The Danish Energy Agency

Anonymous Audit Report
from a Textile company

ENERTEAM, Friday, March 28, 2025

Content

Introduction to the context

On March 13, 2019, the Decision No. 280/QD-TTg on approval of the National Energy Efficiency Programme (VNEEP) for the period of 2019-2030 was issued by the Prime Minister.

The VNEEP implements synchronously activities in the field of economical and efficient use of energy, showing commitments of all levels of government, associations, businesses, organizations, individuals to energy efficiency in particular and to climate change resilience and environmental protection in general.

The Vietnam-Denmark Energy Partnership Program Phase 3 (DEPP3) for the period 2020-2025 implement a number of activities, making substantial and effective contributions to help Vietnam's energy sector transition towards green growth, reduce carbon emissions through the development of a green energy system, operate a flexible power system, efficiently enforce policies and measures promoting energy efficiency and conservation.

One of the very important activities of promoting energy efficiency through Energy Audit in a broad variety of industrial sectors in Vietnam.

This document contains an anonymised summery of a specific energy audit report conducted as a part of the DEPP3 program. The audit has been conducted on a textile production plant, by Energy Conservation Research and Development Center (ENERTEAM), in collaboration with an international expert from Viegand Maagøe.

Summary

Through the on-site Energy Audit, the Energy Savings Measures were identified and agreed upon from all sides (the consultant team and the factory) in the on-site closing meeting. The energy saving findings cover both electrical and thermal systems, with savings and investment costs ranging from low to high.

It would be ideal if the factory can implement all of the recommendations (details are described in the following tables) as they cover both Utility system and Production system including:

- Projects for compressed air system optimization and improvement.
- Projects for wastewater treatment optimization (air blowers).
- Projects to improve thermal system supply side (boiler and thermal oil heater), with recommendations for both optimization and new investment potentials.
- Projects to address and minimize thermal losses in production areas, including recommendations for stenter (main thermal oil user) and washing machine (steam user).
- Projects to explore clean energy potential (roof top solar PV system) and improve energy management status.

The recommended projects are divided into two main groups: Level A and Level B. Level B projects cover all identified and agreed-upon potentials, while Level A projects are screened from Level B projects. Level A projects are particularly interesting for the factory and are characterized by their large-scale technical and

financial aspects, which could need further studies to accurately quantify the savings and return of interest.

Summary of the energy savings opportunities, annual cost savings and CO_2e emission reductions is shown in the following table:

Summary of the energy savings opportunities

Group of ECMs	Energy savings		Cost savings	GHG emission reduction
	Electricity *(kWh/yr)*	***Biomass*** *(kg/yr)*	*(million VND/yr)*	*(tCO_2e/year)*
No investment cost or low investment cost[1]	163,417	-	536	941.2
Medium investment cost[2]	103,305	598,466	2,147	90.5
High investment cost[3]	-	960,582	3,151	33.1
Total	**266,721**	**1,559,049**	**5,834**	**1,065**
Percentage of savings	**5.4%**	**28.9%**	**-**	**-**

1 About the enterprise

The factory specializes in manufacturing textiles, dyeing and finishing of all kinds of fabrics.

In addition to improving product quality to meet customer demands, the factory also pays great attention to environmental issues. It saves energy intending to create a green brand for the company. Therefore, the factory is determined to reduce energy costs to reduce production costs and increase competitiveness.

1.1 Description of the company

- Sector: Textile manufacturing
- Main raw materials: Yarn – Polyester, Nylon, Spandex
  - Polyester: 2,122 (ton/year)
  - Nylon: 462 (ton/year)
  - Spandex: 72 (ton/year)
- Main products: Knitted/Weaved Fabric, Dyed Fabric
  - Knitted/Weaved Fabric: 1,832 (tons/year)
  - Dyed Fabric: 1,802 (tons/year)
- Annual energy total consumption (2023)

[1] No investment cost or low investment cost: Investment cost ≤ 100 million VND.

[2] Medium investment cost: 100 million VND < Investment cost ≤ 01 billion VND.

[3] High investment cost: Investment cost > 01 billion VND.

    - Electricity:
        - Grid: 4,918,600 (kWh), equivalent to 759 (TOE), 17,706,960 (MJ)
    - Diesel oil: 45,221 (L), equivalent to 40 (TOE), 1,388,377 (MJ)
    - Biomass: 5,402 (tons), equivalent to 2,303 (TOE), 96,445,169 (MJ)
- Annual carbon footprint (2023): 3,617 tCO_2e

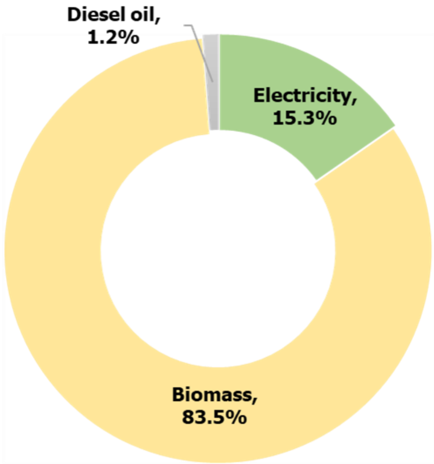


Figure 1.1. Structure of energy consumption

The chart above shows that biomass is the most consumed energy in the factory, accounting for about 83.5%. The rest consists of electricity, which accounts for 15.3%, and diesel oil, accounting for 1.2%.

1.2 Description of the process

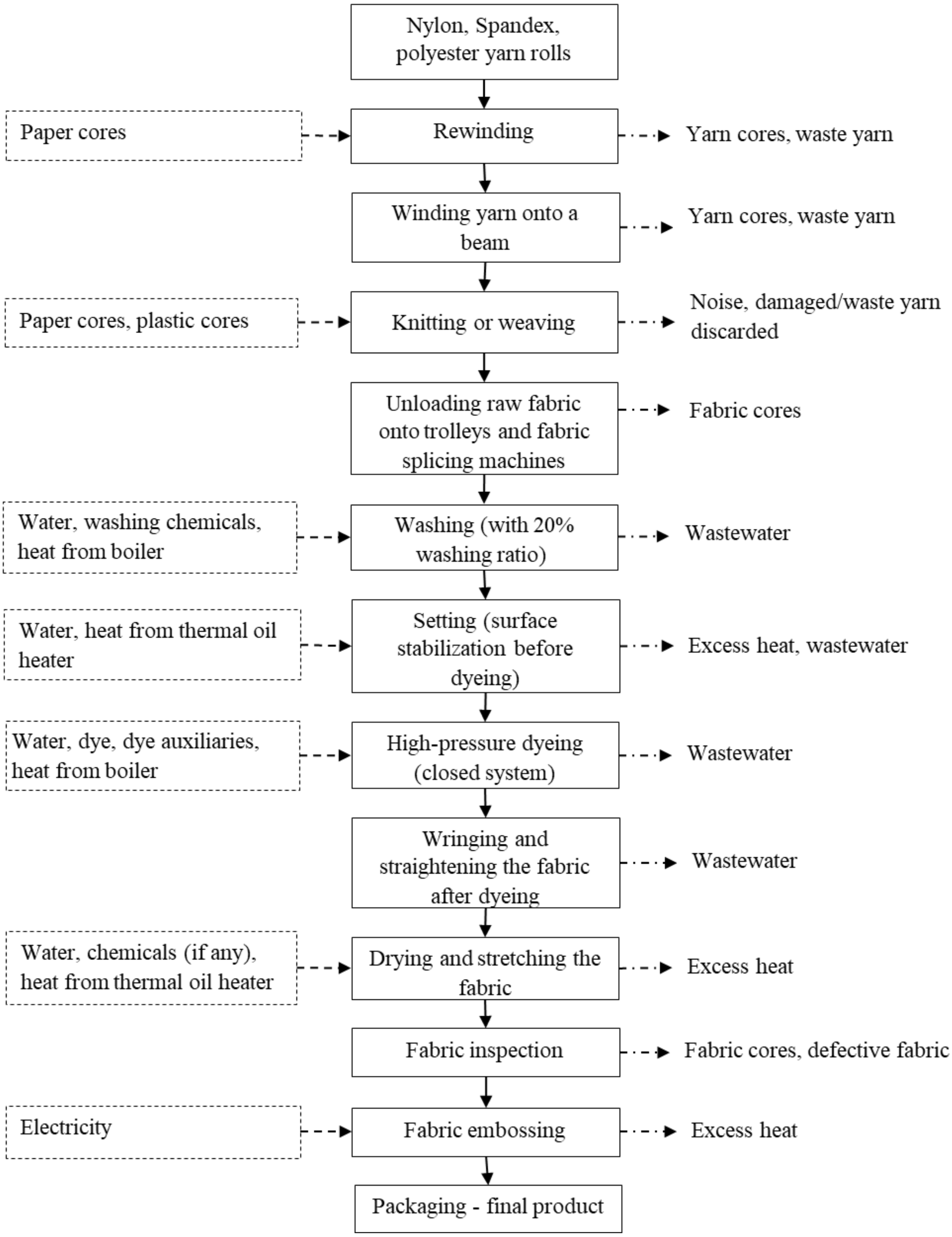


Figure 1.2. The production process flowchart

Production process description:

Raw Materials:

- Polyester: 80%
- Nylon and Spandex: 20%

Knitting/Weaving production process:

1. Fiber Processing and Winding: Raw material rolls are processed into smaller or larger rolls to achieve the required weight for production.
2. Spool Winding: The rolls of fibers are fed into the winding machine to create large fibers beams (200 - 1,000 fibers per beam).
3. Weaving Fabric:
- Knitted Fabric: Uses 4 round knitting machines and 34 flat knitting machines.
- Woven Fabric: There are 30 weaving machines.
4. Production: Total production: 12,750,000 m^2/year (4,500 tons), with 70% dyed (8,925,000 m^2) and 30% sold as white fabric (3,825,000 m^2).
5. Unloading Fabric: Raw fabric (3,150 tons/year) is transferred to the dyeing workshop, going through washing, setting, or directly to dyeing.

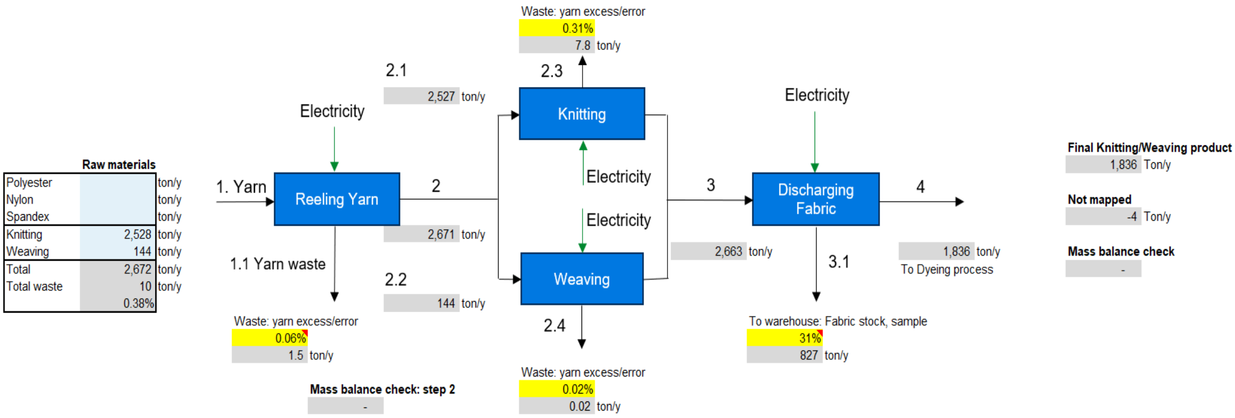
Raw/Greige fabric from knitting/weaving process will go through the dyeing workshop. Depending on the quality requirement, not all greige fabric must go through all pre-treatment processes before being dyed. The ratio is specified below:

- Washing and setting: 20%
- Only setting: 65%
- No setting: 15%

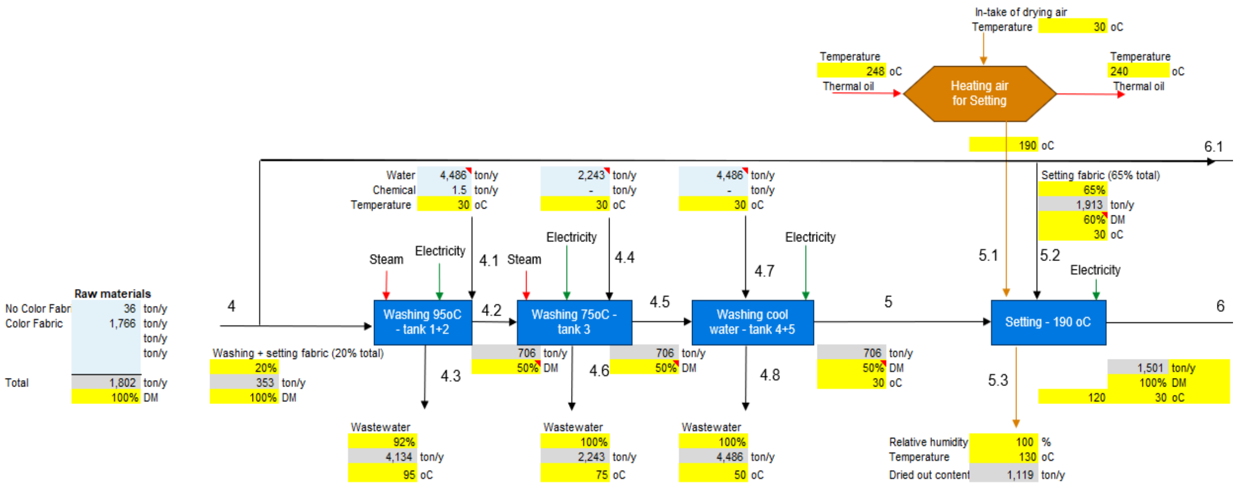
6. Washing: 630 tons/year of fabric are washed using a washing machine with 4 compartments, using chemicals (NaOH, ORS, F-MBF).
7. Fabric Setting: Fabric after washing and setting is straightened before dyeing at a temperature of 190-200°C.
8. Dyeing: Uses 21 dyeing machines with varying capacities. The dyeing process is controlled through ERP and Orgatex systems.
9. Squeezing and Straightening Fabric After Dyeing: The dyed fabric is squeezed to remove excess water.
10. Drying and Stretching Fabric: Dried at a temperature of 160-170°C. Chemicals are used to stiffen the fabric or water is used to soften it.
11. Quality Check and Packaging: Finished fabric is inspected for quality and packaged. 13% of the fabric is printed with patterns as per customer requirements.

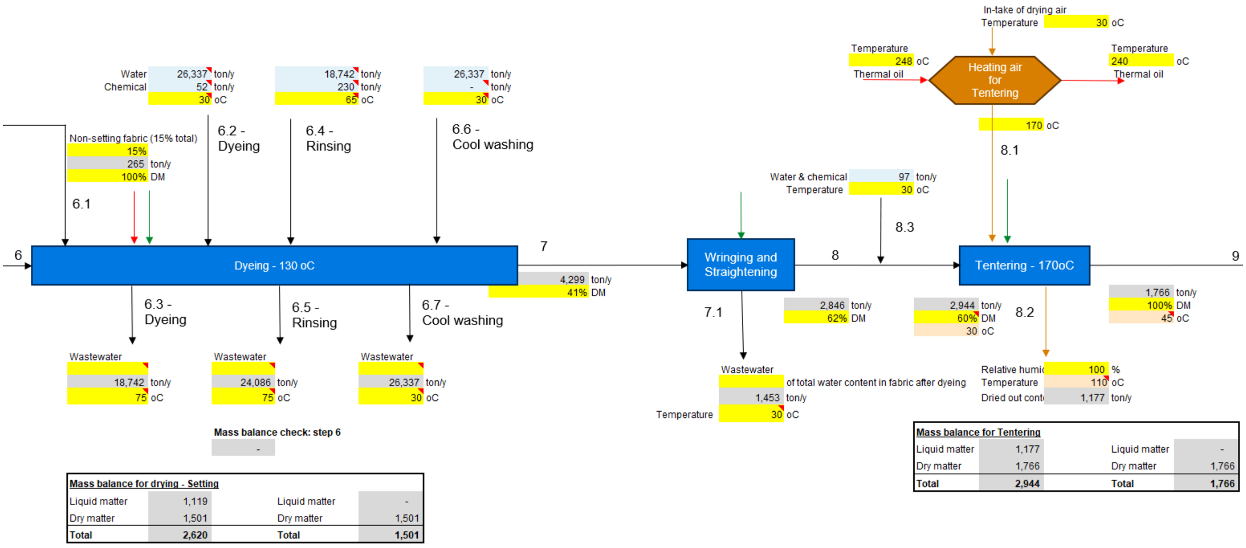
The production process with mass flow analysis is visualized below:

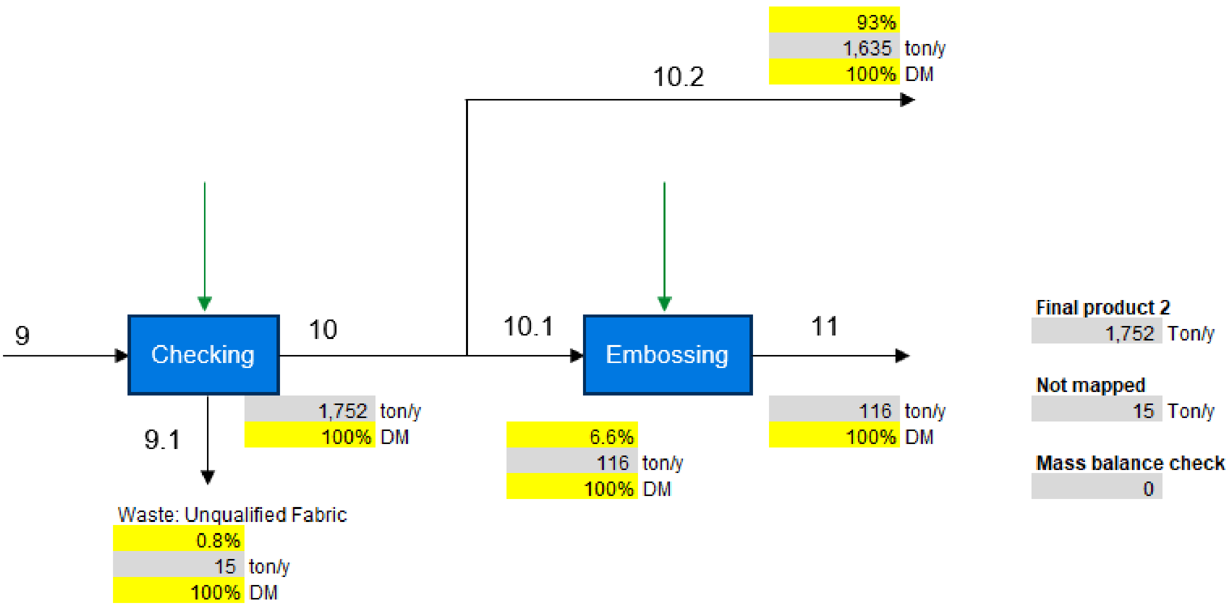
- Knitting/Weaving process



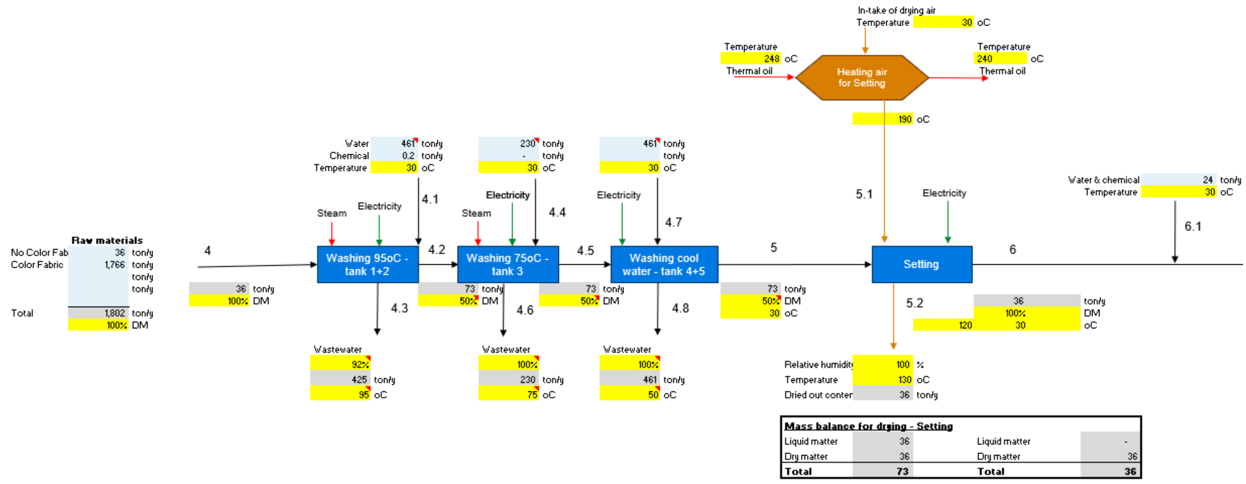
■ Dyeing colored fabric

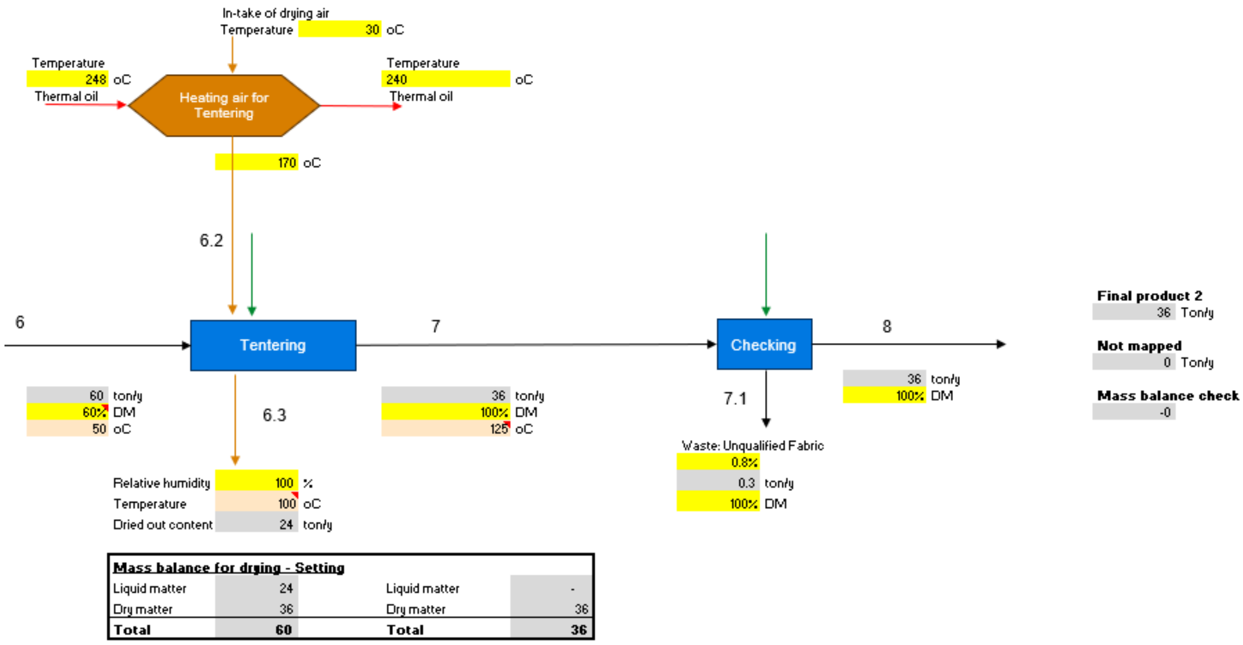






■ Dyeing non-color fabric





1.2.1 Knitting workshop

The knitting workshop typically operates at a load of around 50–80%, demonstrating efficient use of capacity. The facility is well-organized and clean, creating an optimal working environment. Two types of knitting machines are used in the workshop: flat knitting machines and round knitting machines. While flat knitting machines come in various models, they can generally be categorized into new and old models. From the status of workshop, there is potential to replace the older machines with newer models, which could facilitate a significant renovation or future expansion of the workshop.

Table 1.1. Summary of the current machinery and equipment list of knitting workshop

No.	Name of Machinery	Quantity	Rated power *(kW)*	Rated output *(kg/day)*
1	DUK SOO (1.1)	1	3.7	400
2	DUK SOO (1.2)	1	3.7	400

No.	Name of Machinery	Quantity	Rated power *(kW)*	Rated output *(kg/day)*
3	DUK SOO (1.3)	1	3.7	350
4	DUK SOO (1.4)	1	3.7	300
5	DUK SOO (1.5)	1	3.7	250
6	KARL MAYER (1.6)	1	18.5	600
7	KARL MAYER (1.7)	1	18.5	700
8	DUK SOO (2.1)	1	7.5	100
9	DUK SOO (2.2)	1	7.5	100
10	DUK SOO (2.3)	1	7.5	100
11	KARL MAYER (2.4)	1	18.5	300
12	KARL MAYER (2.5)	1	18.5	200
13	KARL MAYER (2.6)	1	18.5	200
14	KARL MAYER (2.7)	1	18.5	200
15	KARL MAYER (2.8)	1	18.5	200
16	KARL MAYER (3.1)	1	18.5	800
17	KARL MAYER (3.2)	1	18.5	600
18	KARL MAYER (3.3)	1	13	200
19	KARL MAYER (3.4)	1	13	300
20	KARL MAYER (3.5)	1	13	300
21	KARL MAYER (3.6)	1	13	300
22	KARL MAYER (3.7)	1	13	200
23	KARL MAYER (3.8)	1	7.5	300
24	DUK SOO (3.9)	1	3.7	100
25	DUK SOO (3.10)	1	3.7	NOT OPERATING (3100)
26	KARL MAYER (4.1)	1	3.7	200
27	KARL MAYER (4.2)	1	3.7	200

No.	Name of Machinery	Quantity	Rated power *(kW)*	Rated output *(kg/day)*
28	KARL MAYER (4.3)	1	3.7	200
29	KARL MAYER (4.4)	1	3.7	100
30	KARL MAYER (4.5)	1	3.7	100
31	KARL MAYER (4.6)	1	3.7	300
32	KARL MAYER (4.7)	1	3.7	200
33	KARL MAYER (4.8)	1	3.7	200
34	KARL MAYER (4.9)	1	3.7	100
35	KEUMYONG (5.1)	1	3.7	100
36	KEUMYONG (5.2)	1	3.7	100
37	KEUMYONG (5.3)	1	3.7	100
38	KEUMYONG (5.4)	1	3.7	NOT OPERATING

1.2.2 Weaving workshop

The weaving workshop operates at a load of around 30–50%, with a well-organized setup and new weaving machines equipped with high-efficiency motors, enhancing productivity and energy savings. However, some unoccupied areas or spaces with natural light still have lamps turned on, highlighting the potential to further save energy by turning off unnecessary lighting in these areas.

Table 1.2. Summary of the current machinery and equipment list of weaving workshop

No.	Name of Machinery	Quantity	Rated output *(unit)*	Operating time *(hous/year)*	Operation control mode
1	ITEMA	22	300 yard/machine	6578	AUTOMATIC
2	ITEMA-STAUBLI	4	300 yard/machine	6578	AUTOMATIC

1.2.3 Dyeing workshop

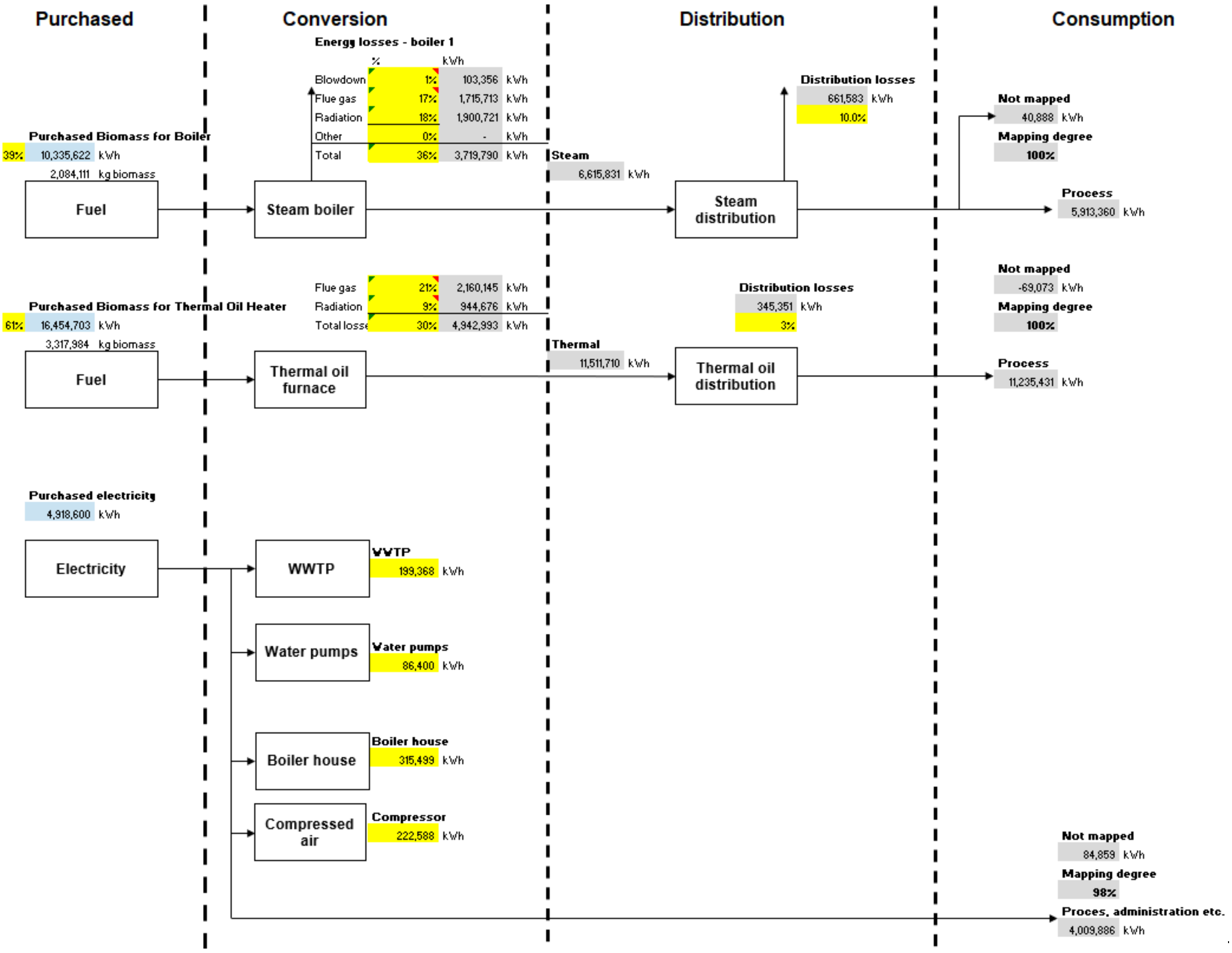
The exhaust flow in the drying chambers is currently being adjusted based on the experience of the machine operator. Additionally, the stenter exhaust fans are set to maintain a rotation speed of approximately 1300 rpm for all fabric products. However, these current control methods are not optimal, indicating a significant potential for energy savings.

Table 1.3. Summary of the current machinery and equipment list of dyeing workshop

No.	Name of Machinery	Capacity	Quantity	Hours of operation per day	Days of operation per year
1	Sample machine 1-2-3 (10kg)	10 kg/batch	3	24	300
2	Sample machine 4-5 (20kg)	20 kg/batch	2	24	300
3	Dyeing machine 1-2-3-4 (100kg)	80 kg/batch, 15 kW	4	24	300
4	Dyeing machine 5-6 (100kg)	80 kg/batch, 14 kW	2	24	300
5	Dyeing machine 7-8-9-10 (250kg)	200 kg/batch, 16 kW	4	24	300
6	Dyeing machine 11-12 (500kg)	400 kg/batch, 23 kW	2	24	300
7	Dyeing machine 13 (500kg)	400 kg/batch, 23 kW	1	24	300
8	Dyeing machine 14 (800kg)	800 kg/batch	1	24	300
9	Stenter 1	168 kW	1	20	300
10	Stenter 2	180 kW	1	20	300
11	Fabric de-twisting machine	1.5 kW/máy	2	17	300
12	Relax machine	52.25 kW	1	8	100
13	Embossing machine	3.7 kW	2	8	200
14	Fabric inspection machine	1.55 kW	5	24	300
15	Edge slitting machine	4.1 kW	1	2	100
16	Fabric centrifuge	4.4 kW	1	24	300

No.	Name of Machinery	Capacity	Quantity	Hours of operation per day	Days of operation per year
17	Mini stretching machine	12 kW	1	8	300
18	Sample fabric drying machine	3 kW	2	24	300
19	Water filtration system		2	24	300
20	Automatic color pump MPS-D 100L	7 kW	1	24	300
21	Automatic color pump MPS-D 300L	6 kW	1	24	300
22	Automatic chemical pump MPS-L	3 kW	1	24	300
23	Heat recovery system	5.5 kW	1	24	300
24	Exhaust gas treatment system for stretching machines		2	17	300

1.3 Description of the utility systems



1.3.1 Steam and thermal oil

The fixed grate biomass-fired boiler (8TPH) and thermal oil heater (2,000,000 kcal/h) currently lack air preheaters and economizers, resulting in low combustion efficiency, with the steam boiler operating at approximately 64% and the thermal oil furnace at around 70%. This situation indicates a significant potential for improving boiler efficiency. Additionally, the ID fans of both the boiler and heater are equipped with Variable Speed Drives (VSD), but they are controlled manually, suggesting further opportunities to optimize control. Furthermore, some hot surfaces are not insulated, highlighting potential for improved insulation to enhance energy efficiency.

Figure 1.3. Status of the boiler house

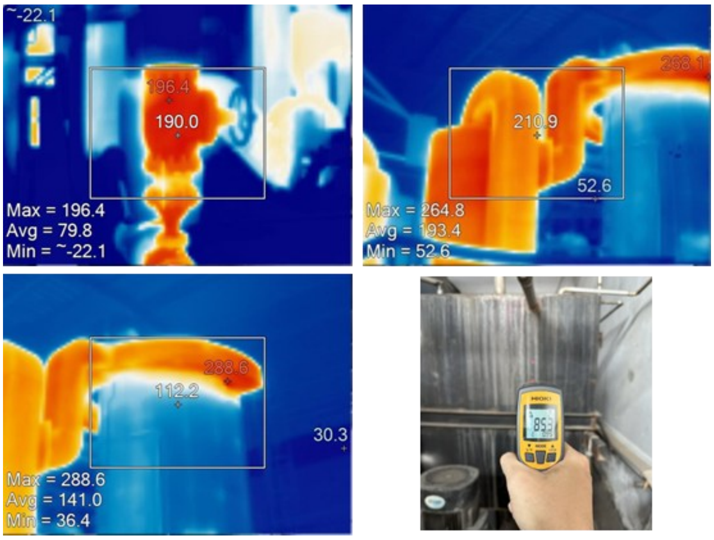


Figure 1.4. Thermal images at the boiler house

1.3.2 Compressed air

The factory uses 02 air compressors. Each of them has the following specifications: it features a rated power of 22 kW and a capacity of 3.64 m³/min. The set pressure ranges from 6.0 to 6.5 bar, ensuring efficient operation for various applications.

Figure 1.5. Status of the air compressors at the factory

The audit team has conducted measurements of electrical consumption and power for the two air compressors, as shown in the following load profile:

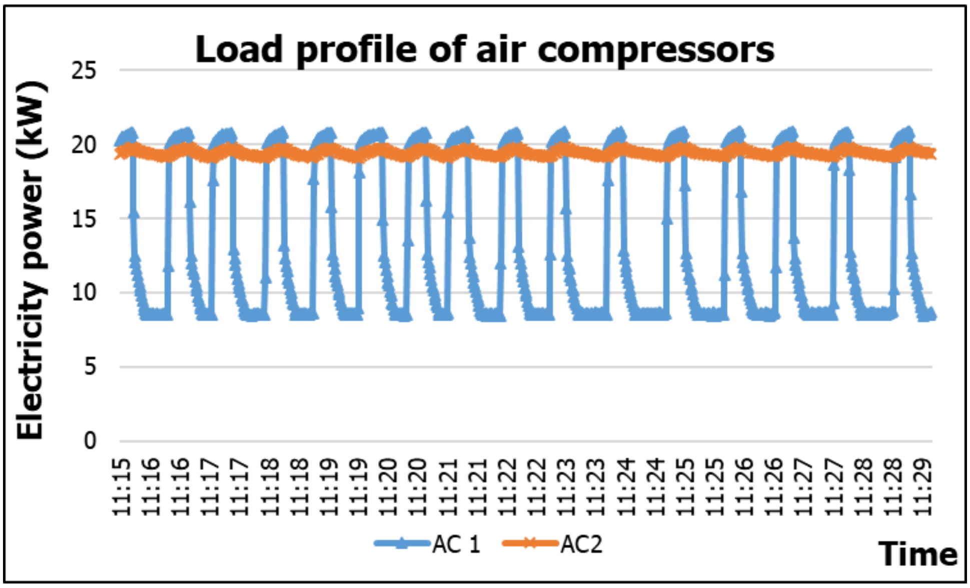


Figure 1.6. Status of the air compressors at the factory

Air compressor No. 1 frequently experiences long unloading cycles, which leads to unnecessary energy losses during the unloading operation. This situation highlights the potential for reducing these losses by optimizing the unloading process.

1.3.3 Water treatment

Electricity used for air blowers accounts for the largest proportion in wastewater treatment systems. The air blower at the factory has the following specifications: it features two rated power configurations of 2 x 22 kW and 2 x 7.5 kW, with a capacity of 20 m^3/min and 6 m^3/min, respectively. The operating pressure ranges from 0.57 to 0.68 bar.

Figure 1.7. Status of the air blowers at the factory

The air blower operates in an on/off mode with a fixed speed. The dissolved oxygen (DO) norm is typically around 2 to 4 mg/L, while the actual DO test value recorded during the assessment is 6.5 mg/L. This indicates a potential opportunity to control the air blowers based on the DO value, which could lead to significant energy savings.

Figure 1.8. The dissolved oxygen (DO) norm measured at the factory

2 Methodology used to identify EE projects

2.1 How EE projects have been identified and developed

A throughout understanding of energy saving potentials in a specific company necessitates a good initial data collection and a seria of methodologies to apply in analysis of the energy consumption pattern.

- **Understanding the energy service:** An advanced understanding of the energy consumption in a company can often be described via the “onion diagram”, which illustrates that for any significant energy user there is a reason for why significant amounts of energy is needed.

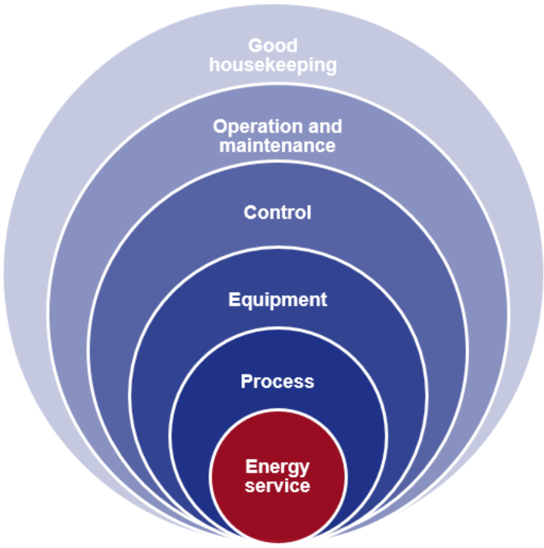


Figure 2.1. The “Onion diagram” for advanced understanding of energy consumption

- **Energy balances – Sankey diagrams:** For the most significant energy users, an energy balance should be established to illustrate the total energy balance and which losses that occur in the operation. Such an energy balance is often name a “Sankey diagram”.
- **“Level-2”-mapping:** For companies with complex energy supply structures and multiple consumers of thermal energy (heating and cooling), a further assessment of design parameters for each consumer of cooling and heating must be carried out. It is important to understand that such large differences in delta-T, i.e. differences in process demand-temperature and delivered utility-temperature, can represent significant energy saving potentials. To enable such an understanding, companies with such energy supply patterns should carry out a “level-2”-mapping, where any thermal energy demand (heating and cooling) should be mapped by energy demand and temperatures.
- **Utility structures:** The understanding of hot/cool utility requirements with the Level-2-mapping should also be carried out.
- **Heat recovery schemes:** In most facilities heat recovery schemes represent significant energy saving potentials and overall, the following options are to be considered:

    - Improved efficiency of already existing heat recovery systems
    - Installation of new heat recovery systems internal at significant energy users
    - Heat recovery systems across multiple energy consumers
- **Large fan and pumping systems:** In certain sectors like cement, iron & steel, paper & pulp and chemical industry (fertilizers), comprehensive fan- and cooling water systems are operated. Such systems are often complex and with low efficiency, which shall be assessed carefully.
    - For large fans, the control strategy as well as the total fan efficiency must be assessed.
    - For large cooling water systems, a careful comparison of delivered cooling and consumed electricity for fans and pumps should be monitored continuously.
- **BAT-assessments:** A throughout understanding of Best Available Technology (BAT) can provide important information on potential energy savings in existing plants. It is important to stress that BAT-solution often will address the core unit operations in a facility and therefore is to be considered as a major and very expensive rehabilitation. Such changes are most often only possible if other benefits than energy savings can be achieved, by example increase production capacity, improved product quality, better flexibility of operation etc.
- Maintenance procedures: most industries have significant energy saving potentials simply via improving maintenance procedures for the most important energy users, by example:
    - Regular control of boiler efficiency (02-% and temperature in exhaust gas)
    - Repair or installation of missing insulation at all hot surfaces (piping, valves etc.)
    - Repair of leaks in compressed air piping systems
    - Cleaning of fouled heat exchangers
    - Monitoring of water content in ammonia in refrigeration systems
    - Removal/purging of air in condensers in freezing plants
    - Repair of steam traps in steam distribution systems
    - Etc.
- **Operational control and KPIs:** Most companies tend to monitor energy consumption on a regular basis (monitoring overall production output and overall energy consumption) – thus calculating a specific energy consumption-index (SEC) every week, month or year. Such a KPI (SEC) can only be used to monitor overall and long-term trends in energy usage and can’t be used to improve energy efficiency as the SEC-KPI is influenced by many external factors. During the course of an energy audit, is shall therefore be identified if losses from inefficient operation of processes and utility systems occur and how such losses can be prevented.
- **Energy Management Systems:** Evaluation of the facility energy management status must be conducted through interviewing and onsite surveying (assessing metering infrastructure; reviewing document; etc.). Organization of energy management shall

be proposed including identification of relevant staff requirements to cover the necessary positions (e.g. energy managers, boards for energy management).

2.1.1 Electricity consumption structure of production equipment

Table 2.1. Electricity consumption by main areas/ production lines

No.	Areas	Electricity consumption *(kWh)*	Share *(%)*
1	Reeling Yarn	66,340	1.3%
2	Knitting	1,334,103	27.1%
3	Weaving	256,040	5.2%
4	Discharging Fabric	10,710	0.2%
5	Washing	6,419	0.1%
6	Setting	747,867	15.2%
7	Dyeing	809,280	16.5%
8	Wringing and Straightening	22,176	0.5%
9	Tentering	704,023	14.3%
10	Checking	44,640	0.9%
11	Embosing	8,288	0.2%
12	WWTP	199,368	4.1%
13	Water pumps	86,400	1.8%
14	Boiler house	315,499	6.4%
15	Compressor	222,588	4.5%
16	Others	84,859	1.7%
Total		**4,918,600**	**100%**

Profile of the electricity consumption share by main areas/ production lines is shown in the following chart:

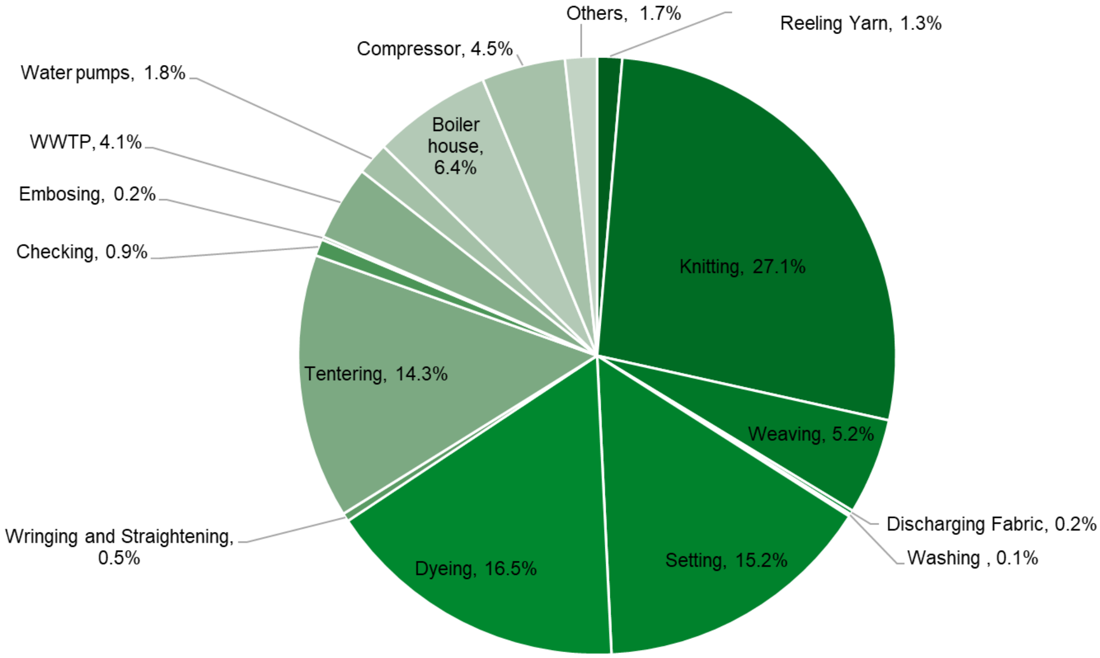


Figure 2.2 Electricity consumption share by main areas in 2023

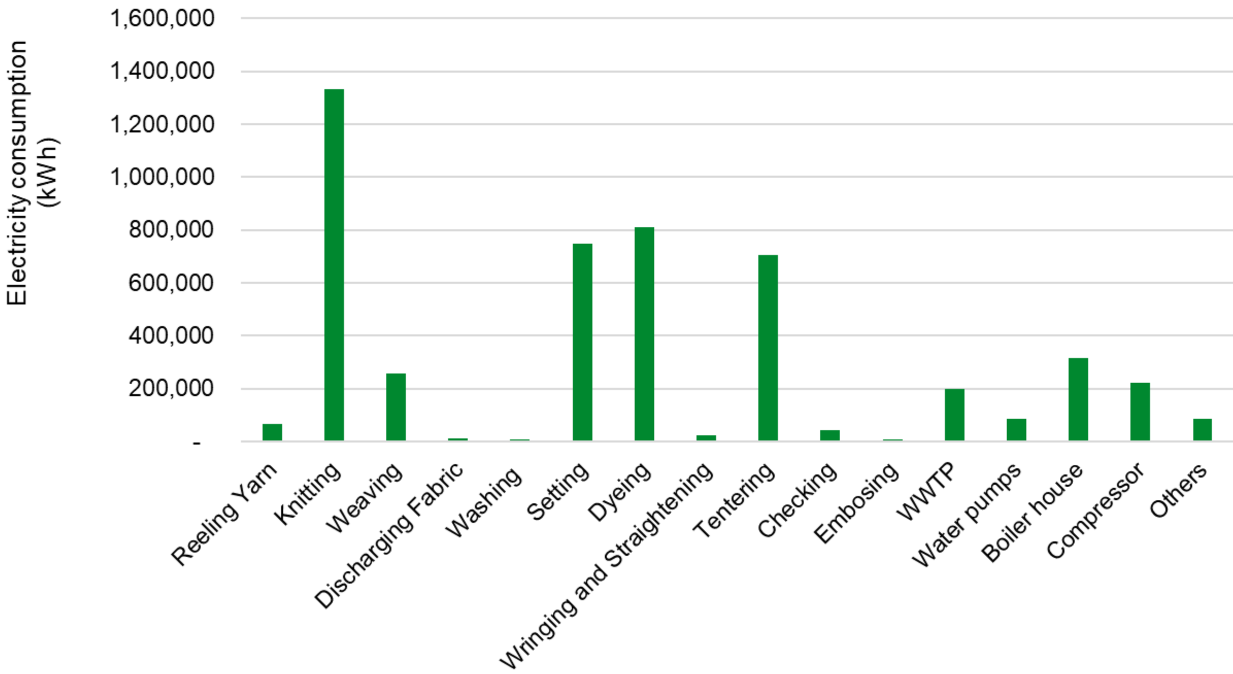


Figure 2.3 Distribution of electricity consumption in 2023

The chart shows the electricity consumption rates of the main equipment groups at the Company as follows: knitting accounts for 27.1%, dyeing accounts for 16.5%, setting accounts for 15.2%, and tentering accounts for 14.3%. Utility such as boiler house, compressed air and WWTP have the largest ratio of 6.4%, 4.5% and 4.1% respectively.

2.1.2 Energy consumption from biomass

2.1.2.1 Steam system

The boiler receives energy from a biomass source to produce saturated steam, which is supplied to the production processes. Steam is primarily supplied for the washing and dyeing processes.

The energy consumption structure of steam-consuming equipment presented as follows:

Table 2.2. Energy consumption by main areas/ production lines using steam

No.	**Areas**	**Energy consumption** *(kWh)* [4]	**Share** *(%)*
1	Washing 95°C - Color product	351,890	3.4%
2	Washing 75°C - Color product	144,311	1.4%
3	Dyeing - Dye process	4,885,640	47.3%
4	Dyeing - Rinse process	480,564	4.6%
5	Washing 95°C - Non-color product	36,136	0.3%
6	Washing 75°C - Non-color product	14,819	0.1%
7	Losses (boiler, steam distribution system, steam consumption end-users)	4,298,585	41.6%
8	Others	123,677	1.2%
Total		**10,335,622**	**100.0%**

Profile of the steam consumption share by main areas/ production lines is shown in the following chart:

[4] Energy consumption in production processes, boiler converted to kWh

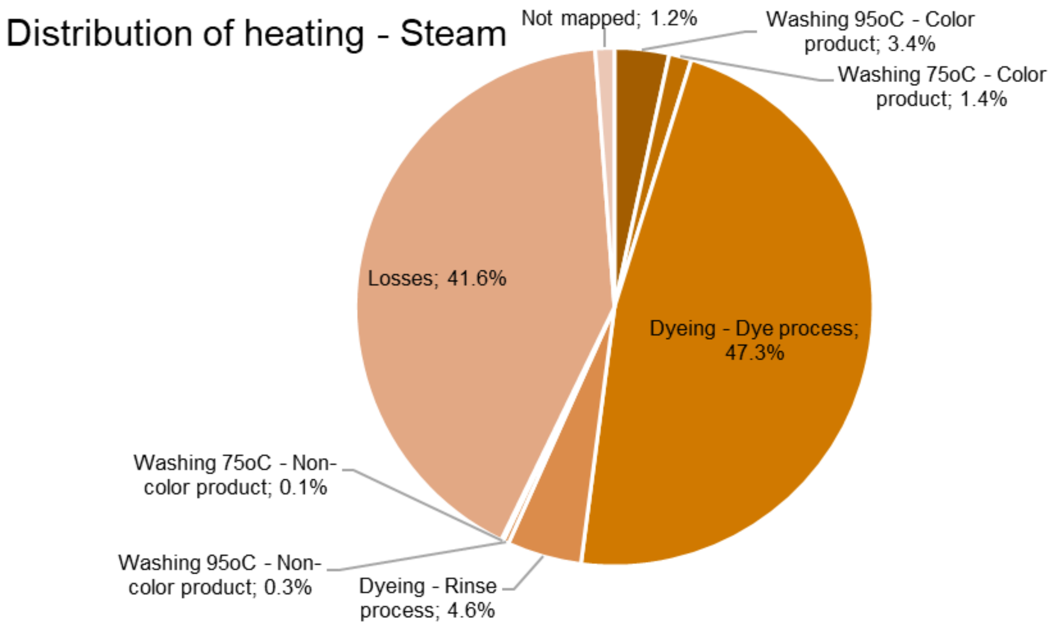


Figure 2.4 Primary energy consumption structure of steam-consuming equipment

The chart shows that the dyeing process consumes 47.3% of the primary energy from biomass. Energy losses in the boiler and steam distribution system are significant, accounting for about 41.6% of the input energy. The major energy losses in the steam system are mainly due to the boiler's design, manual firing, and the lack of water economizer and air preheater. In addition, steam users such as washing and dyeing processes use steam to make hot water, and some losses are found due to the use of cool feed water instead of hot feed water from the hot water tank.

2.1.2.2 Thermal oil heater

The thermal oil heater receives energy from a biomass source to generate heat, which is supplied to the production processes. Heat from the thermal oil is primarily used in the Setting and Stretching processes.

The energy consumption structure of heat-consuming equipment presented as follows:

Table 2.3. Energy consumption by main areas/ production lines using heat

No.	Areas	Energy consumption *(kWh)* [5]	Share *(%)*
1	Setting	5,992,230	36.4%
2	Drying and Stretching (Tentering)	5,243,201	31.9%
3	Losses	5,218,115	31.7%
4	Other	1,156	0.01%
Total		**16,454,703**	**100%**

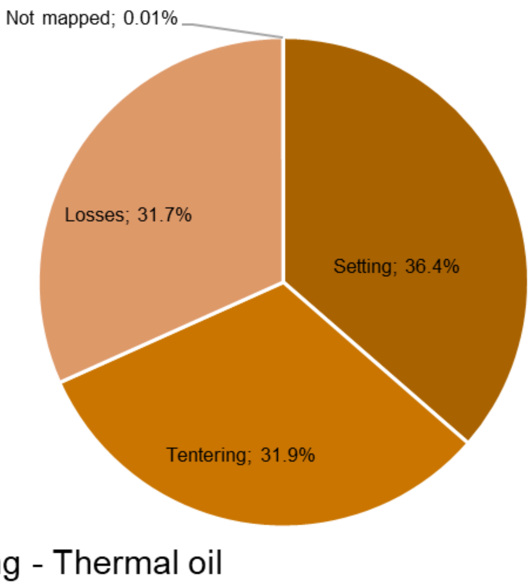


Figure 2.5 Energy consumption from thermal oil system share by main areas in 2023

The chart shows that energy losses in the thermal oil system are significant, accounting for 31.7% of the energy from biomass supplied to thermal oil furnace. Similar to the boiler, energy losses in the thermal oil system are largely due to the oil furnace's simple design, manual firing, and the lack of an air preheater. Beside the losses from TOH, some losses were identified from the stenters, mostly through the control and heat loss from the exhaust air.

[5] Heat consumption in production processes, thermal oil furnace converted to kWh

2.1.2.3 Waste heat from processes

Waste heat from manufacturing processes is presented as follows:

Table 2.4. Waste heat by main areas/ production lines

No.	Areas/ production lines	Energy consumption *(kWh)* [6]	Share *(%)*
1	Washing 95°C - Color product	167,994	3.0%
2	Washing 75°C - Color product	65,103	1.1%
3	Washing 30°C - Color product	52,082	0.9%
4	Setting	2,247,086	39.6%
5	Dyeing - Dye process	544,032	9.6%
6	Dyeing - Rinse process	699,168	12.3%
7	Tentering	1,872,572	33.0%
8	Washing 95°C - Non-color product	17,251	0.3%
9	Washing 75°C - Non-color product	6,685	0.1%
10	Washing 30°C - Non-color product	5,348	0.1%
	Total	**5,677,322**	**100.0%**

[6] Waste heat sources in production processes converted to kWh

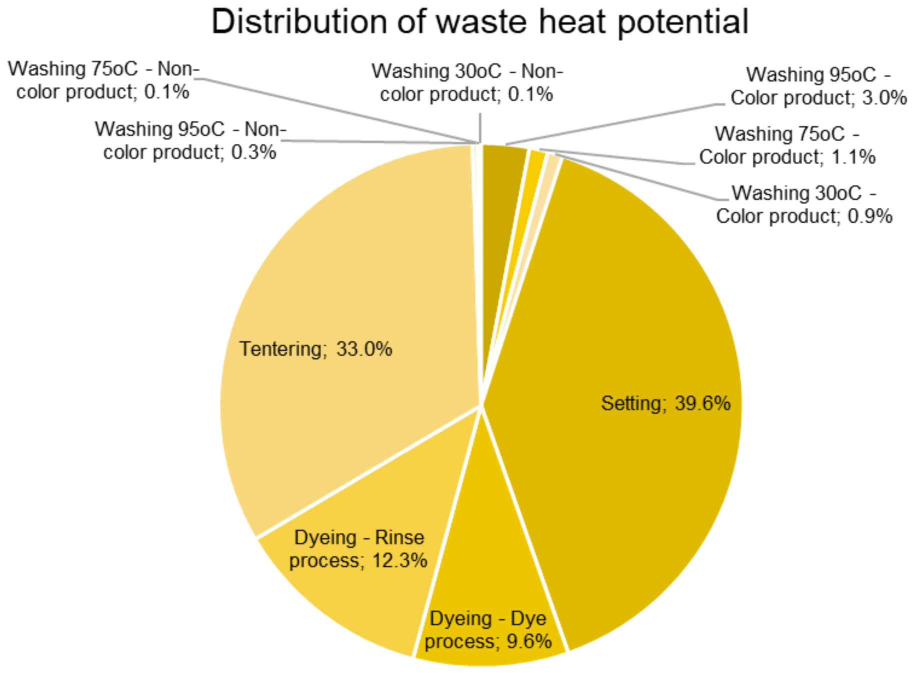


Figure 2.6 Waste heat from processes

The chart shows that waste heat in the setting and tentering is significant, accounting for 39.6% and 33.0% total waste heat of processes. Waste heat from dyeing and washing mostly from discharged wastewater, which has been recovered through a heat exchanger to preheat feed water that is stored in the hot water tank after.

2.1.3 Potential for energy saving through energy mapping

Based on the situation above, it can be seen that most of the waste heat potentials come from the production processes of stenters, dyeing and washing machines.

The heat losses of both steam and thermal oil systems are high. These losses mostly lie in the poor design and operation status of the thermal oil heater and steam boiler.

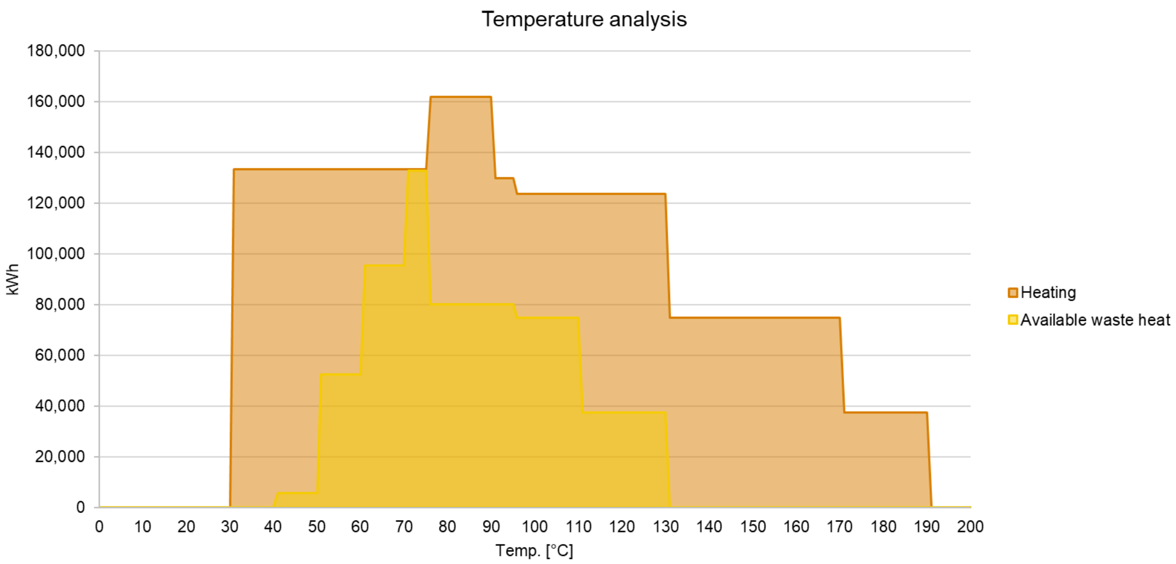


Figure 2.7 Temperature and energy relation analysis

The graph above show that energy for heating processes has the highest consumption rate between the temperature range of 30 – 130^oC, this is for the dyeing/washing processes. However, the waste heat from wet processes (dyeing and washing) is already recovered by the factory, using a heat exchanger to utilize waste heat from discharged water from processes to the WWTP to preheat cool feed water. The available waste heat from stenters (yellow graph, 110 – 130^oC) is considerable and has not been recovered or utilized.

Based on these findings, some focus areas for improvement are listed below:

- Reduce thermal losses at the supply sides for both boiler and TOH;
- Optimize control of the stenters to reduce heat load;
- Recover waste heat from stenters;
- Utilize hot water for wet processes as much as possible;
- Some electricity saving potentials for high load utility system: compressed air system, air blower at WWTP.

2.1.4 Energy Management Status

To evaluate the energy management status of the factory, a 5-row and 6-column matrix was developed. The columns correspond to the evaluation criteria according to the PDCA structure (Plan – Do – Check – Act) in the energy management model. The rows are scored from 0 - 4 points corresponding to the level of performance of the management system. The higher the rating, the better the level of maturity of the energy management system. Details of the matrix is presented below:

Table 2.5. Matrix table to evaluate the energy management status

Level	Energy policy	Organize structure	Training & awareness	Measure, monitor	Communication	Investment
4	There is an energy policy, an action plan, and a commitment from the CEO.	Energy management is one of the contents of the plant management	There are regular channels of information on energy management at the plant.	There is a system to set energy consumption, complete monitoring for factories, workshops and large energy users.	There is always information, advertising about the plant and energy efficiency activities both inside and outside the plant.	There are specific and detailed plans for new investments and improvements to existing equipment.
3	There is an energy policy, but without CEO commitment	There is an energy management committee/group at the plant.	The Energy Department has always had direct contact with the key energy users.	There are measurement and monitoring systems for factories and workshops.	Regular campaigns to raise awareness about energy management throughout the plant.	Use the return on investment criteria to grade investment activities
2	No clear energy policy	Energy management responsibilities are not clearly defined.	Contact the main consumers through a temporary management board	There is only measurement and monitoring system for the plant level.	There is regular communication but only in a few parts of the plant.	Considering investment only in terms of quick payback.

Level	Energy policy	Organize structure	Training & awareness	Measure, monitor	Communication	Investment
1	There are no written energy efficiency guidelines.	The energy manager has a limited role in the plant.	Informal contact between engineers and users	Data analysis based on energy bills	There are not often communication activities	Only implemented low-cost measures.
0	There is no energy policy	There is no organization/individual responsible for energy consumption at the plant.	No contact with users	There is no information and measurement system.	No communication about energy efficiency	No investment plan to improve energy efficiency

Based on the above matrix, the following table show the evaluation of the factory energy management status:

Table 2.6. Matrix table to evaluate the energy management status

Criteria	Description of status	Evaluation level
Energy policy	There was no evidence of an existing official document for energy policy during the onsite assessment. The factory does take notice of the overall energy consumption of production processes, but there are no specific KPIs or official documents regarding this issue.	1
Organize structure	The factory has an energy manager responsible for overall energy management tasks. However, the role and level of impact of the energy manager are not well-defined (the energy manager also works as a safety and compliance officer). There are still limitations in the capability and jurisdiction of the energy manager.	2
Training & awareness	There is no mandatory training regarding energy efficiency in the factory. There is however occasional reminder and discussion about energy saving between production line manager and staffs.	1
Measure, monitor	the factory only has level 1 power meters (EVN meter and self-installed meter) to record the daily electricity consumption of main areas/workshops. Data from the level 1 power meters are not transmitted to a central computer or cloud system. The technicians have to record daily data by hand. Therefore, the accuracy of the data is not high, and more importantly the factory does not have access to the profiles of important loads that need to be constantly monitored.	2
Communication	There are no regular communication activities regarding energy efficiency in the factory. Energy efficiency issues are sometime mentioned in the periodic reporting meetings.	1
Investment	The factory is interested in energy efficiency investments. For investments with high costs or high technical issues (e.g., installing a new thermal oil heater or rooftop solar PV system), the factory will	4

Criteria	Description of status	Evaluation level
	develop detailed plans and present them to the board of directors before any implementation or decision-making.	

Based on the above results, it can be seen that the factory has not yet had an official energy management system.

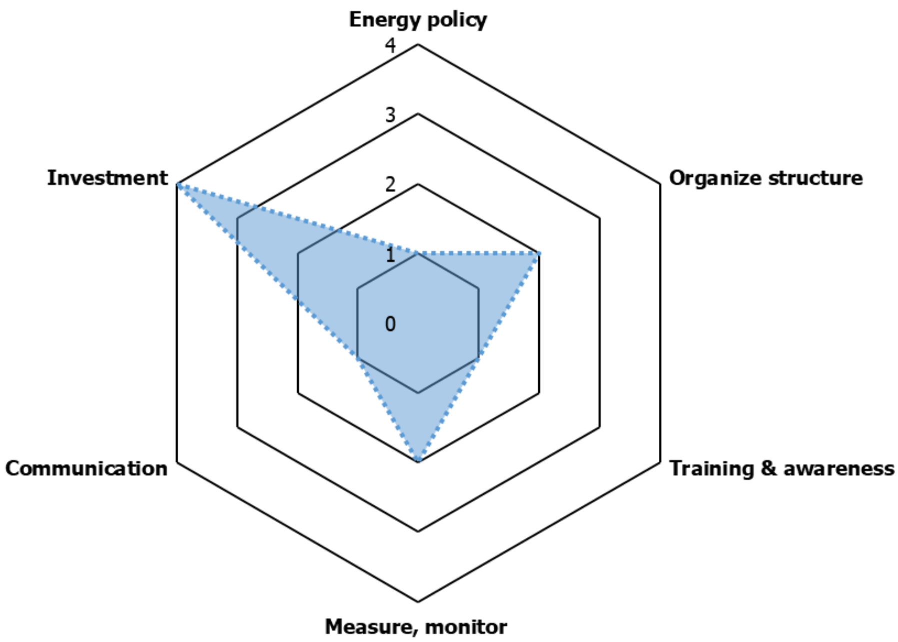


Figure 2.8 Overall evaluation of the factory energy management status

Based on this evaluation, a recommendation to establish an Energy Management System will be presented in the Energy Saving Measures section below.

2.1.5 Classification of project level A, B

During the energy audit process, many observations will be made which could have potential energy savings. All these observations should not be analysed in detail, but they should at a minimum be mentioned within the energy audit. At the beginning of the energy audit, it is advised to make a working document where all the observations will be noted throughout the audit. Thereby a large screening list can be created.

The observations within the list will be referred to as level B projects, where the potential energy savings and investment are evaluated based on estimates if possible.

The screening list of level B projects should be evaluated and up to 5 projects should be selected for further development. These projects will be called level A projects and should be developed enough for making a decision of whether to carry out a pre-feasibility study.

Examples of content in level A and B project development:

Level A:

- Project description
- Energy savings

- Financial savings
- Investment
- Payback time
- Simple system process flow diagram (PFD)
- Simple Risk analysis

Level B:

- Project description (one or two lines)
- Energy savings
- Financial savings
- Investment (based on experience)
- Payback time

There is a total of 12 recommended projects (level B) for energy saving. In these 12 projects, some are expected to have high investment and technical complexity, these are classified as project level A. To make sure that the energy and economic saving potentials of level A projects are properly realized, additional steps must be taken for further evaluation through deep dive pre-feasibility/feasibility studies.

ECM group	Scope
Group I: Projects level B	Including initial findings and general projects. Usually required low investment and are relatively simple to implement regarding the technical issues.
Group II: Projects level A	Screened projects from level B with high investment and technical complexity (potential to implement deep dive pre-feasibility/feasibility study).

2.2 EE Project evaluation

Basic technical constraints:

2.2.1 Data collection

The audit team has obtained information on:

- Characteristics of equipment/utilities system;
- The operating data of equipment/utilities system collected through recording notebooks;
- The operating data of the equipment/utilities system collected through on-site measurements;
- Operating conditions of equipment/utilities system are based on design documents or other relevant technical documents.

Based on collected data, the audit team screened and combined parameters with values, analyzing the trend of fluctuations with difference from the parameters of the equipment/utilities system that must be achieved or can be achieved. That is the potential for energy saving opportunities.

2.2.2 Identify energy saving opportunities

In order to identify the options to detected energy saving potential, the audit team has calculated to demonstrate quantitatively the energy savings for each proposed improvement option.

2.2.3 Identify investment costs

Most calculations can use a simple payback period approach through dividing the investment cost of energy saving opportunities by the energy saving value, resulting is a simple payback period in years.

In case there are significant differences between the trend of changing in energy prices and interest rates or if the investment costs of the energy saving opportunity is unreasonable in various stages compared to the energy saving capacity that can be achieved at different times, the audit team will perform a life cycle cost assessment to better recognize investment performance for energy saving opportunities

2.3 EE Project prioritisation

The main criteria select the energy efficiency projects for further evaluation through deep dive pre-feasibility/feasibility studies:

- High potential for energy saving and reducing carbon emission.
- High energy/costs saving.
- Technical complexity.
- Consistent with the Company's future technology investment.
- The potential for future expansion or a model for other businesses to refer to and implement.

2.4 Enterprises feedback

After conducting the energy audit, the consulting unit reported the results to the Company within the framework of the project. The proposed energy saving solutions were received positive feedback. The Company was interested in investment solutions at level A.

The Company has developed a working plan with Enerteam on feasibility studies for Level A solutions.

3 EE Projects identified

This section includes projects that cover all identified and agreed-upon potentials (Level B).

Table 1: Groos list (level B mapping)

Gross list							
Project no.	Name of Project	Energy form (gas, electricity, oil, etc.)	Investment Cost [Mil. VND]	Saving			Simple Payback [Years]
				Energy [MJ]	CO_2 [ton]	Financial [Mil. VND]	

1	Develop a preventative program to prevent compressed air leakage	Electricity	None	92,112	17.3	45.5	Instantly
2	Optimize the current VSD control for air compressors	Electricity	None	103,451	19.4	51.1	Instantly
3	Separate current compressed air system for cleaning and production	Electricity	220.0	172,094	32.3	85.0	2.6
4	Install VSDs for air blowers in the wastewater treatment system and control by DO signal	Electricity	64.1	392,736	73.8	194.1	0.3
5	Optimize the existing steam boiler and thermal oil heater	Biomass	585.6	6,752,371	13.0	1,240.6	0.5
6	Optimize the control of Exhaust Humidity in Stenter machine	Electricity & Biomass	528.0	2,984,580	10.0	555.4	1.0
7	Use water from the hot water tank for the washing machine	Biomass	300.0	970,378	1.9	178.3	1.7
8	Apply rooftop solar PV system through Direct Power Purchase	Electricity	None	-	830.6	245.2	Instantly

	Agreement (DPPA)						
9	Establish an Energy Management System (EnMS)	Electricity	216.8	177,070	33.3	87.5	2.5
10	Invest in new high-efficiency biomass thermal oil heater	Biomass	4,311.8	5,076,465	9.8	932.7	4.6
11	Invest in new high-efficiency biomass boiler	Biomass	6,399.5	4,302,688	8.3	790.5	8.1
12	Install heat recovery systems for stenters	Biomass	3,000.0	7,770,404	15.0	1,427.6	2.1

4 Selected EE Projects for further supports

This section includes projects that has been chosen to be developed further (Level A)[7].

4.1 Invest in new high-efficiency biomass thermal oil heater

Project information		
Project: Invest in new high-efficiency biomass thermal oil heater	**Project no. 1**	**Date: 2024**
Project description		
Current situation: The current biomass thermal oi heater (TOH) has low efficiency due to its design and operation. **Operation:** as mentioned in the previous section, the operation of TOH has multiple draw backs that can be optimize to increase its efficiency. However, integrating new controls into an existing system can bring benefits, but it cannot match the capabilities of a system that has been optimally controlled from the start. **Design:** The TOH itself is not very well designed. There is no air preheater, which has been addressed in the previous section. The TOH outer surfaces have relatively high temperatures, indicating poor insulation which can lead to heat losses. The TOH is fixed grate, fuel must be fed manually thus the combustion efficiency is not high. In addition, the TOH has been in operation for nearly 10 years, so its maximum efficiency has already dropped due to equipment deterioration. The factory Director shared that the factory is planning to replace the current TOH in the first quarter of 2026.		
Proposed project: The factory should focus on facilitating the project of replacing the current TOH. The selection of TOH technology should consider the lifecycle cost of the system, rather than just focusing on the initial investment cost. The system should be fully automatic with a built-in air preheater.		
Project illustration		

[7] The project developed at level B is not described in a section for itself because it is included in gross list.

Figure 4.1. Reference of high efficiency TOH system/technology

Project Budget

Element	Units	Unit costs (VND)	Costs (VND)
1. New 2 million kCal biomass boiler	1	3,749,428,571	3,749,428,571
2. Contengency costs (cost difference of actual quotation), estimated 10-20% equipment costs.	-	-	562,414,286
Total	**4,311,842,857**		

Time schedule (month)

Activity	1	2	3	4	5	6	7	8	9	10	11	12
Feasibility study	■											
Order Placement		■	■	■								
Equipment delivery				■	■	■						
Installation (depending on the production schedule, etc.)							■	■	■	■		

Testing, commissioning Trial run+ staff training	

Saving	
Biomass savings: **284,343 kg/yr**	Financial savings: **932.7 mil. VND**
GHG reduction: **9.8 tCO_2e/yr**	Simple Payback: **4.6 yrs**

Risk Analysis
Not gain efficiency as expected: The risk could be mitigated by regularly maintaining the TOH system as well as the calibration of dedicated sensors. **Technical failure due to lack of operation familiarity/breakdown:** Provide adequate technical training for the operating staff and robust participation of operators in the trial run, testing, and handover process. **Stop the boiler system when retrofitted equipment:** The system can be switched to manual mode while sensors and related auto control devices are maintained.

Non-Energy benefits
Supporting sustainability in business (by reducing greenhouse gas emissions). Reduce operation costs (fuel cost). Reduce labor through automatic operation.

4.2 Invest in new high-efficiency biomass boiler

A

Project information		
Project: Invest in new high-efficiency biomass boiler	**Project no. 2**	**Date: 2024**

Project description
Current situation: The current biomass boiler has low efficiency due to its design and operation. **Operation:** as mentioned in the previous section, the operation of boiler has multiple draw backs that can be optimize to increase its efficiency. However, integrating new controls into an existing system can bring benefits, but it cannot match the capabilities of a system that has been optimally controlled from the start. **Design:** The boiler itself is not very well designed. There are no air preheater and economizer, which has been addressed in the previous section. The boiler outer surfaces have relatively high temperatures, indicating poor insulation which can lead to heat losses. The boiler is fixed grate, fuel must be fed manually thus the combustion efficiency is not high. In addition, the boiler has been in operation for nearly 10 years, so its maximum efficiency has already dropped due to equipment deterioration. The factory Director shared that the factory is planning to replace the current boiler in the next few years after the TOH replacement.
Proposed project: The factory should focus on facilitating the project of replacing the current boiler. The selection of boiler technology should consider the lifecycle cost of the system, rather than just focusing on the initial investment cost. The system should be fully automatic with built-in air preheater and economizer.
Project illustration

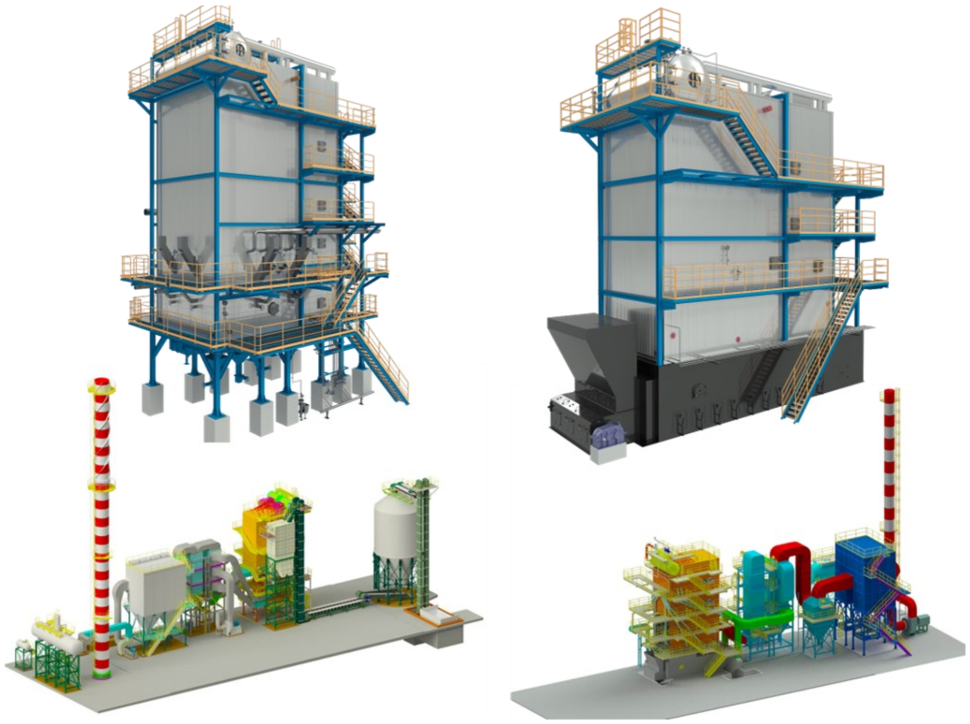


Figure 4.2. Reference of high efficiency TOH system/technology

Project Budget			
Element	Units	Unit costs (VND)	Costs (VND)
3. New 8 TPH biomass boiler	1	5,564,776,800	5,564,776,800
4. Contengency costs (cost difference of actual quotation), estimated 10-20% equipment costs.	-	-	834,716,520
Total	**6,399,493,320**		

Time schedule (month)												
Activity	1	2	3	4	5	6	7	8	9	10	11	12
Feasibility study												
Order Placement												
Equipment delivery												
Installation (depending on												

the production schedule, etc.)	
Testing, commissioning	
Trial run+ staff training	
Saving	
Biomass savings: **241,003 kg/yr**	Financial savings: **790.5 mil. VND**
GHG reduction: **8.3 tCO_2e/yr**	Simple Payback: **8.1 yrs**
Risk Analysis	
Not gain efficiency as expected: The risk could be mitigated by regularly maintaining the boiler system as well as the calibration of dedicated sensors. **Technical failure due to lack of operation familiarity/breakdown:** Provide adequate technical training for the operating staff and robust participation of operators in the trial run, testing, and handover process. **Stop the boiler system when retrofitted equipment:** The system can be switched to manual mode while sensors and related auto control devices are maintained.	
Non-Energy benefits	
Supporting sustainability in business (by reducing greenhouse gas emissions). Reduce operation costs (fuel cost). Reduce labor through automatic operation.	

4.3 Install heat recovery systems for stenters

Project information		
Project: Install heat recovery systems for stenters	**Project no. 3**	**Date: 2024**

Project description

Current situation:

The stenters at the factory do not have exhaust air heat exchangers. These stenters are used for two main purposes:

Fabric setting: The required temperature in stenter chambers is 190 – 200°C.

Fabric drying and stretching: The required temperature in stenter chambers is 160 – 170°C.

Both processes have high temperature requirements. Therefore, the stenter exhaust air during these processes usually has high temperature (> 120°C) and flow, meaning there is great potential for utilizing heat from this exhaust air. The factory can refer to the previous section to see the energy loss from stack loss (exhaust air).

Figure 4.3. Stenter exhaust air status

Proposed project:

The factory can consider retrofitting exhaust air heat exchangers for the current stenters or investing in new stenters with built in heat exchangers if there is plan for expansion in the future. The waste heat energy from stenter exhaust air can be recover up to 20% depending on the capability of the heat exchanger. This help reduce heat load (for heating feed air of drying chambers) for stenter, thereby reducing fuel consumption of TOH.

Project illustration

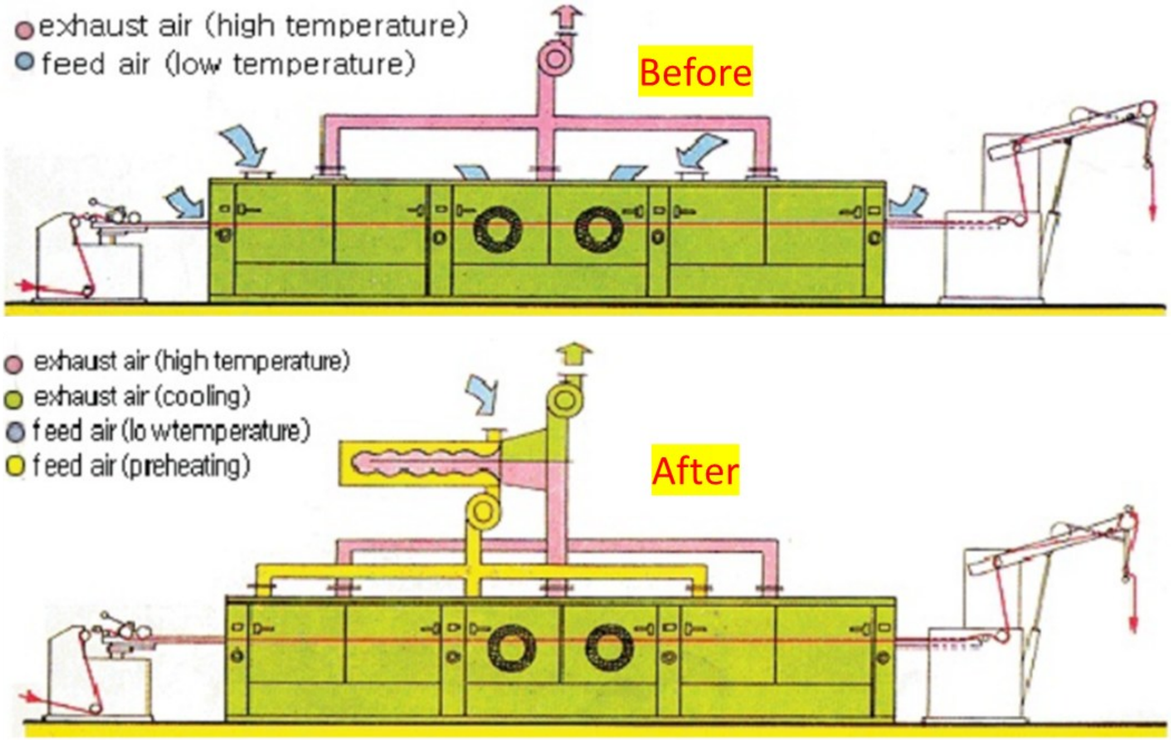


Figure 4.4. Example of retrofitting heat exchanger for stenter

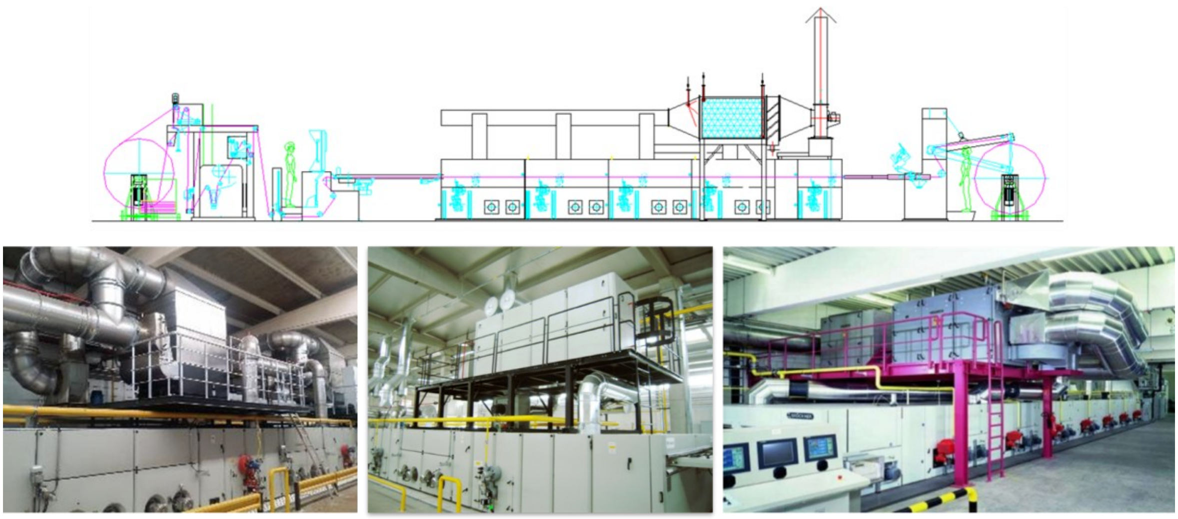


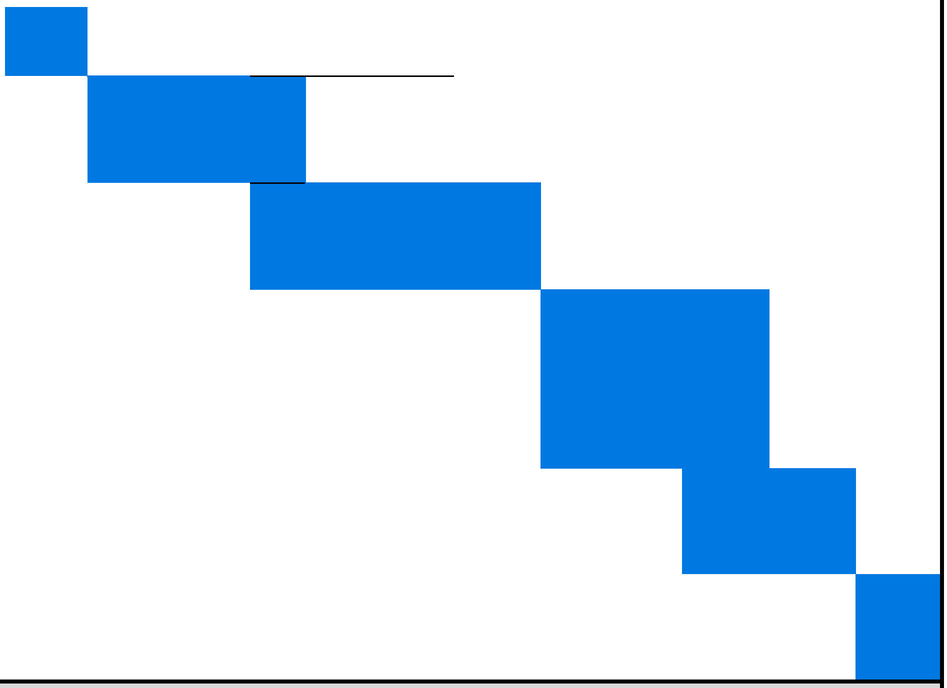
Figure 4.5. Case studies of applying heat exchanger for stenter

Project Budget

Element	Units	Unit costs (VND)	Costs (VND)
5. Heat recovery systems for stenters	2	1,000,000,000	2,000,000,000

6. Contingency costs (cost difference of actual quotation), estimated 50% equipment costs.	-	-	1,000,000,000
Total	**3,000,000,000**		

Time schedule (month)												
Activity	1	2	3	4	5	6	7	8	9	10	11	12
Feasibility study												
Order Placement												
Equipment delivery												
Installation (depending on the production schedule, etc.)												
Testing, commissioning												
Trial run+ staff training												



Saving	
Biomass savings: **435,237 kg/yr**	Financial savings: **1,427.6 mil. VND**
GHG reduction: **15.0 tCO_2e/yr**	Simple Payback: **2.1 yrs**

Risk Analysis

Not gain efficiency as expected: The risk is not high as the payback time with the estimated efficiency is quite short. This could also be mitigated by regularly maintaining the heat exchangers.

Technical failure due to lack of operation familiarity/breakdown: Provide adequate technical training for the operating staff and robust participation of operators in the trial run, testing, and handover process.

Cannot be implemented for the current stenters: The factory can consider this project for future expansion with new stenters procurement.

Non-Energy benefits

Supporting sustainability in business (by reducing greenhouse gas emissions).
Reduce operation costs (fuel cost).