Report

The Potential for Sustainable Biomass in the Romanian Energy Sector
Value chain analysis for potential black pellets investments

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SUMMARY
The main objective of this activity is to conduct a value chain analysis for assessing the potential of using black pellets instead of coal for energy production in Romania. The landscape of biomass production in Romania has grown increasingly competitive due to the rising demand and the proliferation of pellet producers seeking raw materials. Additionally, this shift stems from the decline in wood processing and exploitation activities over recent years, primarily due to reduced access to forest resources, legislative instability, and bureaucratic hurdles. Romania officially harvests 19 million cubic meters of wood annually, exploiting only 50% of its sustainable potential exploitation rate which is the growth rate of forests. Operating costs for the value chain of power production from black pellets and coal are estimated, which was 100.68 million RON/year for black pellets value chain. This is more than 5 times higher than that of using coal, estimated to 18.18 million RON/year. The difference is mainly due to the extraction phase since biomass harvesting is more costly than coal mining activity. The black pellets value chain includes their production from biomass, namely pretreatment and steam explosion which require electricity to be feasible. It is important to note that there is a significant difference in ash contents of these two fuels which would make a difference in total costs due to ash disposal costs. However, local data from Romania was not available as per today and thus not included in the calculations.

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1 Introduction

The main objective of this activity is to conduct a value chain analysis for assessing the potential of using black pellets instead of coal for energy production in Romania. The secondary objectives are listed below:

- Overview of feedstock availability in Romania for black pellets production
- Comparative analysis of operational costs for using black pellets versus coal for energy production

The black pellet manufacturing industry has drastically advanced in the last years, as a clear alternative to the use of conventional forest products, given the advantages obtained through the use of value-added forest and agricultural products and a reliable and efficient waste management. This has been obtained due to the creation of black pellets that are considered as renewable sources of energy production. The high energy efficiency is due to the high density, heat value and low moisture, but also due to the low costs of storage and transport. The use of black pellets has equally become relevant for residential and industrial use, in both production of energy and heat.

Due to the higher increase in demand for more renewable sources, the demand for black pellets has sky-rocketed and posted significant pressure on the supply side. This has led to the increase of black pellet production facilities, competing on a limited amount of wood resources. Given the scarce wood and agricultural resources and the increased competition, the production facilities have continually optimized their production, logistics, and sale operations in order to maintain their shares in the market.

The concept of value chain was first proposed by Porter who defined it as a sequence of key activities performed within an organization that generates value with respect to a product or service [1]. The value chain is seen as a general framework for thinking strategically about the activities involved in any business and assessing their relative cost and role in differentiation. More specifically, the value chain displays the total value of a firm and consists of value activities and margins. In Porter's framework, value activities are the physically and technologically distinct activities a firm performs, that is, building blocks by which a firm creates a product valuable to its buyers. According to Porter [1], the margin is the difference between the total value and the collective cost of performing the value activities.

The value activities have been split into two categories, primary activities, and support activities. The primary activities are those related to the physical creation of the product and its sale and transfer to the buyer and the after-sale assistance. They comprise of inbound logistics, operations, outbound logistics, marketing, and sales and service activities. The value chain tracks all the activities within a firm which contribute to the completion of a product or service from its conception to the final form that brings the biggest added value while it moves across the supply chain. The basic idea is that every component within the value chain generates value that exceeds the expenses associated with product or service manufacturing and production, thus resulting in the creation of a positive net revenue. Thus, it can be inferred that maximizing the profit can be obtained through maximizing the value obtained at every stage of the supply chain, while minimizing concomitantly the cost. The value chain concept involves not only internal factors but also external ones, such as suppliers and sellers, and the relationships within their activities. Also, competition may impact the dynamic and performance of the value chain. The competitive advantage can be obtained through diminishing the cost or by altering and optimizing the value chain. Value chains differ from one firm to another, and from one industry to another.

The supply chain defines a network of buyers and sellers which are related to the movement of the raw materials through production processes to final customers. Meanwhile, the value chain defines a set of processes and activities that take place in a company or sector that add value to a product or service, considering both primary and secondary processes of production, distribution and use of the good or service. The literature on the topic interchangeably uses the terms of supply and value chain. However, the processes are different, with the supply chain defining a series of firms or separate agents which carry their own value chains that push materials forward and make products and services reach the customers.

Value chain optimization can be achieved when a company's manufacturing functions within the supply chain integrate and coordinate more effectively through suitable value chain governance at the operational level. This enhances the overall efficiency of the supply chain. Consequently, we can infer that more effective management of distribution channels, sustainable operations, advanced long-term forecasting, and improved operational methods in the black pellet supply chain will result in an enhanced value chain. To accomplish this, a range of operational management strategies in the supply chain should be employed and refined, and the exploration of various modelling techniques will lead to a more optimal fit for modelling the black pellet supply chain under evolving market conditions.

In the following we will describe the challenges of the value chain analysis of a typical black pellet production facility. The black pellet production process consists of drying, grinding, conditioning, pelletizing, screening for fine separation, and packaging/storing of the final product. The main black pellets are wood pellets, and the raw materials used for wood pellet manufacturing are mainly wood shavings and sawdust from the wood processing industry. However, woody biomass may come from a large range of sources, such as mill waste, urban clearing, harvest residuals, roundwood, etc. This is then complemented by agricultural biomass. The most up-to-date technologies allow that from 7.5 m^3 of sawdust, with a moisture content of 7% up to 10%, to produce one ton of pellets.

The start of the wood pellet value chain is the harvesting operation on the forest landowner's site. This involves the importance of securing a sufficient wood fibre supply and evaluating the transportation costs associated with moving the biomass from the harvesting location to the biomass facility. After undergoing production and cooling process, the pellets are either packed in small bags (for residential customers) or large containers (for industrial customers) or stored in bulk within silos or industrial storage facilities. The bulk of the cost of the black pellets is the cost of the raw materials and that for drying the pellets, while their maintenance and storing costs are rather low.

1.1 Romanian biomass providers for black pellet producers

In Romania there are three types of black pellets producers:

1. Integrated producers: These form the bulk producers and primarily utilize wood residuals, particularly sawdust, to manufacture pellets.

2. Standalone producers: These producers purchase sawdust and wood from other wood producers, often in regions like Suceava county. They are willing to offer premium prices for raw materials like sawdust and leftover wood due to the substantial value added during their production process.
3. Agropellet producers: These producers focus on agricultural pellets, manufacturing them from materials like straw and corn cobs. Agropellets contain higher levels of silicon, making them unsuitable for household use as they generate excessive amounts of ash.

The landscape of biomass production in Romania has grown increasingly competitive due to the rising demand and the proliferation of pellet producers seeking raw materials. Additionally, this shift stems from the decline in wood processing and exploitation activities over recent years, primarily due to reduced access to forest resources, legislative instability, and bureaucratic hurdles.

Utilizing biomass for electricity production is contingent on the use of certified biomass, a challenging endeavor. Certification of forest-harvested biomass poses difficulties, and maintaining traceability and origin source records can be equally challenging. The introduction of price caps has prompted some producers to shift their focus toward international markets. The instability in legislative and fiscal domains has compelled producers to diversify their distribution channels, both domestically and externally, as a safeguard against potential disruptions in an unpredictable environment.

Presently, the residential pellet consumption market in Romania consists of approximately 90,000-100,000 households, each with an average annual consumption of 3 tons. Additionally, there are roughly 100,000 semi-industrial consumers, such as farms and bakeries, utilizing black pellets for commercial use.

Romania officially harvests 19 million cubic meters of wood, exploiting only 50% of its sustainable potential exploitation rate, that is, the growth rate of forests. In contrast, Nordic countries and Germany operate at a rate of approximately 95%. However, the extent of illegal logging remains a highly debated issue. According to the Ministry of Environment's European Semester Report from 2020, illegal wood harvesting, primarily due to illegal logging, results in annual losses of around 6 billion EUR.

With the impending introduction of financial incentives for forest owners who preserve their woodlands through carbon credits, it is expected that fewer forest owners will engage in wood harvesting. Another challenge in black pellet production pertains to the access to biomass sources, particularly the existing infrastructure of roads.

2 Overview of feedstock availability in Romania

This analysis is based on production of black pellets from sawdust that originates from woody biomass referred to as wood throughout the report. Available stock of forest and removal of round wood in Romania are shown in Table 1 [2].

Table 1 Available stock of forest and removal of round wood in Romania, data from [2].

Available stock of forest			Removal of round wood		
Amount in 1990	Amount in 2015	Yearly increase	Total amount in 2017	For fuelwood in 2017	For other purposes in 2017
1.3×10^9 m^3	1.9×10^9 m^3	1.5%	15×10^6 m^3	4.85×10^6 m^3	10.15×10^6 m^3

A quantity of 4.85×10^6 m^3 fuelwood, assuming a density of $d_{wood} = 0.53$ t/m^3 for Douglas fir [3], corresponds to 2,570 kilotons (denoted as M_{wood}). Douglas fir is an important species in forestry and is commonly used in construction for lumber, plywood, etc. It has recently been suggested for wider plantation in Romania due to its resistance and resilience to drought [4]. The amount of wood required to operate a 50 MW power plant, equivalent to 157.28 kt/y (see Table 3) accounts for only 6.13% of the total wood fuel harvested in Romania in 2017.

In a generic analysis of the value chain of co-firing steam exploded biomass (black pellets) and pulverized coal, the HHVs of coal and black pellets were estimated to be 25.82 MJ/kg and 21.4 MJ/kg, respectively [5]. Using the above HHVs, the amounts of feedstock $\dot{M}_{fuel}$ needed for the annual operation of a 50 MW power plant can be calculated from the following formula:

$$\dot{M}_{fuel} = W_{capacity} / HHV_{fuel} \times t_{annual} \times (3600\ s/h) \times (10^{-6}\ kt/kg),$$

where $W_{capacity} = 50$ MW, HHV_{fuel} is the heating value of the corresponding fuel, and t_{annual} is the annual number of hourly operation assumed to be t_{annual} = 8,000 hrs/year. For coal and black pellets, the annual amounts of feedstock needed for a 50 MW power plant are presented in Table 2.

Table 2 Higher heating values (MJ/kg) and annual amounts (kt/y) of fuels for a 50 MW power plant.

Feedstock	HHV [MJ/kg]	$\dot{M}_{fuel}$ [kilotons/year]
Coal	25.82	55.77
Black pellets	21.3	67.61

3 Operational cost estimation for a 50 MW power plant

In the following, two distinct value chains are considered to estimate the operational costs of a power plant with 50 MW fuel input: Coal based power plant (reference case) and a black pellets-based power plant for production of heat and power with 50 MW capacity. A schematic representation of the two value chains is given in Figure 1.

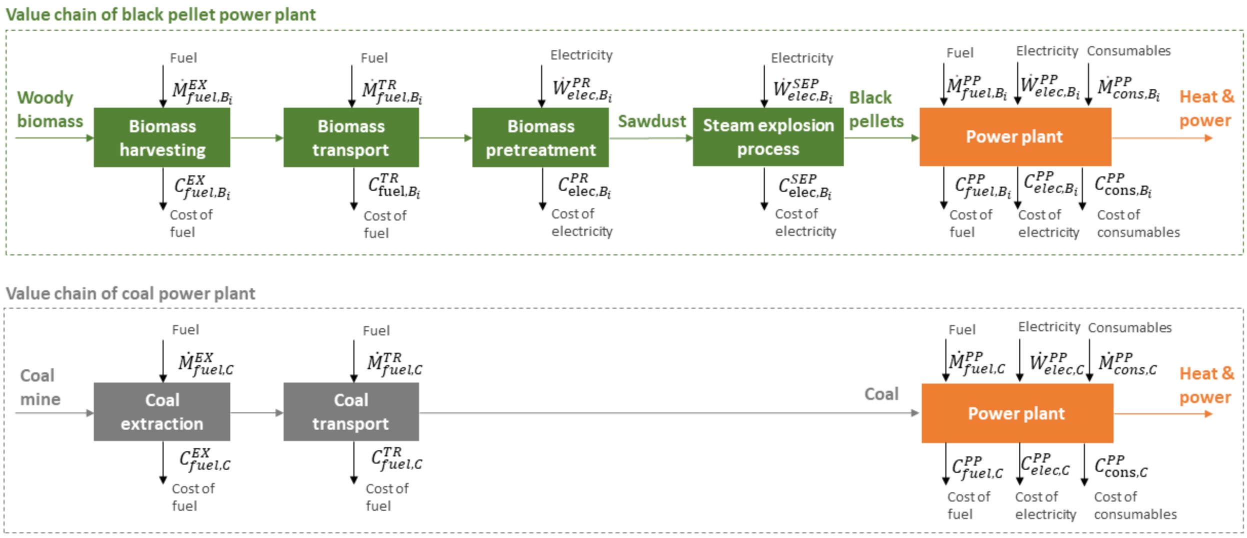

Figure 1 Schematic representation of the overall value chain considered here which entails combustion of black pellets produced from steam explosion of woody biomass in a power plant and combustion of coal in a power plant. The schematics is adopted from the value chain model considered in the analysis of [5].

Both value chains cover feedstock extraction/harvesting from the source, transport, and use in the power plant. Estimation of fuel requirements based on a 50 MW plant capacity and 8,000 hours of annual operation is given in Table 3. Sawdust to black pellets conversion yield ($y_{blackpellet}$) is estimated as 2.09 kg sawdust/kg black pellet based on the data from [5]. Similarly, the amount of wood required to supply the necessary sawdust is estimated as 157.28 kt/year, using the mass conversion yield ($y_{sawdust}$) of 1.11 kg wood/kg sawdust from the same source. Calculations are shown below.

$$\dot{M}_{blackpellet,B_i} = \dot{M}_{sawdust,B_i} \times y_{blackpellet}$$

$$\dot{M}_{sawdust,B_i} = \dot{M}_{wood,B_i} \times y_{sawdust}$$

Table 3 Estimation of annual fuel amount for coal based and black pellet-based power plants data from [5].

Coal power plant		Black pellet power plant	
Coal amount (kt/y)	55.77	Black pellet amount (kt/y)	67.61
		Sawdust amount (kt/y)	141.55
		Wood amount (kt/y)	157.28

3.1 Lists of parameters and variables

Tables 4 and 5 contain lists of parameters and variables that are used in the value chain model for power production based on black pellets and coal. Table 4 contains the list of parameters with the applied values in the current study. Table 5 contains the list of variables that are calculated by the value chain model.

Table 4 List of parameters for the black pellets and coal value chains.

Parameter	Symbol	Value
Higher heating value of coal	HHV_{coal}	25.82 MJ/kg
Higher heating value of black pellet	$HHV_{blackpellet}$	21.3 MJ/kg
Wood to sawdust mass yield	$y_{sawdust}$	1.11 kg wood/kg sawdust
Sawdust to black pellet mass yield	$y_{blackpellet}$	2.09 kg sawdust/kg black pellet
Density of wood – Douglas fir	d_{wood}	0.53 t/ m^3
Diesel consumption of chain saw	$m_{diesel,wood}$	2 l/m^3
Cost of diesel	c_{diesel}	6.75 RON/l diesel
Diesel consumption of truck	$m_{diesel,truck}$	0.3 l/km
Load capacity of truck	$m_{load,truck,B_i}$	12 t/shipment
Average transport distance from biomass source to the plant	$L_{wood,Bi}$	200 km/shipment
Cost of electricity	c_{elec}	0.47 RON/kWh
Specific electricity consumption for log debarking and milling	w_{elec,B_i}^{dm}	36.7 kWh/t
Specific electricity consumption for sieving	w_{elec,B_i}^{s}	7 kWh/t
Specific electricity consumption for dust receiving and scalping	w_{elec,B_i}^{rc}	1.5 kWh/t
Specific electricity consumption for pre-drying	w_{elec,B_i}^{predry}	15 kWh/t
Specific electricity consumption for dust screening and sieving	w_{elec,B_i}^{ss}	4 kWh/t
Specific electricity consumption for dried dust milling	w_{elec,B_i}^{dmill}	11 kWh/t
Specific electricity consumption for steam explosion unit	w_{elec,B_i}^{SEU}	25 kWh/t
Specific electricity consumption for post-drying	$w_{elec,B_i}^{postdry}$	26 kWh/t
Specific electricity consumption for black pellets milling	w_{elec,B_i}^{bpmill}	4 kWh/t
Specific electricity consumption for pelleting	w_{elec,B_i}^{pellet}	103 kWh/t
Fuel oil used in auxiliary burners of black pellet power plant	m_{fuel,B_i}^{PP}	0.06 l/GJ input fuel
Specific ammonia consumption in power plant	$m_{ammonia,B_i}^{PP}$	5.44 l/t input fuel
Specific water consumption in power plant	m_{water,B_i}^{PP}	715.5 l/t input fuel
Specific limestone consumption in power plant	$m_{limestone,B_i}^{PP}$	34.74 kg/t input fuel
Cost of ammonia	$c_{ammonia}$	7.74 RON/l

Cost of water	c_{water}	0.23 RON/m^3
Cost of limestone	$c_{limestone}$	178.5 RON/t
Efficiency for nominal power production	η_{nom}	33%
Efficiency for net power production	η_{net}	30%
Plant capacity	$W_{capacity}$	50 MW
Specific cost of coal extraction	$c_{coal,C}^{EX}$	173.85 RON/t
Load capacity of truck for coal transport	$m_{load,truck,C}$	32 t/shipment
Average transport distance from coal source to power plant	$L_{coal,C}$	90 km
Fuel oil used in auxiliary burners of coal power plant	$m_{fuel,C}^{PP}$	0.06 l/GJ input fuel
Specific ammonia consumption in power plant	$m_{ammonia,C}^{PP}$	5.44 l/t input fuel
Specific water consumption in power plant	$m_{water,C}^{PP}$	715.5 l/t input fuel
Specific limestone consumption in power plant	$m_{limestone,C}^{PP}$	34.74 kg/t input fuel

Table 5 List of variables for the black pellets and coal value chains.

Variable	Symbol
Annual amount of wood	$\dot{M}_{wood,B_i}$
Fuel required for biomass harvesting	$\dot{M}_{fuel,B_i}^{EX}$
Operational cost of biomass harvesting	C_{fuel,B_i}^{EX}
Fuel required for biomass transport	$\dot{M}_{fuel,B_i}^{TR}$
Operational cost of biomass transport	C_{fuel,B_i}^{TR}
Operational cost of biomass pretreatment	C_{elec,B_i}^{PR}
Total electricity consumption of biomass pretreatment	$\dot{W}_{elec,B_i}^{PR}$
Total electricity consumption of steam explosion process	$\dot{W}_{elec,B_i}^{SEP}$
Operational cost of steam explosion process	C_{elec,B_i}^{SE}
Annual amount of sawdust	$\dot{M}_{sawdust,B_i}$
Annual amount of black pellet	$\dot{M}_{blackpellets,B_i}$
Operational cost of black pellet powered power plant	$C_{blackpellet,B_i}^{PP}$
Internal power consumption of power plant	$\dot{W}_{elec,B_i}^{PP}$
Amount of fuel oil used in auxiliary burners	$\dot{M}_{fuel,B_i}^{PP}$
Cost of consumables	$C_{cons,Bi}^{PP}$
Operational cost of coal extraction	$C_{coal,C}^{EX}$
Operational cost of coal transport	$C_{fuel,C}^{TR}$
Fuel required for coal transport	$\dot{M}_{fuel,C}^{TR}$
Operational cost of coal-fired power plant	$C_{coal,C}^{PP}$
Internal power consumption of coal power plant	$\dot{W}_{elec,C}^{PP}$

Annual amount of coal	$\dot{M}_{coal,C}$
Internal power consumption of power plant	$\dot{W}^{PP}_{elec,C}$
Amount of fuel oil used in auxiliary burners	$\dot{M}^{PP}_{coal,C}$
Cost of consumables	$C^{PP}_{cons,C}$

3.2 Operational cost for value chain of black pellet power plant

3.2.1 Biomass harvesting

Biomass harvesting consists of cutting trees with diesel-powered chain saws. The use of diesel is given as $m_{diesel,wood}$ = 2 liter/m^3 for wood cut in the literature [6], and the cost of diesel is set to c_{diesel} = 6.75 RON/l diesel (average cost for July 2023) [7]. The costs that arise from biomass harvesting are assumed to be due to the use of diesel only and given by

$$C^{EX}_{fuel,B_i} = \dot{M}^{EX}_{fuel,B_i} \times c_{diesel},$$

where the fuel required for biomass harvesting is

$$\dot{M}^{EX}_{fuel,B_i} = \dot{M}_{wood,B_i} \times m_{diesel,wood} \,/\, d_{wood}.$$

Here, d_{wood} is the density of dry wood, assumed to be the d_{wood} = 0.53 t/m^3 (density of Douglas Fir) in this work [8].

3.2.2 Biomass transport

Biomass transport consists of transporting the harvested biomass to a biomass pretreatment location. The transport is assumed to be done by trucks using diesel as fuel. Costs arising from transport, C^{TR}_{fuel,B_i}, is due to diesel consumption and given by

$$C^{TR}_{fuel,B_i} = \dot{M}^{TR}_{fuel,B_i} \times c_{diesel},$$

$$\dot{M}^{TR}_{fuel,B_i} = \dot{M}_{wood,B_i} \times m_{diesel,truck} \times L_{wood,Bi} \,/\, m_{load,truck},$$

where $\dot{M}^{TR}_{fuel,B_i}$ is the annual amount of diesel consumption, $m_{diesel,truck}$ is the diesel consumption of a truck (0.3 liter/km [9]), $m_{load,truck,B_i}$ is the load capacity of a truck (12 tons/shipment [10]), and $L_{wood,Bi}$ is the average transport distance from biomass source to the plant (200 km/shipment [10]).

3.2.3 Biomass pretreatment

Biomass pretreatment is the production of sawdust from wood and consists of log debarking and milling and sieving. Costs arising from pretreatment is due to electricity use with a cost of c_{elec} = 0.47 RON/kWh for Romania based on average of August 2023 [11]. The operational cost of biomass treatment is then given by

$$C^{PR}_{elec,B_i} = \dot{W}^{PR}_{elec,B_i} \times c_{elec},$$

$$\dot{W}_{el,B_i}^{PR} = \dot{M}_{wood,B_i}(w_{elec,B_i}^{dm} + w_{elec,B_i}^{s}),$$

where $\dot{W}_{el,B_i}^{PR}$ is the total electricity consumption of biomass treatment, w_{elec,B_i}^{dm} is the specific electricity consumption per input solid feedstock for log debarking and milling (36.7 kWh/t [5]), and w_{elec,B_i}^{s} is the corresponding electricity consumption for sieving (7 kWh/t) [5].

3.2.4 Steam explosion process

Steam explosion converts sawdust to black pellets, and costs arising is due to electricity use of its constituents (in kWh per ton of input solid feedstock): dust receiving and scalping w_{elec,B_i}^{rc} (1.5 kWh/t), pre-drying w_{elec,B_i}^{predry}(15 kWh/t), dust screening and sieving w_{elec,B_i}^{ss} (4 kWh/t), dried dust milling w_{elec,B_i}^{dmill} (11 kWh/t), steam explosion unit w_{elec,B_i}^{SEU} (25 kWh/t), post-drying $w_{elec,B_i}^{postdry}$ (26 kWh/t), black pellets milling w_{elec,B_i}^{bpmill} (4 kWh/t), and pelleting w_{elec,B_i}^{pellet}(103 kWh/t) [5]. The operational cost of the steam explosion process then becomes

$$C_{elec,B_i}^{SE} = \dot{W}_{elec,B_i}^{SEP} \times c_{elec},$$

$$\dot{W}_{elec,B_i}^{SEP} = \dot{M}_{sawdust,B_i}(w_{elec,B_i}^{rc} + w_{elec,B_i}^{predry} + w_{elec,B_i}^{ss} + w_{elec,B_i}^{dmill} + w_{elec,B_i}^{SEU} + w_{elec,B_i}^{postdry} + w_{elec,B_i}^{bpmill} + w_{elec,B_i}^{pellet}),$$

where $\dot{W}_{elec,B_i}^{SEP}$ and $\dot{M}_{sawdust,B_i}$ are the total electric power consumed in the steam explosion process in a year and the amount of sawdust used per year in kt/y, respectively.

3.2.5 Black pellet combustion power plant

Costs arising from power production using black pellets, $C_{blackpellet,B_i}^{PP}$, are due to use of utilities i.e., fuel oil used in auxiliary burners m_{fuel,B_i}^{PP} (0.06 liter/GJ input fuel), the internal power consumption $\dot{W}_{elec,B_i}^{PP}$, and the use of consumables which are ammonia $m_{ammonia,B_i}^{PP}$ (5.44 liter/ton input fuel), process water m_{water,B_i}^{PP} (715.5 liter/ton input fuel), and limestone $m_{limestone,B_i}^{PP}$ (34.74 kg/ton input fuel) obtained from [5]. The cost of ammonia, water and limestone are $c_{ammonia}$ = 7.74 RON/liter [10], c_{water} = 0.23 RON/m^3 [10], and $c_{limestone}$ = 178.5 RON/ton [10], respectively. The internal power consumption is the difference between nominal and net power production. The operational cost of a power plant powered by black pellets is then

$$C_{blackpellet,B_i}^{PP} = \dot{M}_{fuel,B_i}^{PP} \times c_{diesel} + \dot{W}_{elec,B_i}^{PP} \times c_{elec} + C_{cons,B_i}^{PP},$$

$$\dot{M}_{fuel,B_i}^{PP} = m_{fuel,B_i}^{PP} \times \dot{M}_{blackpellet,B_i} \times HHV_{blackpellet}$$

$$C_{cons,B_i}^{PP} = \dot{M}_{blackpellet,B_i}(m_{ammonia,B_i}^{PP} \times c_{ammonia} + m_{water,B_i}^{PP} \times c_{water} + m_{limestone,B_i}^{PP} \times c_{limestone}),$$

$$\dot{W}_{elec,B_i}^{PP} = W_{capacity}\,(\eta_{nom} - \eta_{net}),$$

where C^{PP}_{cons,B_i} is the cost of consumables, $\dot{M}^{PP}_{fuel,B_i}$ is the annual amount of fuel oil used in auxiliary burners, $\dot{M}_{blackpellet,B_i}$ is the annual amount of black pellets, $W_{capacity}$ is the plant capacity (50 MW), η_{nom} (33%) and η_{net} (30%) are the applied efficiencies for nominal and net power production.

3.3 Operational cost for value chain of coal power plant

3.3.1 Coal extraction

Coal extraction consists of mining activities and the operational costs of these activities, given as $c^{EX}_{coal,C}$ = 173.85 RON/ton coal [12]. The cost of coal extraction $C^{EX}_{coal,C}$ is calculated by

$$C^{EX}_{coal,C} = \dot{M}_{coal,C} \times c^{EX}_{coal,C},$$

where $\dot{M}^{EX}_{coal,C}$ is the annual amount of coal extracted.

3.3.2 Coal transport

The transport of coal consists of transporting the extracted coal to the coal power plant. The transport is assumed to be done by trucks using diesel as fuel. The cost arising from transport, $C^{TR}_{fuel,C}$, is

$$C^{TR}_{fuel,C} = \dot{M}^{TR}_{fuel,C} \times c_{diesel},$$

$$\dot{M}^{TR}_{fuel,C} = \dot{M}_{coal,C} \times m_{diesel,truck} \times L_{coal,C} \,/\, m_{load,truck,C},$$

where $\dot{M}^{TR}_{fuel,C}$ is the annual amount of diesel consumption, $m_{load,truck,C}$ is the load capacity of truck for coal transport (32 ton/shipment) [10], and $L_{coal,C}$ is the average transport distance from coal source to power plant (90 km) estimated based on the distance between Hunedoara coal mine and Paroșeni power station.

3.3.3 Coal combustion power plant

Costs arising from power production using coal, $C^{PP}_{coal,C}$, are due to use of utilities, i.e., fuel oil used in auxiliary burners $m^{PP}_{fuel,C}$ (0.06 liter/GJ input fuel), internal power consumption $\dot{W}^{PP}_{elec,C}$, and the use of consumables $C^{PP}_{cons,C}$ which are ammonia $m^{PP}_{ammonia,C}$ (5.44 liter/ton input fuel), process water, $m^{PP}_{water,C}$ (715.5 liter/ton input fuel) and limestone, $m^{PP}_{limestone,C}$ (34.74 kg/ton input fuel), all values obtained from [5]. The operational cost of a coal-fired power plant is

$$C^{PP}_{coal,C} = \dot{M}^{PP}_{fuel,C} \times c_{diesel} + \dot{W}^{PP}_{elec,C} \times c_{elec} + C^{PP}_{cons,C},$$

$$\dot{M}^{PP}_{fuel,C} = m^{PP}_{fuel,C} \times \dot{M}_{coal,C} \times HHV_{coal}$$

$$C^{PP}_{cons,C} = \dot{M}_{coal,C}(m^{PP}_{ammonia,C} \times c_{ammonia} + m^{PP}_{water,C} \times c_{water} + m^{PP}_{limestone,C} \times c_{limestone})$$

$$\dot{W}^{PP}_{elec,C} = W_{capacity}\,(\eta_{nom} - \eta_{net}),$$

where $W_{capacity}$ is the plant capacity (50 MW), $\dot{M}_{fuel,C}^{PP}$ is the annual amount of fuel oil used in auxiliary burners, and η_{nom} and η_{net} are the applied efficiencies for nominal and net power production, respectively.

3.4 Comparison of operational costs of black pellet vs coal powered power plant

Estimates of the costs for the value chain of power production from black pellets and coal are presented in the table below.

Table 6 Operational costs for the value chain of power produced from black pellets and coal.

		Black pellets value chain [million RON/year]	Coal value chain [million RON/year]
Harvesting/extraction		70.77	9.70
Transport		5.3	0.3
Pretreatment		3.23	n/a
Steam explosion		12.61	n/a
Power production	Fuel	0.58	0.58
	Electricity	4.90	4.90
	Consumables	3.28	2.70
TOTAL		**100.68**	**18.18**

The total operational cost for power production using black pellets is calculated to 100.68 million RON/year. This is more than 5 times higher than that of using coal, which is calculated to 18.18 million RON/year. The difference is mainly due to the extraction phase since biomass harvesting is more costly than coal mining activity. Furthermore, due to the difference in heating values of the two fuels, the amount necessary for the same plant capacity is different, i.e., higher for black pellets which results in a higher cost of transport as well. The black pellets value chain includes their production from biomass, namely pretreatment and steam explosion which require electricity to be feasible. Fuel used in auxiliary burners and internal power consumption is defined per MJ fuel, and hence, costs associated with these were the same for both value chains. On the other hand, consumption of consumables was defined in terms of per ton of fuel, which is higher for black pellets value chain and resulting in higher costs.

It is important to note that there is a significant difference in ash contents of these two fuels which would make a difference in total costs due to ash disposal costs. However, local data from Romania was not available as per today, thus not included in calculations.

4 Conclusions

A value chain analysis was performed to assess the potential of using black pellets instead of coal for energy production in Romania. An overview of black pellets producers in Romania were provided together with evaluation of biomass feedstock availability. The overview showed that the landscape of biomass production in Romania has grown increasingly competitive due to the rising demand and the proliferation of pellet producers seeking raw materials, in addition to the decline in wood processing and exploitation activities over recent years, primarily due to reduced access to forest resources, legislative instability, and bureaucratic hurdles. The results obtained showed that Romania officially harvests 19 million cubic meters of wood, exploiting only 50% of its sustainable potential exploitation rate which is the growth rate of forests.

In the second step of this activity, value chain assessment was done. Operating costs for both value chains were estimated. The cost was 100.68 million RON/year for the black pellets value chain. This is more than 5 times higher than that of using coal, calculated as 18.18 million RON/year. The difference is mainly due to the extraction phase since biomass harvesting is more costly than coal mining activity. The black pellets value chain includes their production from biomass, namely pretreatment and steam explosion which require electricity to be feasible and imposes costs as well. It is important to note that there is a significant difference in ash contents of these two fuels which would make a difference in total costs due to ash disposal costs. However, local data from Romania was not available as per today and thus not included in the calculations. Another cost factor would arise due to higher CO_2 emissions in coal value chain which would increase the economic favourability of using black pellets.

SINTEF

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