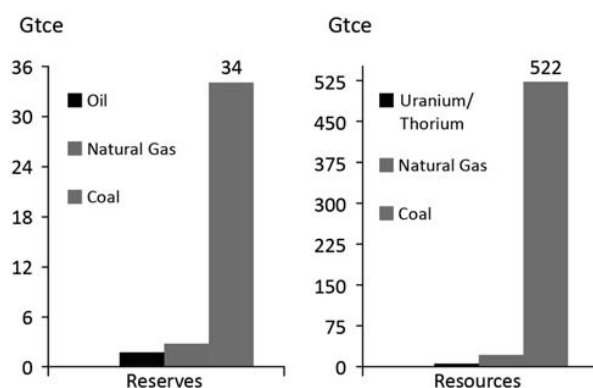


Fig. 4 Comparative energy supplies in the EU.
(Source: BGR and DERA Rohstoffinformationen)

The challenges faced by the energy world – and the coal industry in particular – are getting more complex. Global energy markets have become increasingly competitive and Europe finds itself in a race for resources and investments. Energy policies and political commitments have had to adapt in the wake of the economic crisis. US shale gas has brought cheaper coal from the US to Europe, shifting the balance in Europe between gas and coal. At the same time, global energy-related CO₂ emissions in 2012 reached a new historic high, whilst scientific consensus on the direct link between our use of energy and climate change, described in the latest IPCC report, has never been stronger, said Philip Lowe, *Director-General for Energy* from European Commission [4].

To deal with these challenges, EU policy makers, together with Member States, are working to find the right balance between sustainability, competitiveness and security of supply concerns, not just in our current strategy and programs, but also for the forthcoming EU 2030 energy and climate policy framework. These challenges also have an impact on the coal industry in Europe which has undergone a transformation. The economic arguments for coal have changed recently

in its favor. Coal provides much-needed security of supply in our electricity network. After years of decline, demand for coal in the EU has started rising again, with coal imports up 7% in 2012. On the other hand, many coal plants will be faced with closure due to new air pollution limits coming into force in 2016. EU coal production will be affected by the phase out of state aid by 2018. In addition, policies to reduce greenhouse gas emissions have a particularly profound impact on the coal industry and coal-fired power generation.

Local availability of coal and the contribution of coal mining to the EU economy add to its relative benefits when compared to other energy options. Almost 600,000 jobs in the EU depend on the coal mining industry and the use of indigenously mined coal allows many countries to maintain a healthy balance of payments. The value of EU-wide coal and lignite production totals more than €27 billion each year. If coal used in the EU was replaced by natural gas, the annual cost would exceed €50 billion, with the entire sum leaving the EU to finance imported natural gas, much of it coming from Russia, which raises particularly strong energy security concerns given recent events in Eastern Europe [3].

Coal provides not only a low-cost source for electricity, but can also contribute to alleviating fuel poverty. One of the most effective ways of using coal for heat generation is in combined heat and power plants (CHP). In Europe, CHP plants supply a large share of heating services in Denmark, Finland, Latvia, and the Netherlands. The principle behind CHP is the simultaneous utilization of heat and power from a fuel or energy source such as coal. CHP technology can achieve energy conversion efficiency rates of up to 80% or higher—nearly double that of the current state-of-the-art coal-fired power plants. Keeping coal as part of the EU energy supply does not mean accepting the status quo on climate change. There is huge scope for achieving significant efficiency improvements as the existing fleet of power plants are replaced over the next 10–20 years with new, higher efficiency supercritical and ultra-supercritical plants. By replacing old plants with high-efficiency, low-emissions coal technologies, the EU's emissions from coal-based power generation can be reduced by around 15% [3].

It is known that 87% of CO₂ emissions in EU come from energy production or use, that make energy industries remain the dominant source. The only way to reconcile the use of coal with a low-carbon and efficient energy system is with greater flexibility, more efficiency and the widespread uptake of carbon dioxide capture and storage – CCS. It is important for the coal and power

industries to be competitive, therefore to develop more low-carbon options for coal-fired electricity generation.

Making progress on CCS development is not just a technical and financial challenge, but also a political issue. It is necessary to cross many obstacles which need to be overcome. It is desired that the coal industry, electricity generators based coal and coal investors' work together to find innovative solutions for the future of coal and to ensure that coal continues to be a useful resource in a low-carbon energy system.

The European Union is the world's third largest coal-using region, after China and North America. Each year, around 130 million tonnes of hard coal are mined and a further 210 million tonnes are imported making it the world's largest importer after China. At 430 million tonnes, EU lignite production far exceeds that from any other region. Russia, Australia, the USA and Turkey each mine around 70 million tonnes, far behind Germany which produced 185 million tonnes in 2012. Most Europeans never see a lump of coal, but they use it in their homes in the form of electricity: 27% of EU electricity production comes from burning coal and lignite in power stations. EU hard coal and lignite production and consumption for power generation are shown in Table 2 [5].

Table 2 *EU coal production and consumption for power generation*

	EU Hard coal production		Consumption of indig. hard coal for power generation**	
Country	1-12 2013 Mt	1-12 2012 Mt	1-12 2013 Mt	1-12 2012 Mt
Bulgaria*	2.1	2.3	1.7	2.1
Czech Republic	8.6	11.4	2.8	3.3
Germany	7.5	10.8	6.4	9.8
Poland	76.5	79.2	n.a	52.0
Romania	1.8	1.9	1.8	1.9
Spain	4.4	6.1	2.9	6.5
UK	12.8	16.8	n.a	15.2
EU-27	113.7	128.5	n.a	90.8

* *brown and black coal*

** *only hard coal producing countries*

Despite these remarkable statistics, coal and lignite are not always viewed positively. They are abundant, affordable and accessible so they add to the security and competitiveness of energy supply in the EU. 88% of EU fossil energy reserves are in the form of coal and lignite. However, burning fossil fuels of any type – coal, oil or gas – releases

carbon dioxide (CO₂) into the atmosphere that is thought to cause global warming and climate change. It is right that the coal industry is taking steps to reduce emissions. EURACOAL itself calls for a three-step strategy encompassing power plant modernization to improve efficiency using technologies that are commercial today, research and development into even more efficient technologies for tomorrow and finally deploying CO₂ capture and storage in the next period.

In too many countries, there is a reluctance to take even the first of these practical steps as policy shifts against coal. This needs to be reversed so that the EU is not left behind in a world that is embracing coal like never before. Europe needs to demonstrate how to use coal cleanly and efficiently. There are good examples that we can be proud of and use to promote European technology. In Denmark, one can find the world's most efficient coal-fired power plants. In Germany, lignite-fired power plants that have opened in the last couple of years are the world's most flexible – perfect for balancing the increasing share of electricity from renewable energy sources under the German Energiewende. In the Netherlands, new coal-fired power plants will open shortly and ensure that the country does not become dependent on imported gas as its own North Sea gas reserves deplete. These are all good examples, but looking to Eastern and South Eastern Europe a different picture emerges [8, 11].

Newer member states have not been so lucky because the investment climate has not favoured renewal of their ageing and often inefficient coal-fired assets. The basics must be in place to support economic growth. For most countries, this means a reliable and affordable electricity supply that does not pollute the countryside. Whilst many in Western Europe can be satisfied with the progress that has been made in that direction, the same is not true across all parts of the EU.

3. Coal-based energy generation management in Romania

Romania displays a varied range – yet limited in amount – of fossil and mineral primary energy resources: crude oil, natural gas, uranium, as well as an important potential of renewable resources that could be turned to good account [1].

The generation structure of the National Energy System on resources types is presented in Figure 5. It is mentioned in Romania's energy strategy [15], that until 2020 there are proven coal energy production deposits for the next 155 years. Almost 80 % of the country's primary energy demand is met by indigenous energy resources.

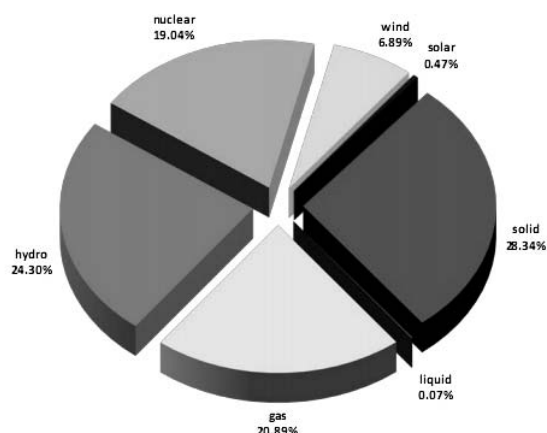


Fig. 5 Electricity structure by primary sources (delivered by generators with dispatchable units), February 2014 (Source: *Monthly reports of generators – Romanian Energy Regulatory Authority*)

Current oil reserves are estimated at 82 million tones with an annual production of around 4 million tones [5].

Natural gas reserves are estimated at 109 billion cubic meters with an annual production of around 11 billion cubic meters. New offshore gas could enable Romania to become a net gas exporter by 2025 [5].

Hard coal reserves and resources are estimated at 2 446 million tones, of which 252.5 million tones are commercially exploitable within the currently leased perimeters, although as little as 11 million tones might be economically recoverable [5].

The evolution of delivered electricity structure, during the last 3 years, is that given in Figure 6.

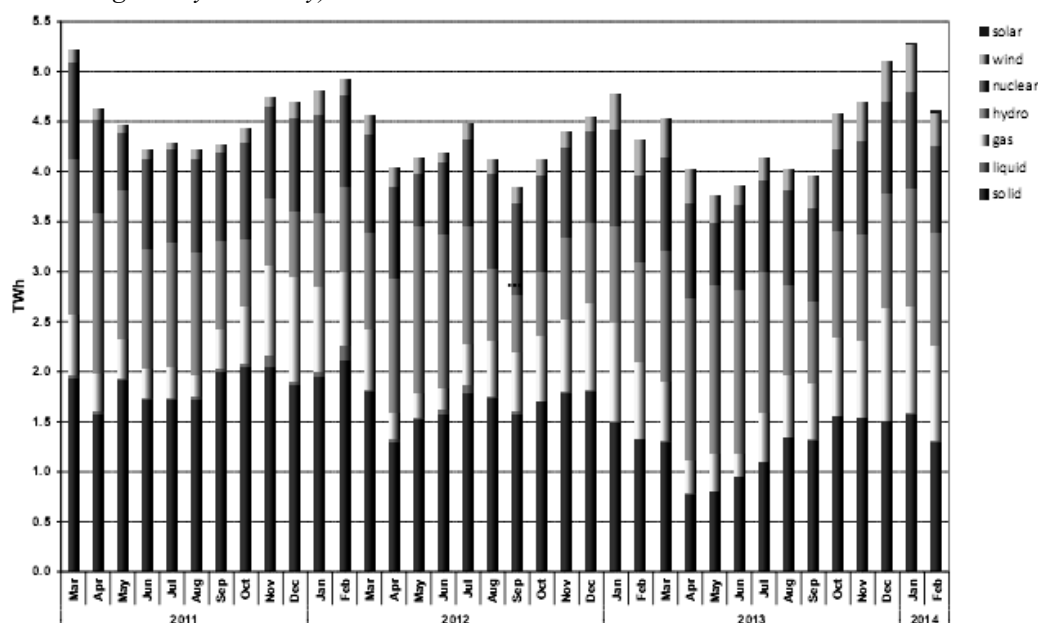


Fig. 6 Evolution of electricity delivered by generators with dispatchable units (Source: *Monthly reports of generators – Romanian Energy Regulatory Authority*)

Proven reserves of lignite total are 280 million tones, with a further 9 640 million tones of resources. 95 % of lignite deposits in Romania are situated in the Oltenia mining basin and more than 80 % of these can be mined in opencast mines. The remaining lignite deposits have low economic potential, explaining why extraction in most other areas has stopped.

Romania's entire hard coal and lignite output is used for heat and power generation. At the end of 2011, the total capacity of installed generation was 20 498 MW; coal – fired power plants had a share of 28.9 % or 5 918 MW, other fossil fuel power plants 5 374 MW (26.2 %), hydro power plants 6 483 MW (31.6 %) and the Cernavodă nuclear power plant 1 411 MW (6.9 %) [15].

The main consumers of hard coal are the thermal power plants at Paroşeni (150 MW) and Mintia- Deva (4x210MW+1x235MW) [17].

Hard coal has the advantage of ensuring a long – term supply for these power plants. Some mines will be obliged to stop their activities due to the enormous land acquisition costs and very high operational costs. More generally, some mining companies urgently need to modernize their equipment to improve performance and productivity.

Lignite mining in Romania offers some competitive advantages with the use of modern technologies and skilled labor. Reserves are concentrated in a relatively small area of about 250 square kilometers where lignite is currently mined

in 19 opencast pits. These reserves provide a long - term secure supply for power plants. In order to avoid impacts on neighboring agricultural land, overburden is placed back in the excavated voids, which also helps reduce costs. The main consumers are nearby power plants, Turceni (5 unit of 330 MW), Rovinari (4 unit of 330 MW) and further to the south lies the 300 MW Craiova power plant and Isalnita (2x315 MW). The map of the distribution of hard coal and lignite in Roamnia is like in Figure 7 [5].

During 2012, the coal industry underwent major restructuring. The lignite mines and power plants were combined into the vertically integrated **OLTENIA ENERGY COMPLEX** to create what the Romanian government hopes will be a national champion [16].

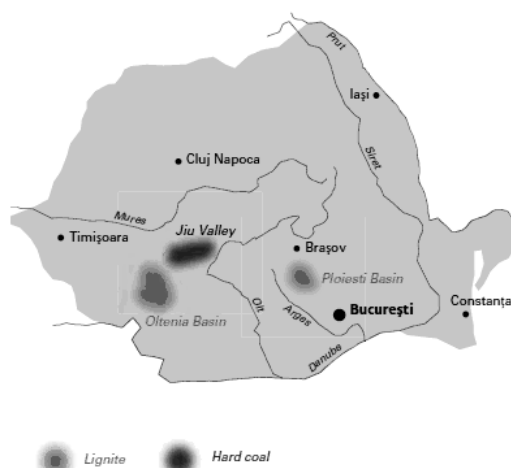


Fig. 7 Map of coal reserves in Romania

Restructuring of the hard coal sector was more problematic and was finalized only at the end of 2012 with the creation of two separate operating units under the **NATIONAL HARD COAL COMPANY (CNH SA Petroşani)**. One will oversee the closure by 2018 of three coal mines in the Jiu Valley that are not viable (Uricani, Paroşeni and Petrila), following Council Decision 2010/787/EU on state aid to the coal industry namely, **JIU VALLEY MINE CLOSURE SOCIETY**. The other unit, will continue to operate the remaining four coal mines without state aid (Lonea, Livezeni, Vulcan and Lupeni), with an annual production capacity of 1.5 million tones [17]. As a result of the implementation of a solution to integrate the economically viable coal mines from Jiu Valley with the energy producers, an organizational integration, **HUNEDOARA ENERGY COMPLEX** any was established in 2012 in Vulcan, Romania. The company has formed after the consolidation between Energy Power Plant Deva and Energy Power Plant Paroseni in 2012, merging with the

National Hard Coal Company in 2013 as a result of readjustment measures for the energy producers.

Job losses will total 2 400, leaving 5 200 employees [5].

The mines part of Hunedoara Energy Complex need to be part of an investment program to bring new technologies to maintain the capacity and ensure the pit coal production which is to be provided to the other two branches of the energy company, Paroseni and Mintia-Deva Energy power plants to produce energy.

The condition of exhaustible energy resources is as follows [9]:

- Hydro-carbon deposits are limited and show a decrease of internal production under the circumstances of no new deposits of significant potential having been identified. Present resources represent 73.7 million tons. Yearly production of crude oil decreased from 14.7 million tons in 1976 to 5 million tons in 2006.
- Natural gas deposits are also limited, and after 1990 internal production witnessed a decline. The present deposits of natural gas represent about 184.9 billion m³. The yearly production of natural gas represented 12.3 billion m³ in 2006, namely 69% of the yearly national total consumption of natural gas.
- The identified hard coal resources of Romania represent 755 million tons out of which 105 million tons are exploitable in areas under concession.
- Romania's lignite resources represent 1490 million tons out of which 445 million tons are exploitable in areas under concession. The resources located in new perimeters which are not under concession represent 1045 million tons. Out of the deposits of 1045 million tons of lignite within the mining basin of Oltenia, 820 million tons afferent to the new perimeters are located in the neighborhood of areas under concession exhibiting the most favorable conditions of capitalization through extending concessions. Owing to the fact that lignite deposits in Oltenia includes 1-8 layers of exploitable coal, their superior exploiting requires the immediate adoption of certain regulations that could guarantee the rational exploiting under total safety conditions (minimal losses) and efficiency conditions.
- Existing and exploitable ore deposits provide the demand for natural uranium until 2017 for the functioning of two nuclear and electric units belonging to Cernavoda plant. The potential new perimeters of uranium ores cannot significantly change the existing condition so that it is necessary to adopt certain specific measures in order to provide natural uranium resources according to the demands that come out of the program of nuclear energy development.

Accordingly, at present the following estimation may be considered [2]:

- Lignite deposits may provide their efficient exploiting for about 40 years at a production level of approximately 30 million tons per year. In the field of lignite extraction the degree of State's intervening is small and mainly consists in giving subsidies only for underground exploiting; in time such subsidies are going to be stopped.
- As regards hard coal, the decrease of perimeters and closure of inefficient mines means that at present only about 30% of the total amounts of hard coal geological deposits are now located within the perimeters under concession detained by coal mines of the Hunedoara Energy Complex. One may infer that the evolution of production costs, of supplemental costs with CO₂ emissions and the

elimination of production subsidies are going to determine the important decrease of internally produced hard coal that becomes less and less competitive and determines the significant decrease of production. From an economic and energy point of view, indigene hard coal becomes a marginal source for the production of electric energy in the case it loses its subsidies. According to the national resources condition of primary energy, Table 3, established in the energy strategy (2007), one may notice that, except for renewable energy sources, lignite is the only internal carrier of primary energy which – when it comes to resources – is able to significantly contribute to providing the demand of consumption in order to produce electric energy for the following 2 – 4 decades [15].

Table 3 *The situation of national primary energy resources*

Fossile fuel	Reserves						Yearly estimated output
	Reserves		Exploitable under concession		Within new perimeters		
	Million tons*	Million. tep	Million tons*	Million tep	Million tons*	Million. tep	
Hard coal	755	422	105	38,8			3,3
Lignite	1490	276	445	82,4	1045	133	32
Crude Oil	74	72	n.a	n.a	n.a	n.a	5,2
Natural Gas	185	159	n.a	n.a	n.a	n.a	12,5
Nuclear energy	n.a	n.a	n.a	n.a	n.a	n.a	n.a

*natural gas exclusively expressed in billion cubic meters

4. Conclusions

Two thirds of all coal produced worldwide is delivered to power plants, or 90 % in the case of lignite. Other major customers for hard coal are in the iron and steel sector, chemical fertiliser manufacture and the process heating market, including cement works, paper mills, food processors and other industries.

In the EU, coal-fired power plants generate electricity at half the price of offshore wind turbines and a quarter of the price of solar PV. Electricity generation from coal is also 10 to 30% less expensive than from natural gas and at least 30% less expensive than from onshore wind turbines—not to mention the additional comparative advantage of coal in terms of being a reliable energy supply that does not require back-up generation capacity.

The coal industry, from extraction to power generation, represents a completely secure value - added industrial supply chain, creating economic wealth and prosperity in the EU.

Beyond Europe, the technologies developed by the European mining and power plant equipment suppliers also contribute to improving the efficiency of coal production, preparation and use in other regions of the world.

The hard coal, both indigenously produced and imported, is much less expensive than imported oil or gas and the majority of EU member states enjoy the benefits of competitive coal - fired electricity generation.

Coal today plays a lesser role in the heating of buildings, except in several eastern European countries, Turkey, China and North Korea. For power generation, coal plays a major role in both developed and emerging economies.

Romania's entire hard coal and lignite output is used for heat and power generation.

References

1. Arad, S., Arad, V.

Prospect on the energy market in Romania, Papers SGEM2014/Conference Proceedings, ISBN 978-619-7105-15-5, ISSN 1314-2704, 433-440 pp, Vol. Energy and clean technologies, Volume 1, DOI:10.5593/sgem2014/BD1, Albena Co., Bulgaria, 2014

2. Arad, S., Samoilă, L.

Future of coal and challenges in energy field, Proc. of Int. Symp. *Universitaria SIMPRO2014*, ISSN–L 1842 – 4449, ISSN 2344 – 4754, pp. 289-295, Universitas Publishing House, University of Petrosani & INSEMEX Petrosani Eds., Petrosani, 2014, www.upet.ro/simpro/2014/

3. Bezdek, R.

A Coal-Based Strategy to Reduce Europe's Dependence on Russian Energy Imports, Cornerstone The Official Journal of World Coal Industry, Volume 2 Issue 3, Autumn 2014, pp. 34-39

4. EURACOAL

Coal industry across europe, ISSN 2034-5682, 5th edition, 2013

5. EURACOAL

Market Report 1/2014, May 2014

6. BGR (Bundesanstalt für Geowissenschaften und Rohstoffe – Federal Institute for Geosciences and Natural Resources) (2013), DERA Rohstoffinformationen 15 (2012)

Energy Study 2012 – Reserves, Resources and Availability of Energy Resources, BGR on behalf of the German Mineral Resources Agency (DERA), Hannover, 28 March 2012.

7. BP (2013a)

BP Statistical Review of World Energy 2013, BP plc, London, June.

8. BP (2013b)

BP Energy Outlook 2030, BP plc, London, January.

9. DG Energy (2013)

EU Energy in Figures – statistical pocketbook 2013, European Commission, Luxembourg.

10. European Commission (2013), “*Energy challenges and policy*”, Commission contribution to the European Council of 22 May 2013.

11. IEA (International Energy Agency) (2012)

World Energy Outlook 2012, OECD / IEA, Paris.

12. IEA (2013a)

Medium - Term Coal Market Review, OECD / IEA, Paris.

13. IEA (2013b)

Coal Information 2013, OECD / IEA, Paris.

14. McCloskey (2013)

IHS McCloskey Coal Information Service.

15. *Strategia energetică a României pentru perioada 2007 – 2020, actualizată pentru perioada 2011 – 2020, 2007*

http://www.minind.ro/energie/STRATEGIA_energetica_actualizata.pdf

16. Oltenia Energy Complex

Public information, www.cenoltenia.ro/

17. Hunedoara Energy Complex

<http://www.cenhhd.ro/>

18. World Coal Association

<http://www.worldcoal.org/>

19. Regulatory Authority for Energy

<http://www.anre.ro/>