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Design and Construction of a Mini Wood Waste Thermal Power Plant (Abong-Mbang - Cameroon)

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ABSTRACT: The present study focussed on the energetic valorization of wood waste with the general objective of contributing to increasing the energy mix and flexibility in wood processing units. Specifically, it was about evaluating the quantity and composition of wood waste available at the Société de Transformation de Bois et Commerce (STBC) and estimating its energy potential, designing and experimenting with a mini-thermal power plant operating using these waste, and estimating the contribution of such an electrical production unit to meeting the company's energy needs and the associated costs. The characterization of wood waste was carried out through methodical monitoring of six (06) logs throughout the production chain and supplemented by monthly production reports and scientific data. At STBC, wood waste accounts for 62% of the volume of wood processed between March and May 2025. These wood waste consist of 24% edgings, 17% trimmings, 16% slabs, and 5% sawdust. The mini thermal power plant, only fueled with edgings and trimmings, was designed using Revit 2024 software and built with local materials. The combustion of 15 Kg of waste produced a gross thermal energy of 181.5 MJ, a useful thermal energy of 86.2 MJ, and an electrical energy of 31.8 MJ, resulting in an electrical efficiency of 17.5%. The electrical needs of STBC are currently 14 KWh/m3 of raw timbers, provided at an average cost of 148 FCFA/KWh. Thus, for a projected production of 40,000 m3 of sawn timber by 2026, the valorization of 25% of waste (13,000 T) within the system would produce 65 KWh/m3 at a competitive cost of 39 FCFA/KWh. The implementation of a thermal power plant would therefore allow STBC to cover all its electrical needs at a lower cost and even meet the electrical demand of surrounding households and services.

KEYWORDS: Sawmill, wood waste, valorization, energy, electricity

INTRODUCTION

Cameroon is facing an electricity deficit due to the low hydroelectric production of the power plants. This is due to hydrological deficits exacerbated by climate change. The interurban network frequently experiences disruptions in the supply of electrical energy. Faced with this situation, the Government, in collaboration with other stakeholders, has taken measures, including involving industries through the rearrangement of their consumption periods and their blackout during periods of high demand (Ndangue, 2025). Thus, the Cameroonian wood industry, which is highly demanding in electricity, experiences severe supply failures and a reduction in its production capacity. To make up for the energy shortage, this industry increasingly consumes wood waste in accordance with program 963 "Valorization of woody and non-woody forest resources," which, focuses among other things, on the energetic valorization of wood waste through cogeneration and electricity production (MINFOF, 2006). Indeed, wood waste, the most competitive source of renewable energy, are abundant and available in wood processing units (WPU).

With the limitation and then the ban on the export of logs of several wood species, the Cameroonian wood industry is one of the most developed in Africa. There are approximately 227 operational WPUs in Cameroon, of which 205 are limited to primary processing for the production of sawn timber (MINFOF, 2022). However, their production yield is only around 30% (GTZ, 2012); thus, up to 70% of the volume of processed wood ends up as waste (Ndinchout, 2020). Yet, the transformation of these wood waste into electricity offers the opportunity to diversify energy production and promote more sustainable resource management (ATIBT, 2011; Donizeau, 2001; Gerard, 2004). Despite this potential, wood waste are still considered as rubbish at STBC.

The operating cost of wood processing facilities remains excessively high, and there is no indication of a trend toward their reduction (ATIBT, 2012). Indeed, the machines used in the wood industry sector are energy-intensive and electricity costs are very high for WPUs powered by the

interurban network despite frequent outages. The situation is alarming for those who are deprived of it due to their location or other constraints; they depend on generators, an equally burdensome alternative, as diesel is expensive and not always available in sufficient quantities.
At STBC, as in the majority of Cameroonian WPUs, the energy mix consists of electricity provided by the interurban network and by a generator running on diesel. This situation drastically reduces its production capacity while increasing related costs. Yet, this factory generates large quantities of wood waste that are burned or left abandoned. Would the use of wood residues as fuel in a thermal power plant for electricity production reduce dependence on current energy sources and lower production costs within the STBC? This research will try to provide evidence-based answers to this question.
The general objective is to contribute to energy flexibility (diversification or empowerment) in WPUs through better management of available waste. Specifically, it involves:
• Characterizing and quantifying the wood waste from the STBC sawmill;
• Designing and implementing a mini-thermal power plant operating with said waste;
• Estimating the contribution of such a system to meeting the company's electrical needs and conducting an economic analysis of the project.

LITERATURE REVIEW

Average yields in African sawmills generally range from 30% to 45%, depending on the type of equipment used, the quality of the logs, the sawing method employed, and the skill level of the staff (Girard et al., 2003). An estimate of sawmill waste in 14 WPUs in eastern Cameroon indicates an annual volume of approximately 528,378 m^3, representing 66% of the volume of logs entering the mill (802,629 m^3). The average production (sawing) yield of these WPUs is therefore 34% (Kamkuimo et al., 2018). The careful monitoring of three months of production at Dino et Fils (March to May 2024) and at CUF (March to May 2025), two first category Cameroonian WPUs (volume of logs entering factory >5000 m^3/year), gave respective production yields of 36% and 39% (Ngahane et al., 2025).
Using sawmill waste and by-products to produce energy is far from common in tropical regions, especially in Africa, despite their considerable energy-producing potential and the fact that the economic and environmental benefits extend beyond the sawmill itself. (Girard et al., 2003). Overall, the current rate of wood waste valorization remains quite low. Indeed, nearly 60% of sawmill waste is burned in the open air, although techniques exist to use wood waste for electricity production (Kamkuimo et al., 2018). It was in this context that a project for the valorization of sawmill wood waste in Central Africa through biomass cogeneration power plants was initiated, with the aim to encourage WPUs located in remote areas, to produce their own electricity by valorizing their biomass, rather than relying on generators (ATIBT, 2015).
The energy requirements of WPUs are significant. Sawmilling requires approximately 50 kWh/m^3 of sawn timber (15 kWh/m^3 of logs) for hardwoods and 35 kWh/m^3 of sawn timber (12 kWh/m^3 of logs) for softwoods (Kamkuimo et al., 2018). However, these requirements can vary considerably depending on the size of the operation and the condition of the processing equipment. For example, at Dino et Fils, the electricity demand was estimated at 24 kWh/m^3 of logs (Ngahane et al., 2025). For the WPUs located in forested areas and involved in the cogeneration project, their consumption was between 6,000 and 12,000 liters of diesel per day, or between 2,100,000 and 4,200,000 liters per year (ATIBT, 2025).
However, the potential for generating electrical and thermal energy from sawmill waste is almost always significantly greater than the sawmill's own energy needs. Depending on the technology used, the available usable energy in the form of electricity is usually between 10% and 27% of the lower heating value (LHV) of the wood (Girard et al., 2003). However, for technologies using the Seebeck effect, electrical efficiency is capped at 9% (Hung-Hsieh et al., 2013). Losses, primarily due to the Joule effect (heat transfer losses from hot equipment to the environment), which exist in all wood energy utilization systems and are influenced by operational conditions such as equipment thermal insulation (Fitzpatrick et al., 2025), negatively impact these electrical efficiencies.
Given the significant quantity of wood waste in the WPUs, the electrical energy recovery process can be considered, as waste valorization remains profitable regardless of the investments made and the types of users involved (Kamkuimo et al., 2018). The wood waste valorization project at Dino et Fils reported an already advantageous and profitable production cost for the company of 48 FCFA/kWh, while its current energy needs are met at a cost of 145 FCFA/kWh (Ngahane et al., 2025).
The valorization of WPUs waste can cover a large portion of the electricity needs of medium-sized cities located near WPUs in tropical environments (Girard et al., 2003) at competitive prices. Electricity prices in Cameroon have not been adjusted since 2012. The tariffs applied are tiered based on customer type and monthly consumption. Households using less than 110 kWh per month pay 50 FCFA per kWh, while non-residential consumers using between 401 kWh and 1,000 kWh pay 99 FCFA/kWh excluding taxes. The distribution of surplus electricity production in WPUs would then fall under the concession regime or under the authorization regime for assets with a power of less than 100 kW or 1 MW in the context of rural electrification (law no. 2011/022) (UN-ECA, 2023).

MATERIALS AND METHODS

Presentation of STBC Sarl

STBC Sarl is a company involved in the exploitation, processing, and trading of wood, that is established in Abong-Mbang, Cameroon (Figure 1) since March 2012. Because of its annual production (> 5000 m^3/year), this company belongs to first category WPUs and engages in the primary, secondary, and tertiary wood processing (MINFOF, 2012). It trades in logs, sawn timber, veneers, and plywood for local sale and export to European and Asian markets. The study focussed on the primary processing chain, whose products (green sawn timber) supply the other levels of processing. Figure 2 presents the aforementioned production chain.

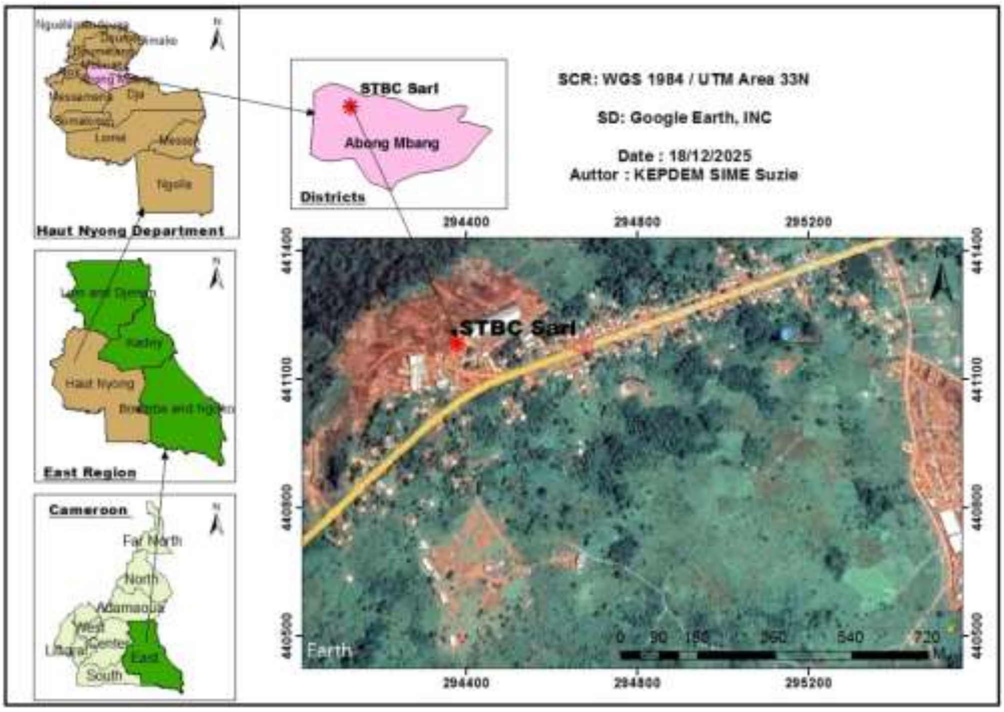

Figure 1. STBC Sarl location map

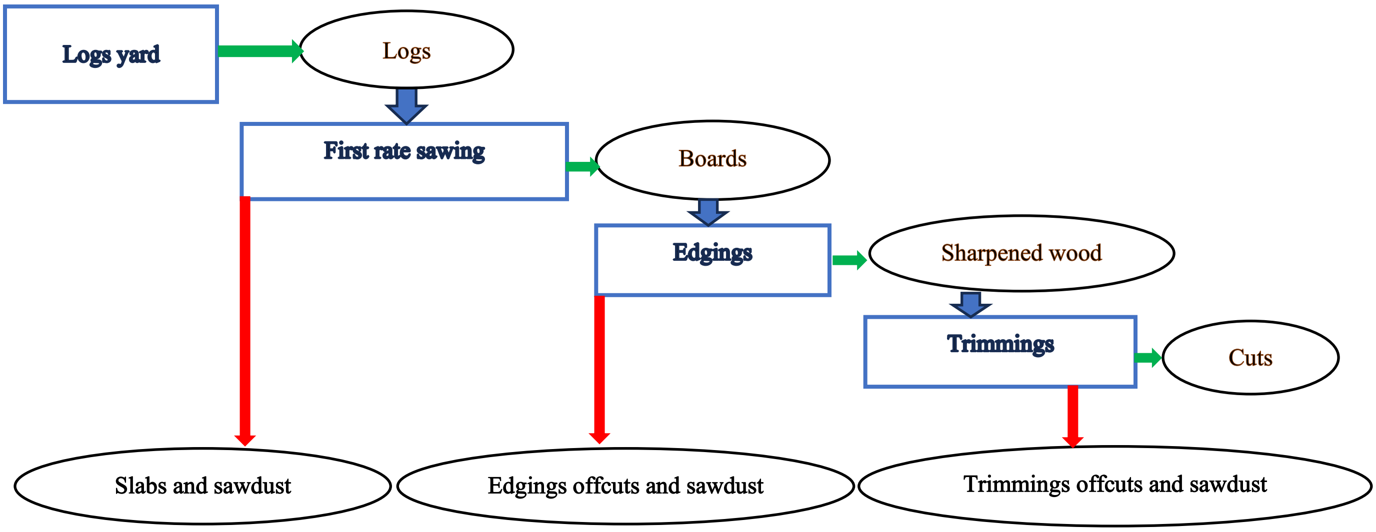

Figure 2. STBC sawmill production line

Characterization of wood waste

The study covered a four (04) months period, from February 15 to June 15, 2025.

- Identification and classification of wood waste

The identification of the types of waste was done through field observations and the analysis of physical parameters (size, shape, dimensions, color, texture, and possible presence of bark). An analysis of the composition was also conducted to identify the nature of the waste (species, hardwood or softwood). Regarding the types of wood waste, we distinguish:

  - Slabs: Curved outer parts of the log with bark;
  - Edgings: Strips of wood of variable width generally presented without bark, consisting of sapwood and high moisture content (≈ 55%);
  - Trimmings: Short pieces of wood (10 to 50 cm) that may contain defects such as cracks, knots, rot...;
  - Sawdust: Fine particles (0.1-1 mm), with high moisture content (≈ 50%).

- Quantification of wood waste

The methodical tracking of six logs at each stage of processing allowed for the evaluation of the volumes and masses of the resulting products (lumber and waste). These precise data obtained were extrapolated to the processing activities recorded during the months of March, April, and May 2025, for which the volumes of wood entering the log yard and the volumes of final cuts obtained were determined.

- Log yard and lumber yard

All the logs received at the yard over three months and the lumber resulting from their processing were measured (diameter, length, width, thickness) using a meter and a decameter. Then, the volume of each log (V_l) and that of the cuts obtained (V_c) were calculated using equations 1 and 2, respectively.

- *Volume of a log:*

$$V_l = \frac{\Pi}{4} \times D^2 \times L \quad (1)$$

With V_l: Volume of log
D: Average diameter of log
L: Length of log

- *Volume of cuts obtained:*

$$V_c = L_P \times l_p \times e_p \times N_p \quad (2)$$

With V_c: Volume of cuts
L_P: Length of sawn products
l_P: Width of sawn products
e_P: Thickness of sawn products
N_P: Number of sawn products

- Primultini SL1600 vertical head saw

The products obtained at this stage of processing are the boards (B) and the residues here are the slabs (S) and the sawdust (S1).

- *Volume of the boards:*

$$V_B = L_B \times l_B \times e_B \times N_B \quad (3)$$

With V_B: Volume of boards
L_B: Length of boards
l_B: Width of boards
e_B: Thickness of the boards
N_B: Number of boards

- *Volume of sawdust:*

$$V_{s_1} = L_B \times l_B \times \lambda \times N_T \quad (4)$$

With V_{s_1}: Volume of sawdust from slabbings
λ: Thickness of saw blade kerf
N_T: Number of saw blade kerf

- *Volume of slabs:*

$$V_S = V_l - (V_B + V_{s_1}) \quad (5)$$

- Primultini MG multi-blade edger

The boards obtained earlier are edged on their left and right sections to obtain pieces of determined width. The residues from this processing step are the edge-flitches (E) and the sawdust (S2).

- *Volume of edgings:*

$$V_E = L_E \times l_E \times e \times N \quad (6)$$

With V_E: Volume of edgings slabs
L, l: Length and width of edgings slabs
N: Number of edgings slabs

- *Volume of sawdust:*

$$V_{s_2} = L_E \times e \times \lambda \times N_T \quad (7)$$

- Primultini SF End-Trimmer

At this stage, the final lengths are given to the boards obtained in the previous step. The waste produced consists of trimmings (T) and sawdust (S3).

- *Volume of trimmings:*

$$V_T = V_B - (V_c + V_{s_3}) \quad (8)$$

With V_T: Volume of trimmings
V_c: Volume of cuts
V_B: Volume of edged boards

- *Volume of sawdust:*

$$V_{s_3} = L \times l \times \lambda \times N_T \quad (9)$$

- *Total volume of sawdust:*

$$V_{s_T} = V_{s_1} + V_{s_2} + V_{s_3} \quad (10)$$

- Other characteristics
  - Humidity

The moisture content of the monitored logs was measured using a Laserliner pin-type moisture meter, whose memory contains six wood groups with calibration.

- Lower heating value (LHV)

The lower calorific value on the gross weight of the wood is estimated from its moisture content (Hpb) and its calorific value in the anhydrous state (LHV_0) using formula 11.

$$LHV = \frac{LHV_0 \times (100 - Hpb)}{100} - 0{,}006 \times Hpb \qquad (11)$$

Design and implementation of the mini thermal power plant

The designed mini-thermal power plant is a system equipped with a furnace in which edgings and trimmings are burned to produce heat. This heat transforms the water into pressurized steam, which, directed toward a propeller, drives an alternator that generates electricity.

- Technical design

For the design of the device, the Revit 2024 software installed on a computer was used, hence the term "computer-aided design" (CAD). Revit is a building information modeling (BIM) software developed to meet the needs of professionals in architecture, engineering, and construction. The Revit 2024 version continues to enhance performance, automation (thanks to Dynamo), documentation, as well as interoperability with other formats such as IFC or AutoCAD, while providing a better user experience for collaborative 3D design.

- Realization of the experimental prototype

The thermal part is made up of:

- A drum of 50 cm diameter and of 70 cm height serving as an oven. Attached to this drum is, on one hand, a pipe of 15 cm diameter and 30 cm length that serves as a chimney for smoke evacuation, and on the other hand, a blower 18 cm long and 10 cm in diameter that serves to provide more oxygen to the drum and accelerate combustion.
- An opening of 40 cm × 40 cm on the oven to ensure its fuel supply.
- An oxygen tank of 0.03 m^3 suspended inside the oven.
- Two small tanks of 0.015 m^3 each, capable of holding 10 L of water; they are suspended above and connected by a 2.5 cm diameter pipe supplying the main tank through another 2 cm diameter and 1.50 m long pipe.
- A valve placed on one of these tanks to allow and stop the passage of water to the main tank.
- Two heat flaps placed at the water inlet of the tank to respectively allow and stop the steam from escaping.

The electrical part is made up of:

- A 12 V alternator that has two components (the propellers and the alternator itself). This alternator is mounted in a 10 cm×10 cm box. The propeller is set in motion by the high-pressure steam escaping from pipes designated to this purpose (3 pipes of 3 cm in diameter, two of which are closed to allow the steam to escape through the third). This mechanically driven propeller is coupled with a 12V alternator that converts mechanical energy into electricity.
- Two circuit breakers protecting the generated current, which is then stepped up using a step-up transformer.
- Some electrical components such as two switches, an outlet, six USB ports, and two CT/RTH bulbs.

- Performance monitoring
  - Temperature

The heat released during the complete combustion of 15 Kg of wood waste in the furnace was measured using a type k thermocouple capable of measuring temperatures ranging from -20 °C to 400 °C.

- Pressure

The water vapour pressure was measured using a Bourdon tube manometer with a measurement range between 1 and 150 bars.

- Useful thermal energy

The useful energy (Q') is the product of the mass (m) of the water, the specific heat capacity of the wood (C), and the temperature variation (ΔT) during the combustion of these wood waste.

$$Q' = m_{water} \times C \times \Delta T \qquad (12)$$

- Useful thermal power

The useful thermal power (P') is the ratio between the useful thermal energy (Q') and the time (t) during which the heat is transferred.

$$P' = \frac{Q'}{t} \qquad (13)$$

- Energy of vaporisation

The vaporisation energy (Q) is the product of the mass of water vapour (M_V) and the latent heat of vaporisation (L_V).

$$Q = Mv \times Lv \qquad (14)$$

- Mechanical power

The mechanical power (Pm) is equal to the mass flow rate of the steam (m = Mv/ΔT) multiplied by the enthalpy change (Δh) of the steam between the inlet and outlet of the propeller.

$$Pm = m \times (\Delta h) \qquad (15)$$

- Current intensity and Voltage

The current intensity (I) and the voltage (U) of the system were measured using a multimeter connected in series with two CT/RTH bulbs.

- Electrical power

The electrical power exchanged in the system (P), the current (I) flowing through it, and the voltage across its terminals (U) are related by equation 16.

$$P = U \times I \qquad (16)$$

Estimation of the potential energy contribution of the system and economic analysis

- Current electrical consumption of production

The production balance was established for the month of April 2025. The total electrical consumption was determined using the diesel and ENEO electricity bills for the said month. This electrical consumption was then rationed by the total volume of wood processed during that month (E in KWh/m^3).

$$E = \frac{Total\ energy\ consumption\ in\ KWh}{Total\ volume\ of\ processed\ wood\ m^3} \quad (17)$$

- Current electrical production cost

Based on the amounts of the invoices for the total monthly electrical consumption and the monthly volume of wood processed at STBC, the average electrical production cost (EC) was calculated in FCFA/KWh and then in FCFA/m^3.

$$EC = \frac{Amount\ of\ energy\ expenditure\ in\ FCFA}{\text{Total volume of processed wood in m}^3} \quad (18)$$

- Electrical production of the projected thermal power plant and related costs

The prospective analysis of annual production, taking into account the changes in sawn timber production at STBC over the past five years, was based on a conservative production target of 40,000 m^3/year of sawn timber from 2026 onwards and with a target of valorising 25% of the waste. The costs considered for the projected thermal power plant are those related to: (i) the initial investment (purchase, installation, and commissioning of the various components) and (ii) the operation (production, maintenance, monitoring). These costs were inspired by those of locally existing systems: gasifiers, ORC systems, steam engines, and steam turbines. The total annual cost is the sum of the annual depreciation (the system's lifespan was considered to be 15 years) and the annual operating cost, to which 10% for contingencies was added. The cost of production or generation of one KWh by the system (Cu = Unit Cost) was then calculated in FCFA/KWh.

$$Cu = \frac{Total\ cost\ spent\ /year}{Total\ number\ of\ KWh/year} \quad (19)$$

RESULTS

Characteristics and quantities of wood waste at the STBC sawmill

- Quantities and composition of wood waste

Table 1 presents the products resulting from the processing of six logs of wood (Vl = 12.102 m^3).

Table 1: Volume of the products obtained from the processimg of six logs

Parameters	Reference equation	Value (m^3)
Logs (V_l)	(1)	12,102
Cuts (V_c)	(2)	4,001
Boards (V_B)	(3)	9,497
Sawdust (V_{S1})	(4)	0,558
Slabs (V_S)	(5)	2,046
Edgings slabs (V_E)	(6)	3,292
Sawdust (V_{S2})	(7)	0,107
Trimmings (V_T)	(8)	2,073
Sawdust (V_{S3})	(9)	0,028
Total volume of sawdust (V_{ST})	(10)	0,693

For a three-months period (March, April and May 2025), STBC recorded a volume of 23,291 m³ of logs entering the factory, a total production of 8,782 m³ of sawn timber and 14,509 m3 of waste, all species combined (Table 2), for a production yield of 38%.

Table 2: Volume of the products from three months of operation at the STBC sawmill

Parameters	March (m^3)	April (m^3)	May (m^3)	TOTAL (m^3)	%
Logs (V_l)	6 042	7 919	9 330	23 291	100
Cuts (V_c)	2 367	2 930	3 485	8 782	38
Slabs (V_S)	1 093	1 198	1 561	3 852	16
Edgings slabs (V_E)	1 588	1 936	2 011	5 535	24
Trimmings (V_T)	679	1 468	1 783	3 930	17
Sawdust (V_{ST})	315	387	490	1 192	5

- Density and mass of wood waste

The estimated density is 0.7 T/m³, equivalent to the average density of all the wood processed at STBC from March to May 2025. For a total volume of 14,509 m^3 of wood waste, the total mass of wood waste produced during this period is therefore estimated at 10,156 T.

- Humidity and calorific potential

The average moisture content of the processed wood during the period from March to May 2025 is 32%, corresponding to a lower heating value (LHV) of 3,347 KWh/t (Eq. 11). The waste produced on the site therefore represents a calorific potential of 33,993 MWh.

Mini-thermal power plant designed and realized

- Presentation of the experimental prototype

Figure 3 presents the system designed using Revit software (a,b) and the prototype realized with local materials (c).

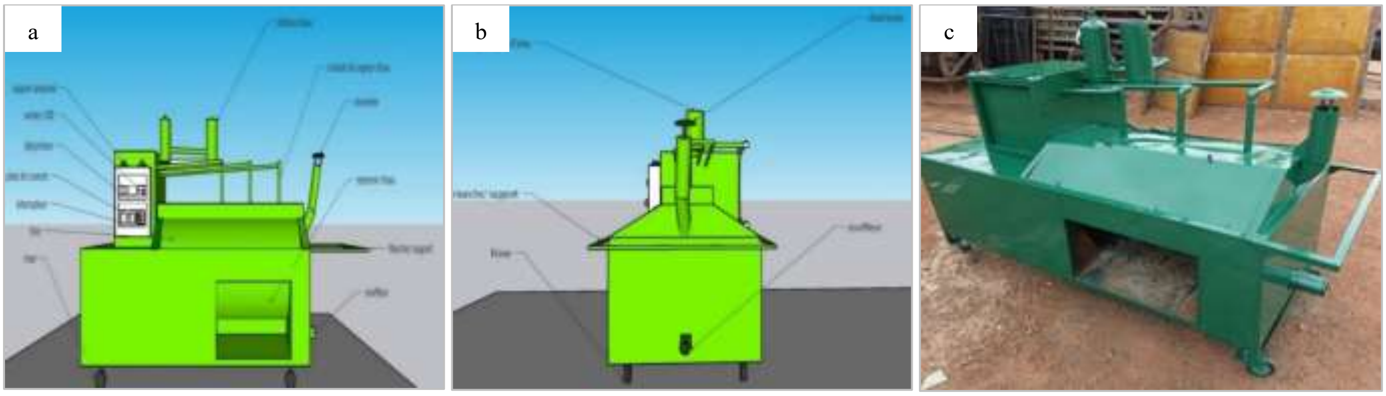

Figure 3. Front view (a) and side view (b) of the designed prototype and the realized prototype (c)

The raw material used consists of edgings and end cuts, the steps for electricity production within the device are as follows:

- The wood waste (15 Kg) is carefully arranged in the oven and then burned; the heat released from the combustion is channelled towards a tank containing 30 litres of water.
- Under the effect of the heat produced by the combustion of wood, the water gradually turns into steam, thus increasing the pressure in the tank.
- The pressurised hot air produced escapes through the valve of the tank and directly hits the alternator's propeller, which will rotate around a fixed axis.
- The movement of the blades drives an alternator located inside. The mechanical energy generated by the rotation is thus converted into electrical energy.
- The electrical energy produced by the alternator is directed towards the step-up transformer, then used to light two CT-RCH bulbs.

- Energy performance of the prototype

Figure 4 illustrates the simultaneous evolution of temperature and water vapour pressure as a function of the combustion time of the waste in the furnace. The useful thermal energy (Q') to heat the water and transform it into steam was estimated at 86.2 MJ (Eq. 12); the corresponding useful power is 13.68 KW (Eq. 13). But only a mass of 21 Kg of water vapour was produced, so the necessary vaporisation energy was estimated at 51.11 MJ (Eq. 14).

The mechanical power (Pm) obtained at the propeller output is approximately 16.29 KW (Eq. 15). This power, generated by high-pressure steam, turned the alternator blades and allowed for the generation of electricity. The two CT-RCH bulbs started to shine after 45 minutes of combustion, the outlet and USB ports also worked. The pressure read was 18 bars, the current intensity was 2.2 A, and the voltage was 9.8 V; the device's power was then 21.56 W (Eq. 16). Figure 5 shows the variation of steam pressure and electrical power provided by the system over time. The total electrical energy produced by the mini thermal power plant is 8.81 KW.

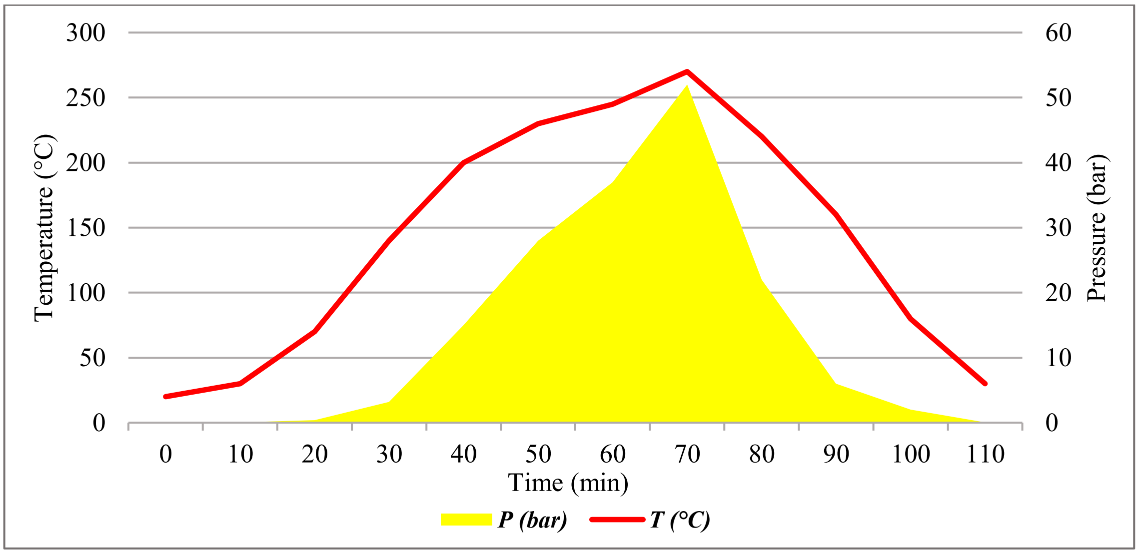

Figure 4. Variation of temperature and water vapour pressure as a function of time

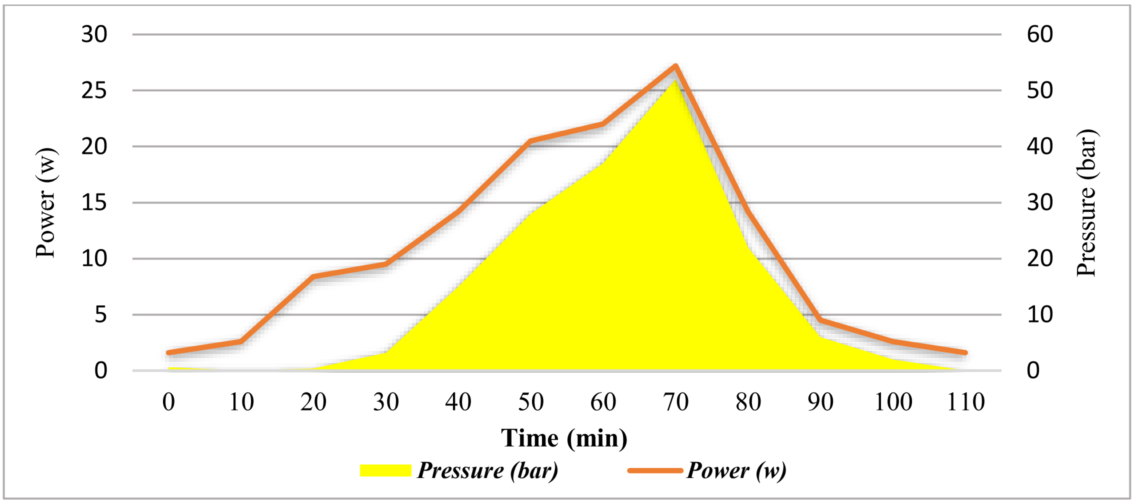

Figure 5. Variation of pressure and electrical power as a function of time

Contribution of the thermal power plant to meeting the energy needs of STBC and economic analysis of the project

- Current electrical consumption for production and related costs

During the month of April 2025, for the processing of 7,919 m^3 of wood, STBC consumed 111,438 KWh provided by ENEO (90,459 KWh) and by the generator (20,979 KWh); resulting in an average energy consumption of E = 14 KWh/m^3 of processed wood (Eq. 17).

Table 3 shows that, from the energy bills received for the month of April 2025, the applied rates are respectively 126 FCFA/KWh for ENEO and 242 FCFA/KWh for diesel. The average electricity cost is EC = 148 FCFA/KWh (Eq. 18).

Table 3: Electricity consumption and costs at the STBC in April 2025

Parameters	Consumption (KWh)	Amount (FCFA)	Average cost (FCFA/KWh)
ENEO	90 459	11 397 834	126
GASOIL	20 979	5 094 900	242
TOTAL	**111 438**	**16 492 734**	**148**

- Electrical production of the projected thermal power plant and related costs

With a minimum annual production of 40,000 m^3 of sawn wood from 2026 onwards, at an average yield of 35%, STBC will use 114,286 m^3 of wood, and produce 74,286 m^3 of wood waste equivalent to 52,000 T in mass annually. With the goal of valorising 25% of wood waste for energy production, 13,000 T of edgings and trimmings cutoffs will be used. Their electrical potential is then 7,397 MWh/year (LHV = 3,347 KWh/T and electrical efficiency = 17%), which is equivalent to 65 KWh/m^3 of processed wood which is higher than the current need of 14 KWh/m^3.

The cost estimation of the system takes into account the initial investment, considering the lifespan of the equipment to be 15 years (Table 4) and the operating expenses (Table 5). With annual expenses (Depreciation + Annual operating costs) of 287,464,031 FCFA, the system would annually produce 7,397 MWh, resulting in a unit cost of Cu = 39 FCFA/KWh (Eq. 19).

Table 4: Investment cost for the planned thermal power plan

SECTION	DESCRIPTION	AMOUNT (FCFA)
Technical equipments		**602 964 050**
Thermoelectric power plant	Stream turbine	393 935 500
	Generator	120 735 450
	Cooling system	1 800 000
Boiler	Boiler	25 251 350
	Fire protection system	3 292 500
Dryer		5 050 500
Transformer		7 000 000
Chimney	Smoke treatment and evacuation	5 898 750
Supply equipments	Furnace, Silos, convoyors, grate, fans	40 000 000
Logistics and installation		**95 000 000**
Customs clearances, transport and logistics		70 000 000
Installation		25 000 000
TOTAL INVESTMENT EXPENDITURE (I)		**697 964 050**
ANNUAL INVESTMENT EXPENDITURES (I')		**46 530 937**

Table 5: Annual operating for the planned thermal power plant

SECTION	DESCRIPTION	AMOUNT (FCFA)
Personnel		**55 200 000**
1 Production manager	500 000 FCFA/month	6 000 000
2 Maintenance technicians	2 x 300 000 FCFA/month	7 200 000
5 Sorting operators	5 x 200 000 FCFA/month	12 000 000
8 Loading operators	8 x 200 000 FCFA/month	19 200 000
2 Ignition operators	2 x 150 000 FCFA/month	3 600 000
4 Ash removal operators	4 x 150 000 FCFA/month	7 200 000
Consumables and services		**159 600 000**
Spare parts		50 000 000
Small tools		10 000 000
Small consumables	PPE, registers, fuel, water, etc.	21 600 000
Maintenance epuipments	Welding, troubleshooting	28 000 000
Control and regulation	Monitoring, control, auditing…	50 000 000
TOTAL OPERATING EXPENSES (II)		**214 800 000**
UNFORESEEN ITEMS [III = 10% (I'+II)]		**26 133 094**
ANNUAL EXPENSES (I'+II+III)		**287 464 031**
ANNUAL PRODUCTION		**7 397 MWh**
UNIT COST (Cu)		**39 FCFA/KWh**

DISCUSSION

During the study period (March, April and May 2025), the production yield at STBC was 38%. This value is not far from the company's average annual yield (36%) and from the average production (sawing) yield of 14 WPUs located in the same region (34%) (Kamkuimo et al., 2018). It is in the general range of 30% to 45% (Girard et al., 2003) and also very close to those found by Ngahane et al. (2025) at Dino et Fils SA (36%) and CUF (39%), two Cameroonian WPUs of the same category. The waste from this processing represent 14,509 m^3, distributed as follows: Edgings (5,535 m^3), Trimmings (3,930 m^3), Slabs (3,852 m^3), and Sawdust (1,192 m^3). These are the classic wastes from primary processing WPUs (Crehay and Marchal, 2004).

The combustion of 15 Kg of wood waste was complete after 105 minutes. The maximum values (270 °C and 52.5 bars) were reached around 70 minutes, corresponding to the optimal phase of energy production. The decreasing phase, after 70 minutes, marks the decline in energy efficiency, reflecting the depletion of fuel in the furnace. With a gross energy potential of 181 MJ for the 15 Kg of waste consumed, the thermal part of the experimental prototype exhibits an efficiency of 47.6% (86.2 MJ). This low thermal efficiency could be explained by the non-optimal combustion conditions (open furnace) and casing losses due to the Joule effect. (Fitzpatrick et *al.*, 2025)

With a gross electrical potential of 50.28 KW for the 15 Kg of wood waste consumed, the overall electrical efficiency of this mini-thermal power plant is 17% (8.81 KW). This efficiency is very promising as it falls within the actual efficiency range (15-30%) of similar systems indirectly producing electricity from heat (IEPF, 2005) and within electrical efficiency range (10-27%) given by Girard et al. (2003). It is higher than that of thermoelectric systems using the Seebeck effect (9%) (Hung-Hsieh et al., 2013).

The current electrical consumption for the processing of 7,919 m^3 of wood at STBC (14 KWh/m^3) falls within, the energy requirement range of WPUs (12-15 kWh/m³) given by Kamkuimo et al. (2018). This value is lower than the 24 KWh/m^3 obtained by Ngahane et al. (2025) at Dino et Fils SA for the processing of 5,131 m^3 of wood. This can be due to economies of scale and the relative obsolescence of the machines operating at Dino et Fils SA since 2006. The average electricity cost (EC = 148 FCFA/KWh) is very close to the 145 FCFA/KWh found by Ngahane et al. (2025).

With an electrical potential from valorisation of 13,000 T of wood waste of 7,397 MWh/year, electrical energy availability (65 KWh/m^3) is greater than current need (14 KWh/m^3). This confirms that the potential for generating electrical and thermal energy from sawmill waste is significantly greater than the sawmill's own energy needs (Girard et al., 2003). Thus, by exploiting the electrical potential of only 25% of its wood waste, STBC would meet all of its production energy needs, could overcome current energy constraints, and even supply the surplus to its surroundings (UN-ECA, 2023).

The production cost (Cu = 39 FCFA/KWh), significantly lower than the current average cost of electricity supply to STBC (EC = 148 FCFA/KWh), would be very advantageous and highly competitive for its production and positioning as an electricity supplier to surrounding households and services in accordance with regulations (Republic of Cameroon, 2012; UN-ECA, 2023). In accordance with Kamkuimo et al. (2018), waste valorization at the STBC remains profitable regardless of the initial investments needed and the types of users involved.

CONCLUSION

With a production yield of 38%, wood waste represents 62% of all the wood processed at the STBC sawmill. The abundance of edgings (24%) and trimmings (17%) and their energy potential make them an interesting and directly available sustainable resource for considering their valorisation within the planned thermal power plant.

The design and implementation of an experimental protocol allowed for the successive production of thermal energy, mechanical energy, and electrical energy from 15 Kg of edgings and trimmings. With an experimental electrical efficiency of 17%, the system proved to be effective and suggests better performance on a real scale and under optimal operational conditions.

The effective establishment of a thermal power plant at STBC, utilising only 25% of its wood waste, would allow it to fully meet its energy needs at a beneficial cost of 39 FCFA/KWh instead of the 148 FCFA/KWh currently spent. This would also allow it to produce at a lower cost, free itself from the constraints of the current energy mix, and even position itself as a local electricity supplier to surrounding households and services.

The energetic valorization of wood waste, which is abundant in Cameroonian WPUs is a viable and effective solution for the energy autonomy of WPUs and an alternative to fossil fuels to increase electricity production, diversify the energy mix, and sustainably support the local economy.

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