The Potential for Sustainable Biomass in the Romanian Energy Sector

Activity 15: Case study Paroseni: from coal to black pellets

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Description of the activity: Based on a field visit and stakeholder interviews, as well as on the examination of the economic and technical parameters of the coal-fired power plant in Paroșeni, we will write a case study on the local potential of coal to black pellets conversion. We will analyze the ideal supply chain potential and potential bottlenecks, as well as examine, if energy crops are to be taken into account, the necessary surface for cultivation, as well as its local availability.

1.Introduction

In the last years in Romania is registered a trend to reduce the contribution of coal dedicated to generate electricity as a main part of the strategy for decarbonization (Ministerul Energiei, 2022). Even so coal represents an important resource for the energy market in Romania. According to the National Energy Regulatory Authority (ANRE), in January 2023 in Romania was registered one of the lowest cote of electricity produced by coal which was injected in the grid (12.02%) (ANRE, 2023).

Traditionally, Romania had important coal resources but in the context of climate change and the new EU Energy Strategy (e.g. European Green Deal, Repower, Fit for 55, Integrated National Energy and Climate Change Plans) doubled by the lack of investments in the coal industry in the last 30 years, the efficiency of coal extraction is very low. Main coal mines were closed and the coal extraction in Romania is decreased continuously. The coal production in Romania was at its highest level of 66.462 million tonnes in 1989 and in December 2020 were reported 15.002 tonnes (CEIC, 2023).

Therefore, also the power plants energy production based on coal decrease continue. To investigate the issue in depth, Paroseni power station is to be considered as a typical example.

2.Paroseni power plant

Short history

SE Paroseni is the oldest coal -based power plant in Romania and was build in 1950. It is also one of the important power station in the south-west of Romania, with a 150MW capacity in cogeneration (Draghina, 2023). It provided 200000 inhabitants of the four mining towns (Vulcani, Paroseni, Lupeni, Petrosani) in the area with hot water and hitting.

Figure 1. SE Paroseni

This thermal power plant from Paroseni was designed to operate with coal from Valea Jiului (with a low caloric value between 3300kcal/kg and 4510kcal/kg) but, due to the reduction in the amount of coal extracted from the mines of the Jiului Valley, it was also operated with imported coal (with a higher caloric value up to 6000kcal/kg) mixed with Valea Jiului coal (80% local coal and only 20% imported coal), so as not to exceed the lower calorific value maximum design of the boiler combustion system.

Last Retrofitting at SE Paroseni

The modernization of the Paroseni Thermal Power Plant was carried out by a consortium made up of Japanese companies Itochu, Hitachi and Toshiba in 2007 and consist in the retrofitting of the power station 4. The project included the refurbishment of a group of 150 megawatts and 150 gigacalories/hour, for which 135 million dollars were spent. There is to mention that the new boiler of the power station 4 (Hitachi-Babcock) can only withstand up to a coal calorific power of 4500 kcal, therefore the supply with coal has to fulfill this requirement.

The electric generator TAKS-RCH installed in 2007 is produced by Toshiba (Japan) and at that time was the only in Europe designed with air cooling.

In 2007 was modernized also the electric power station of 110 kV.

The last retrofitting from 2018 consists in new systems for reducing sulfur and nitrogen oxides and ensuring slag and ashes deposits. The investment of 65.3 Mil Euro in the new system enables the reduction of SO_2 emissions with 94% (Draghina, 2023). Thus according to the data in table no.2 the new SO2 emissions are lower than the EU Emission limit values (200 mg/Nm3) for existing medium combustion plants with a rated thermal input greater than 5 MW, other than engines and gas turbines (Directive EU, 2015). The same situation is registered at NOx emissions which are lower than EU emission limit values (RAM, 2022; RAM 2018; RAM 2017; Radulescu, 2016).
The turbine Turboatom (Ukrain) was modernized in 1995 but is not any more efficient and has to be changed.

The current situation at SE Paroseni

At present SE Paroseni has 197 personnel in site working.

Even that SE Paroseni has an Integrated Environmental Authorization, due to the fact that the mines from Valea Jiului couldn't any more assure the daily amount of coal closed to 2000 tonne/day (1815 tonne/day) starting from the winter of 2019-2020, the supply of thermal energy in the centralized system was stopped.

Unfortunately, due to the lack of an energy strategy in the region, the low efficiency of its power stations and the higher prices for the CO_2 certificates Societatea Complexul Energetic Hunedoara which manage also the Sucursala Electrocentrale Paroseni entered in insolvency.

In parallel in the region the most of the households decided to disconnect from the centralized heating and hot water system and choose new hitting systems based on wall gas boilers. Therefore Paroseni SA power station couldn't use any more its distribution system, which was sold in order to pay a part of its debts. Unfortunately rows from the distribution system of Paroseni were sold on as scrap metal or even were stolen by thieves.

Under these circumstances, Paroseni power station produce energy only occasionally (two days per week). For example the real efficiency of the Paroseni power station is low and varies between 31% and 34% (Table no.1) due to the fact that the cogeneration system cannot be use any more. However at last performance tests from 2015 the boiler efficiency was similar with the nominal technical values of 90% (Table no.1).

Table no. 1 Efficiency of the power station no.4 (2015)

Power station no.4	Boiler Efficiency	Turbine Efficiency	**Total Efficiency**

Condensation 115MW	90.7	55.58	34.75
Condensation 130MW	90.8	55.26	34.01
Condensation 150MW	88.45	55.75	31.86
Cogeneration 115MW+48.75Gcal/h	91.12	68.15	48.94
Cogeneration 130MW+48.75Gcal/h	92.78	66.78	48.25
Cogeneration 150MW+48.75Gcal/h	90.05	65.66	45.52

Source: Societatea Complexul Energetic Hunedoara, 26.04.2023

Due to the lower efficiency of the turbine (55%) the electrical efficiency of the power station no.4 is lower than 34% (Table no.1).

A higher efficiency of the power station no.4 (up to 49%) could be obtain by working in cogeneration, but only with a new distribution system due to the fact that currently at Paroseni there is no functional distribution system for the thermal agent.

3. SE Paroseni CO_2 emissions and the specificity of its supply process with coal

The coal from Valea Jiului has following physical-chemical characteristics: total humidity (11,2 - 6,0 % -(10, 7 % guarantee value)-); ashes (46 - 33,7 % -(38,0 % guarantee value)-); caloric power (3300 - 4510 kcal/kg - (3916 % guarantee value)-) (Sava, 2023).

The emissions (SO2, Nox, CO2, CO and dust) at SE Paroseni are measured at the source and the measured system is supported by a dedicated soft program (Dumitrescu, 2023).

The emissions are correlated with the amount of coal burned. The coal requirement for the power station 4 varies from a minimum of 1200tonne coal/day up to 2000tonne/day (coal with a low caloric value).

The designed amount of coal consumed annually is 665000 tonne at an average calorific value of 3750 kcal/kg, humidity of 6.5% and ashes 43%.

For the planned production the power station uses also 55000 thousand m^3 gas with an average caloric value of 8330 Kcal/Nmc.

There has to be mention that at present power station Paroseni complies with the environmental condition of the European Union (Table no.2).

Table no.2 Emissions at Power Station Paroseni in 2022

Pollutant	Emission limit values Decision UE 1442/2017	Emission mean values at Power station Paroseni
SO_2 (mg/Nm^3)	130	22.6777
NOx (mg/Nm^3)	150	139.448
Dust (mg/Nm^3)	12	7.802

Source: Societatea Complexul Energetic Hunedoara, 26.04.2023

4. Scenaries for Decarbonisation at SE Paroseni

In order to increase the efficiency of the Paroseni power plant the measures have to take into account one of the two hypothesis:

Hypothesis A: Rehabilitation of the centralized thermal energy supply system in Paroseni area

Hypothesis B: Paroseni power station will work only as an electrical power station.

Under the assumption of the **Hypothesis A** the main scenario are presented below.

S1: New Retrofitting of SE Paroseni

Measures:

- Replacing the turbine, for example with one Alstom;
- Changing the burner to increase energy efficiency and reduce the NO_x emissions;
- Replacing the mills system;

- Modernization of high and medium pressure blocks, including the admission system for turbine 4 type K 160-130;
- Modernization of high pressure pre-heater (PIP) for the turbine;
- Replacing the basic ejectors and the sealing one of the turbine with high efficiency vacuum pumps;
- Modernization of the rotary preheater for air related to the boiler
- Modernization of the distribution control system (DCS) of the power station by performing the software and hardware upgrade to the latest existing version;
- Strengthening the walls of slag and ash deposits for landfills and raising them to reduce, until new investments, air and water pollution with residues from the coal burning process (Draghina, 2023)
- CCS

Due to the precarious financial situation and the status of the main company (Societatea Complexul Energetic Hunedoara SA) as an insolvent company, these investments cannot be made.

S2: Conversion from coal to Gas

Measures:

The coal conversion to natural gas in power station is based on two main methods:

- The first one is to retire the coal-fired plant and replace it with a new natural gas-fired combined-cycle (NGCC) plant.
- The second one is to convert the boiler of a coal-fired steam plant to burn other types of fuel, such as natural gas.

Is has to be mention that even the emission of CO_2 are lower from the combustion of fossil gas than from coal, these cannot be neglected. The new fossil gas plants still produce over 300g CO_2/kWh. On the other side for designing gas power plants it has to be evaluate the impact of methane (CH_4) emissions. These have to be estimated for the whole supply process of methane starting with the exploration and dealing with production, transport, distribution and final burning in power stations. Even more methane traps significant more heat than CO_2 (up to 86 times more than CO_2 for a 20 year period) and therefore is twice responsible for global heating (IEA, 2021).

Moreover in order to fulfill the climate targets established by the Paris Agreement the Sustainable Development Scenario proposed by IEA consider that global CH_4 emissions have to decrease with 70% by 2030 compared to the emissions from 2020. Therefore the fossil gas has to be replaced by the energy produced from renewables in parallel with the increase of energy efficiency (IEA, 2020).

Brown (2021) consider that strategies based on switching from coal to fossil gas-fired power generation have high associated financial risks, especially compared to alternative investment opportunities, such as wind and solar power. This risks were already mentioned in the Report of the International Energy Agency (IEA) World Energy Outlook 2020 where was stipulated that the opportunity for coal to gas conversion closes in the 2020s in the United States and the same process is registered also in European Union. The main argument is offered by the increased market share of renewable energy sources (IEA, 2020). EU took even more restrictive measures and proposed emissions limit of 100g CO_2/kWh in the EU Taxonomy for sustainable finance.

This would exclude any new or existing fossil gas plants (without Carbon, Capture and Storage capabilities) from being labelled as sustainable (Brown, 2021). Meanwhile the European Investment Bank (EIB) finance projects for power plants that emit less than 250g CO_2/kWh and discourage all investments for fossil fuels (EIB, 2020).

S3: Conversion from coal to Biomass

Measures:

The new idea for decarbonisation of the SE Paroseni, which is a pulverized coal combustion plant, involves an arrangement of large-scale biomass burning.

Bioenergy plays an important role in reducing CO2 emissions, hence meeting the Romania low carbon objectives by 2050 (Ministerul Energiei, 2022). However there is a need to design and analyze the whole process and the related emissions for each phase from harvesting, transport, processing and burning the biomass. These are influenced by the type of biomass used.

Biomass, or organic material based on plant, is considered to be the main energy resource in the world after oil, coal and gas. The main sustainable biomass which can be considered as a renewable energy source is sourced from forests and agriculture residue (Slade et al, 2011).

According to consultants from Green Building Forum and Grant and Clarke woodchips emissions are 0.015 kg/kWh of net CO2 and also wood pellets have emission of net 0.037 kg/kWh. Therefore we can't speak about zero carbon emissions but these are one to ten of those from burning gas. Hence, "the process of combusting wood produces the same amount of CO2 in the process of coal combustion, both about 0.46 kg/kWh of delivered heat". As a conclusion the supply of power stations with wood by itself is not the best solution for carbon reduction (Affan&Maaroof, 2016).

In practice only few wood has a lowest carbon impacts and these are a very specific and small proportion of forestry products. Therefore in practice is even more difficult to design a supply system only with low carbon sources of wood to be burned in power stations. This assumption indicates that without a proper designing of the supply chain for a power station there is a risk that the used biomass can even increase the amount of carbon emissions.

Another risk by using biomass is the financial one. The progressively reduction of the costs of energy produced from photovoltaic and wind parks put in difficulty the biomass projects for new power stations due to the fact that biomass is in principle an expensive resource (taking into account the whole supply chain). As an example, the main UK power station which is implementing the conversion strategy from coal to biomass has to receive subsidies of £10 billion by 2027 in addition to their carbon tax breaks for being carbon neutral (MacDonald, 2020).

By combusting biomass, CE Paroseni produces no net increase in the CO_2 amount in the atmosphere, due to the fact that the biomass consumes and produces similar amounts of CO_2 while growing and combusting. Moreover, biomass has the ability to produce noticeable reduction in CO_2 emissions in relation to coal-fired and gas-fired generation over its life cycle (Littlecott et all, 2018).

Pulverized Biomass

It has been stated that the combustion of biomass to produce energy results in undesired emissions of CO2. By conversion from coal to biomass the emissions of power station 4 will be significant reduced. In order to use the local biomass there is a need to take into rethink the Romanian Strategy for Biomass which has to include also the construction of large pellets plants which can process biomass (e.g. straw) from local farmers into a readily usable form.

S3: Conversion from coal to black Pellets

Measures:

The main results of the research Activity A10 from this project coordinated by Sintef (Norway) estimates the CO_2 reduction potential of using black pellets for energy production. The estimations were made for the power plant Paroseni as a reference case but only for a 50 MW heat power capacity. This represents only a third part of the total capacity of 150 MW at Paroseni.

These results from activity A10 indicate that due to the conversion from coal to black pellets is estimated a huge reduction of total CO2 emissions from 657,9 ktCO2 to calculated 35.9 ktCO2 per year. "The difference is mainly due to the larger emissions occurring during coal extraction and emissions released during the combustion of coal for power production, while net emissions from combustion of black pellets are zero since the biomass captures CO_2 during its lifetime".

The weak points of this conversion are related to the reduced feedstock availability in Romania.

Based on the data from 2015 (Table no.3) in Romania the potential available wood for energy production and other relevant data is limited (European Bioenergy Outlook,2019). “Available stock of forest increased from $1.3*10^9$ m^3 to $1.9*10^9$ m^3 from 1990 to 2015. Removal of total round wood was $15*10^6$ m^3 in 2017 of which 4849 m^3 was for fuel.

Table no 3 Forest area, 2015 in kilo hectares (*European Bioenergy Outlook, 2019, A10)*

Total land area	Total area of forests and other wooded land	Forests	Forests available for wood supply	Other wooded land
23.907	6.951	6.861	4.627	90

4849 m^3 fuel wood corresponds to 2570 kilotons if we assume Douglas fir whose density is 0.53 t/m^3, d_{wood} (Wood, 2023). Therefore, the amount of wood necessary of a 50 MW power plant is 15% of the wood fuel harvested in 2017 in Romania. It is important to note that the amount of wood waste was 3284 kilotones in 2016 which can potentially be utilized for black pellets, thus energy production”.

It has to be mention that based on this research results for the whole conversion to black pellets of the Paroseni power plant the necessary amount of wood has to be tripled, which may be equivalent whit the around 50% of the wood fuel harvested in 2017 in Romania.

5. Conclusion

The coal conversion strategy is a long term strategy. Big players on the coal power plants market are planning on switching from coal to fossil gas and biomass for power generation from now until 2050.

The case study indicates that isolated measures are not a solution in order to save the bankruptcy of Paroseni power plant. Only a good strategy which will integrate the whole supply chain for the power station and will be also financed and implemented by specialists can avoid the continuous degradation of this power station.

Even so there are significant environmental and economic risks associated with a coal conversion strategy of the Paroseni power station.

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