



ANONYMOUS ENERGY AUDIT REPORT

FROM A SEAFOOD PROCESSING COMPANY

Developed in collaboration with:

Department for Innovation, Green Transition and Industrial Promotion, Ministry of Industry and Trade of Vietnam

Danish Energy Agency

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Energy Conservation Research and Development Center (ENERTEAM)

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Introduction to the context

On March 13, 2019, the Decision No. 280/QĐ-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 summary of a specific energy audit report conducted as a part of the DEPP3 program. The audit has been conducted on a seafood processing production plant, by Energy Conservation Research and Development Center (ENERTEAM), in collaboration with an international expert from Viegand Maagøe.

Summary

Through detailed energy mapping, auditors gained a clear understanding of the energy consumption structure, including the specific purposes of energy use in various production processes. The mapping provided an overview of heating, cooling, and electricity consumption distribution, facilitating the identification of main energy-consuming areas. Additionally, the analysis highlighted energy input/output flows and losses at each production stage, along with the current status of technological equipment used.

By examining the balance between raw material flows, energy consumption, and losses, auditors assessed the overall efficiency of energy use within the production process, identifying potential areas for improvement. As a result, 11 Level B energy-saving projects were recommended. Among these, certain projects involving higher investment and technical complexity were classified as Level A. To ensure accurate realization of the energy and economic saving potentials of these Level A projects, it is recommended to conduct further evaluation through detailed pre-feasibility or feasibility studies.

Details of energy saving potentials are shown in the following table:

Table 0.1. Summary of energy saving opportunities

Group of ECMs	Electricity savings	FO savings	Water savings	Cost savings	Payback	CO ₂ emission reduction
	(kWh/year)	(liter/year)	(m ³ /year)	(million VND/year)	(year)	(ton CO ₂ e/year)
No investment cost or low investment cost¹	36,793	0	21,600	303	1.9	24
Medium investment cost²	401,238	14,126	0	938	2.0	308
High investment cost³	625,853	46,150	0	1,772	2.0	553
Total	1,063,884	60,276	21,600	3,013	-	884.9

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

² Medium investment cost: 100 million VND < Investment cost ≤ 1 billion VND.

³ High investment cost: Investment cost > 1 billion VND.

Percentage of savings	8.1%	33.8%	5.4%	-	-	10.5%
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1 ABOUT THE ENTERPRISE

Factory is one of the seafood processing facilities in Viet Nam specializing in the production and export of frozen seafood products, mainly catfish and shrimp. The factory operates on a relatively large scale with more than 500 employees and a designed production capacity of approximately 25,000 tons of products per year.

The factory applies a closed production model and has continuously invested in upgrading and modernizing its equipment and production lines to enhance productivity, ensure product quality, and maintain food safety. Currently, the facility exports its products to several international markets, including Australia, Japan, and Europe.

In addition, the factory has implemented various international food safety and quality management systems to ensure compliance with global standards and meet the requirements of both domestic and international customers.

1.1 Description of the company

- Sector: Seafood processing
- Main products: Catfish and catfish-based products, shrimp
 - Fillet catfish: 5,793,272 kg/year;
 - Breaded fish: 1,008,195 kg/year;
 - Fish balls, fish sticks: 1,180,274 kg/year;
 - Snack: 3,317 kg/year;
 - Shrimp: 726,014 kg/year.
- Annual energy total consumption:
 - Grid electricity: 11,872,900 kWh;
 - Solar electricity: 1,336,470 kWh;
 - FO: 178,403 kg;
 - DO: 17,040 liters;
 - LPG: 5,535 kg;
 - Water: 396,553 m³.
- Annual carbon footprint: 8,432 ton CO₂e

The share of energy consumption at the company in 2024 are as follows:

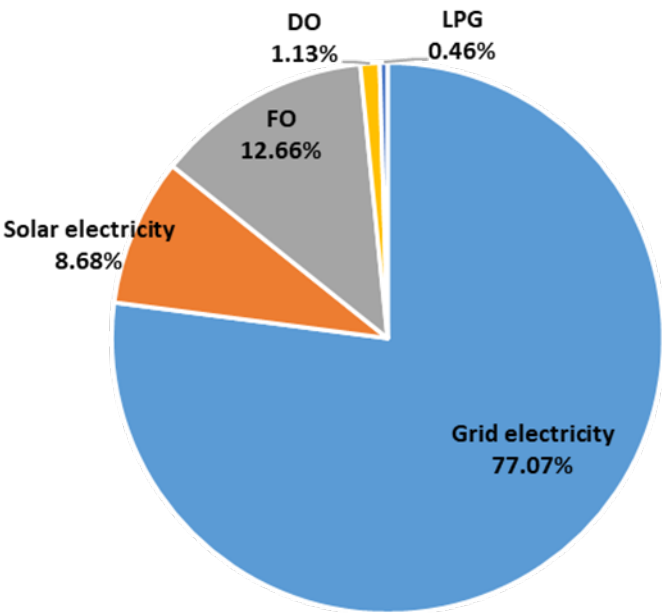


Figure 1.1. Share of energy consumption

The chart above shows that grid electricity is the dominant source of energy consumption at the factory in 2024, accounting for about 77.1% of the total. This is followed by FO at 12.7% and solar electricity at 8.7%. DO and LPG contribute a relatively small share, representing only 1.1% and 0.5%, respectively.

1.2 Description of the process

Catfish fillet production process

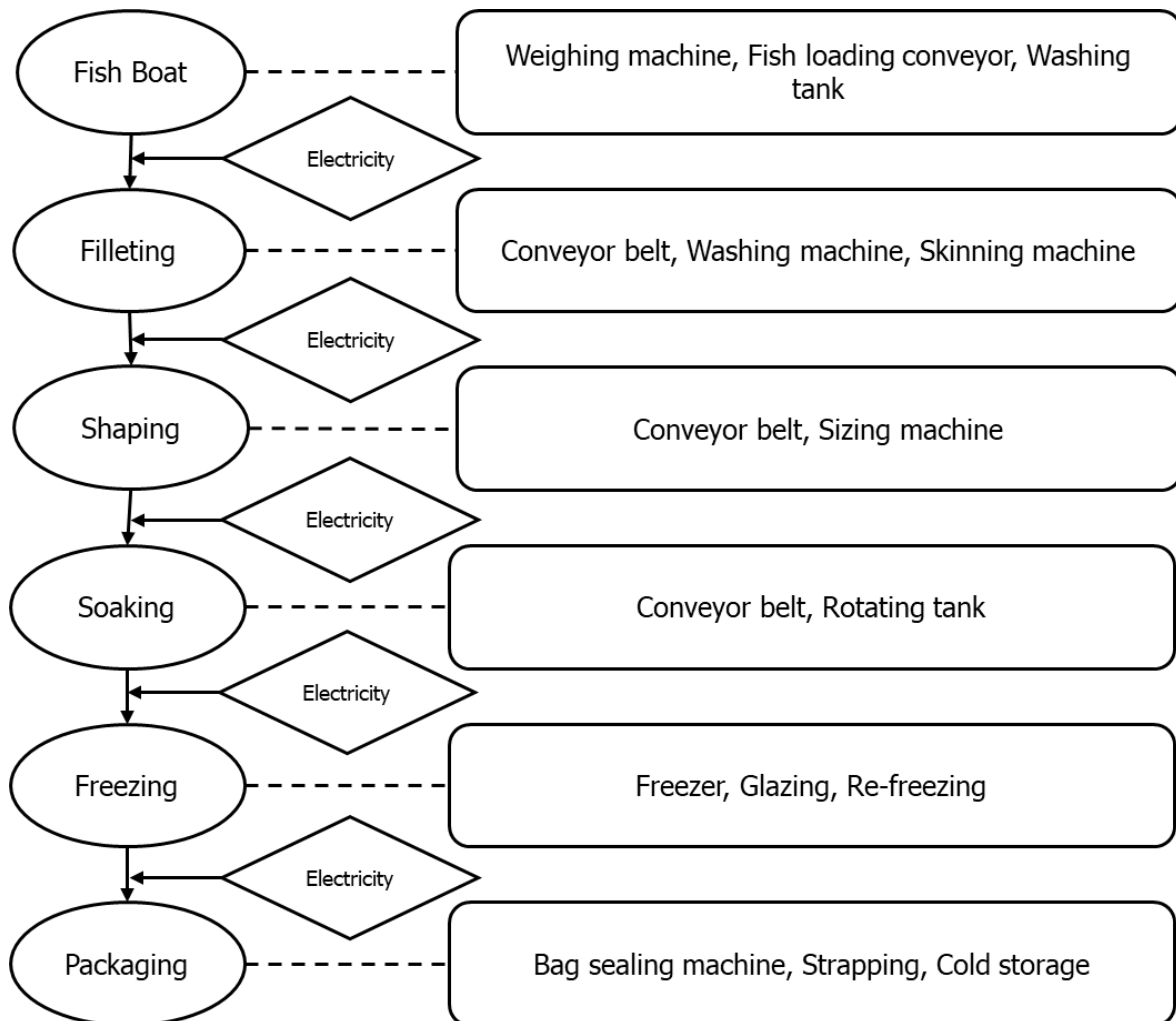


Figure 1.2. Catfish fillet process flowchart

After receiving the raw material, the fish is sent to the slaughtering section where the gills are cut and the blood is removed. Then, the fish is filleted into two pieces and skinned using specialized machines.

The fillets are then shaped to ensure no bones remain, and the surface is smooth and flat. The fillets are washed with a high-pressure spray system to remove blood. After washing, fillets are inspected for parasites, and any contaminated pieces are discarded.

Fillets that meet quality standards are washed again by an automatic system and sized according to weight or customer requirements, either manually or by machine.

Sized fillets are placed into baskets and washed with ice water, then arranged into molds for aesthetic presentation.

The molded fillet blocks are frozen using a contact freezer at a temperature $\leq -35^{\circ}\text{C}$ for 15-20 minutes.

After freezing, the fillets are released from the molds using water at the bottom and packed according to weight, type, and size. Packaging is done according to the order specifications and complies with current frozen seafood processing regulations.

Finally, the frozen fillets are stored in a cold storage at $\leq -18^{\circ}\text{C}$, ready for shipment.

Fish ball and breaded fish production process

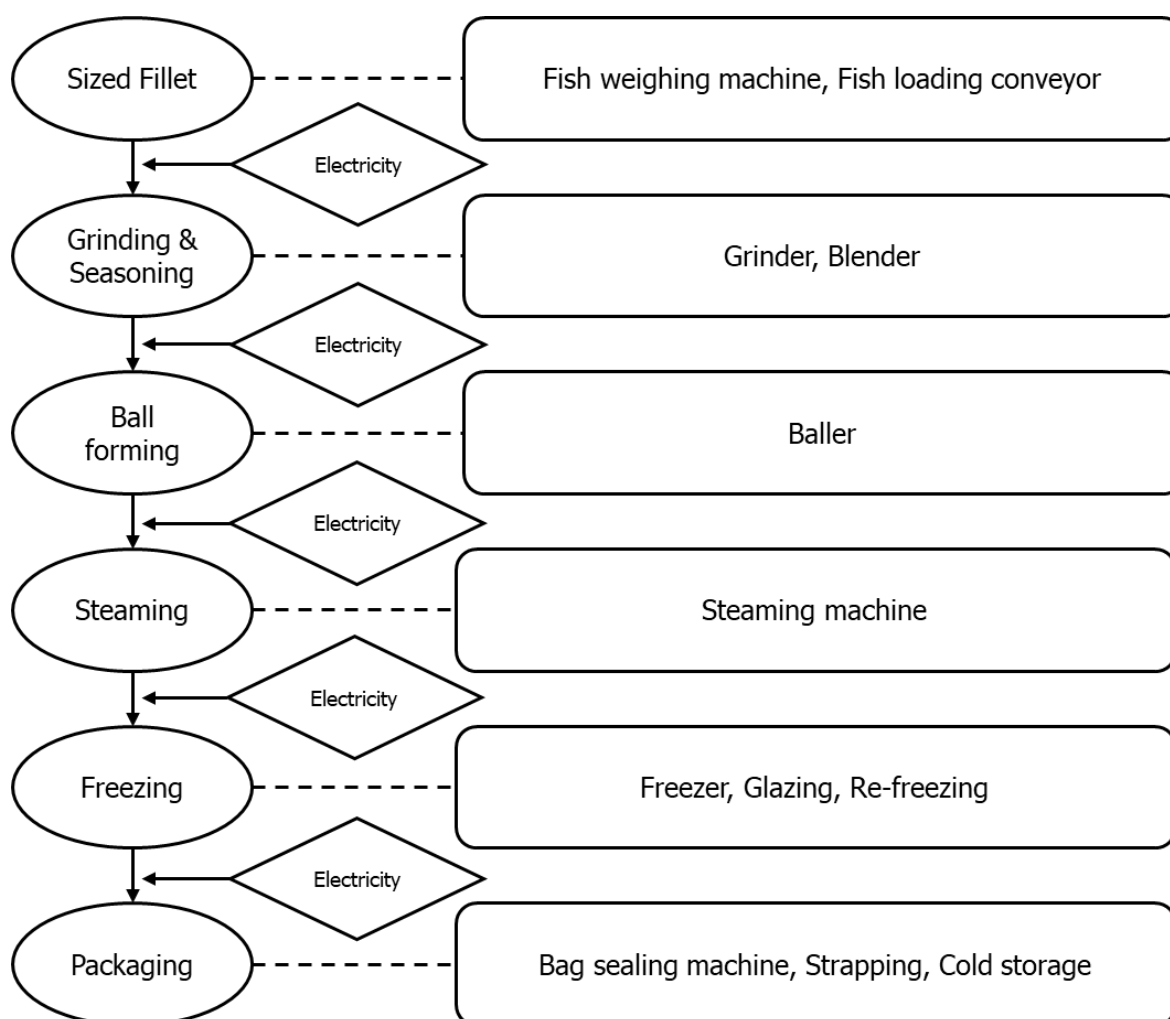


Figure 1.3. Fish ball process flowchart

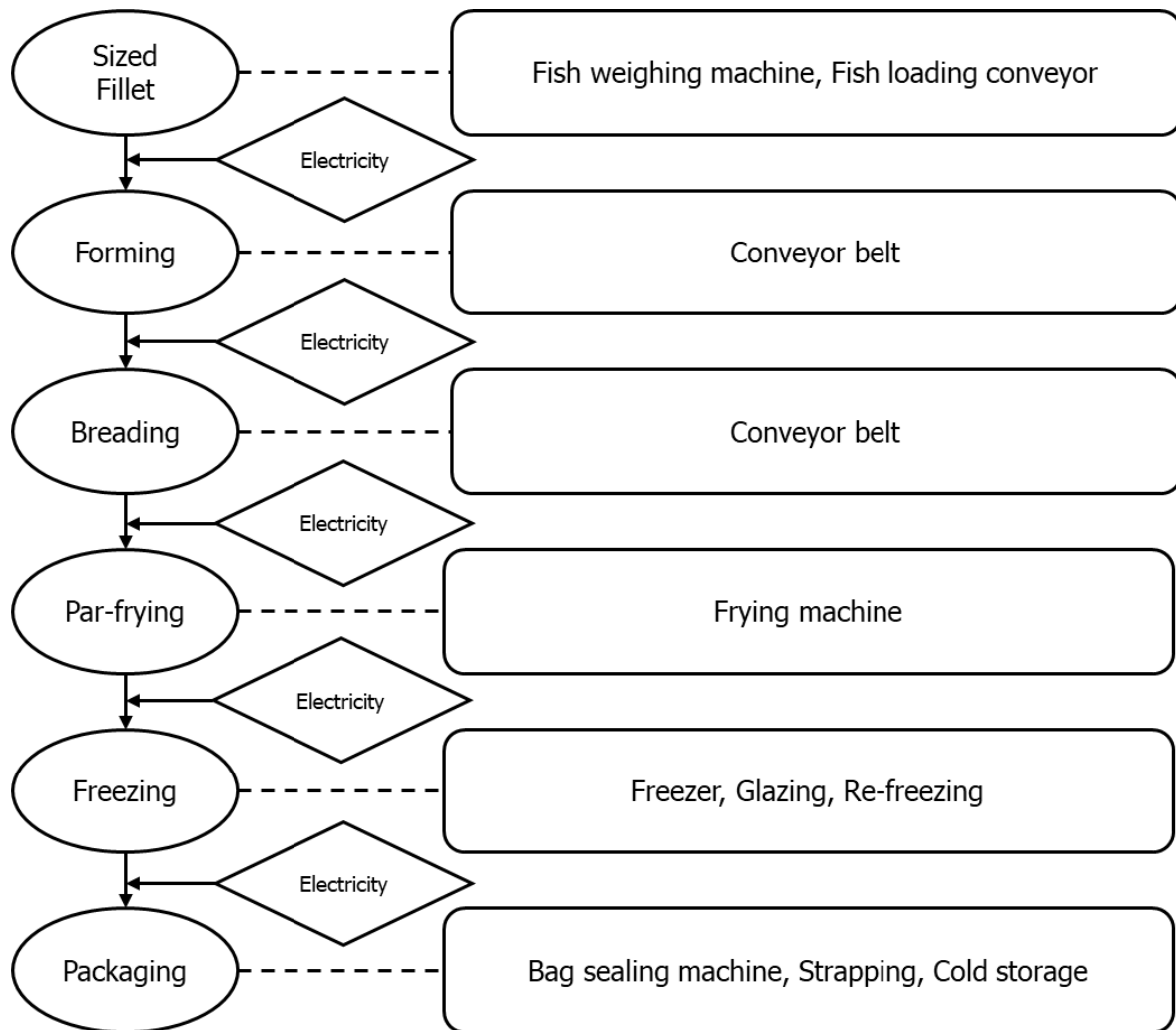


Figure 1.4. Breaded fish process flowchart

A portion of the filleted fish, after cleaning and shaping in the frozen fillet production line, is separated and sent to the pre-processing stage as input for the value-added product production line.

Pre-processing stage: Depending on customer requirements, fillets from the block forming stage or size selection stage in the fillet production line are chosen as raw materials for pre-processing. The selected fillets are shaped according to customer specifications and then washed again.

Seasoned steamed fish products: After pre-processing, the fish is minced, seasoned, formed into balls, and placed in the steaming room for cooking. All stages in the production line are carried out via automatic conveyors. The cooked fish is then sent to the freezing cabinet to be frozen before packaging, cold storage, and distribution.

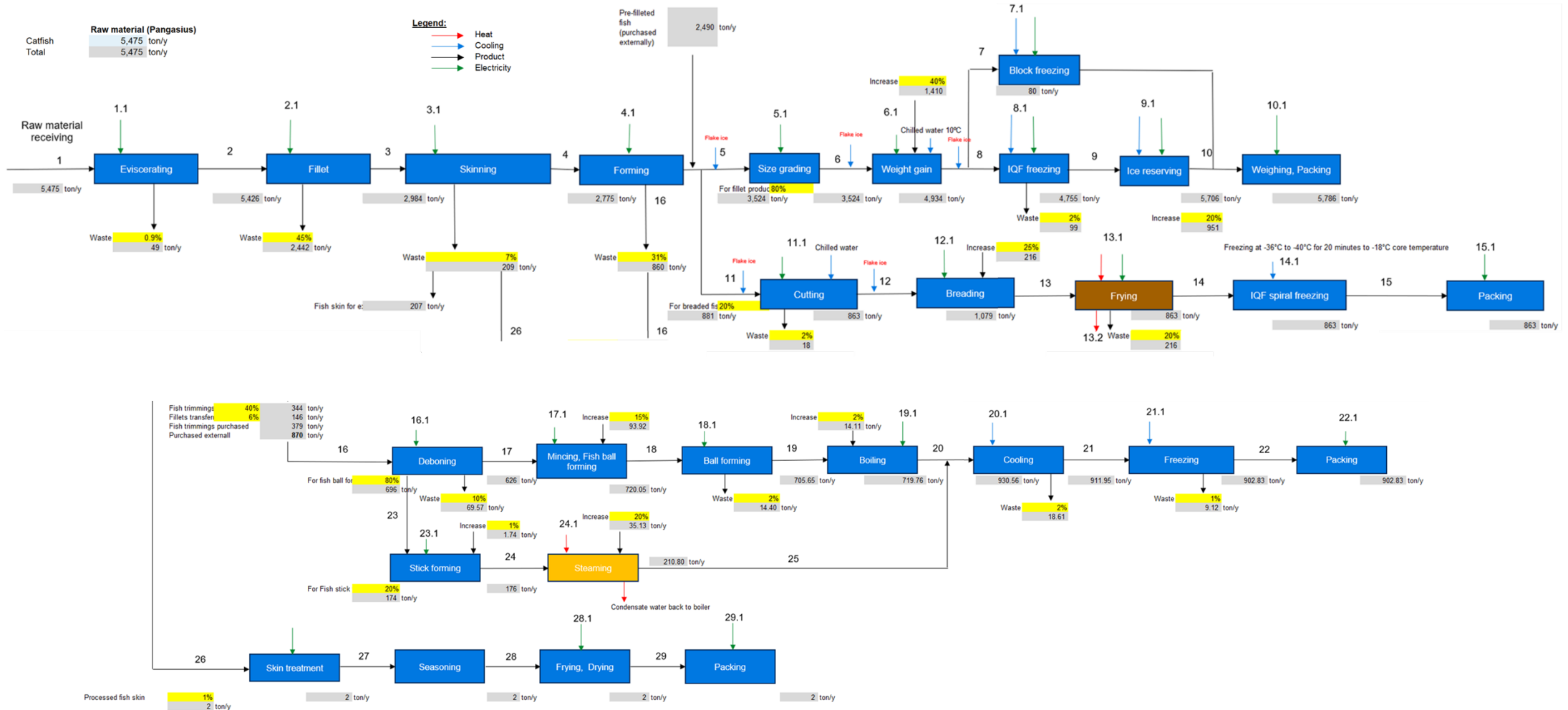
Battered fried fish products: Fillets after pre-processing are coated with batter using an automatic battering system, seasoned, and conveyed into the fryer via a conveyor. The

conveyor carrying the battered fillets automatically lowers them into the hot oil for frying, with temperature and frying time controlled by an automatic control system. After frying, the fish is transferred to the finished product area for freezing, packaging, cold storage, and distribution.

Frozen battered fish products: Fillets after pre-processing and shaping are coated with batter, seasoned, and immediately frozen to produce frozen battered fish products. The products are then placed in cold storage for preservation and distribution.

The mass flow balance diagram of the company is shown below:

Production line: Catfish



The mass flow diagram presents a relatively comprehensive overview of the catfish processing lines, including fillets, battered fried fish, fish balls, and fish skin snacks, from raw material reception to final product packaging and storage. The process consists of multiple stages such as evisceration, filleting, washing, skinning, forming, sorting, weight gain, freezing, and packaging. At each stage, material losses occur, and various forms of energy are consumed, including electricity, water, heating, and cooling.

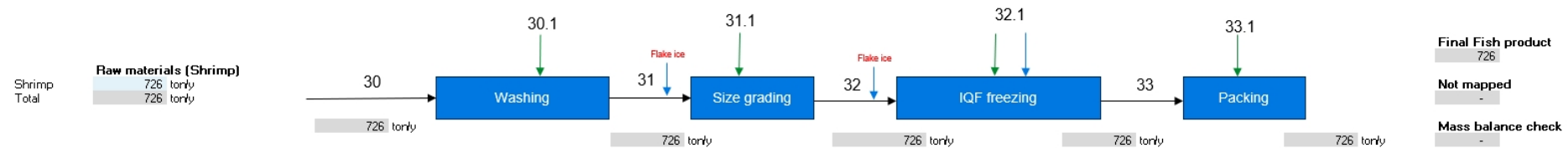
In terms of mass balance, the total finished product output represented in the diagram is 7,554 tons/year, whereas the actual total production reported by the factory is 7,985 tons/year. This results in a difference of 431 tons/year (approximately 5%), which is categorized as “not mapped.” Accordingly, the mapping flow may result from the cumulative effect of small deviations across multiple processing steps, particularly those with relatively high loss rates or limited measurement accuracy, including:

- Filleting stage (loss rate of approximately 45%): losses include heads, bones, viscera, skin, and trimming during fillet shaping. Some by-products may be reused internally or sold externally but are not fully documented in the diagram.
- Weight gain, Breeding: product mass may change due to moisture absorption or loss, which can affect the mass balance.
- Externally purchased pre-filleted catfish: this input stream disrupts the continuity of the mass balance from whole-fish input and complicates the allocation of losses processing stages.

The loss values applied in the diagram are currently derived from a combination of available factory operating data and estimates provided by operational staff. As a result, deviations from actual values may still exist.

In addition to mass balance, the diagram also illustrates energy flows, including electricity, water, and cooling energy, which serve as a basis for evaluating resource consumption at each processing stage. This analysis supports the identification of optimization opportunities to reduce resource losses and improve overall production efficiency.

Production line: Shrimp



1.3 Description of the utility systems

Main energy consumption systems at the factory:

- Lighting system.
- Compressed air system.
- Refrigeration system.
- Boiler and thermal oil heater system.
- Water supply and wastewater treatment system.

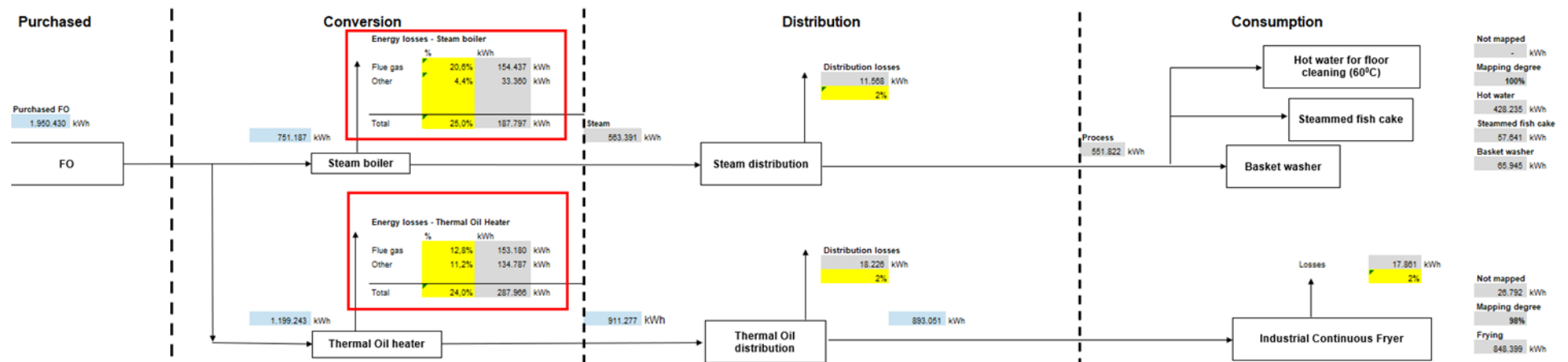


Figure 1.5. Schematic diagram of FO oil-fired utility systems

Based on the energy mapping results of the utility systems, it can be observed that for FO oil-fired loads, including the steam boiler and the thermal oil heater, a significant share of energy losses originates from flue gas. Specifically, in the thermal oil heater, the losses are mainly due to high flue gas temperatures, while in the steam boiler, frequent start-up and shutdown operations reduce combustion

efficiency, leading to increased flue gas losses. These findings indicate considerable potential for recovering and utilizing waste heat to improve overall system energy efficiency.

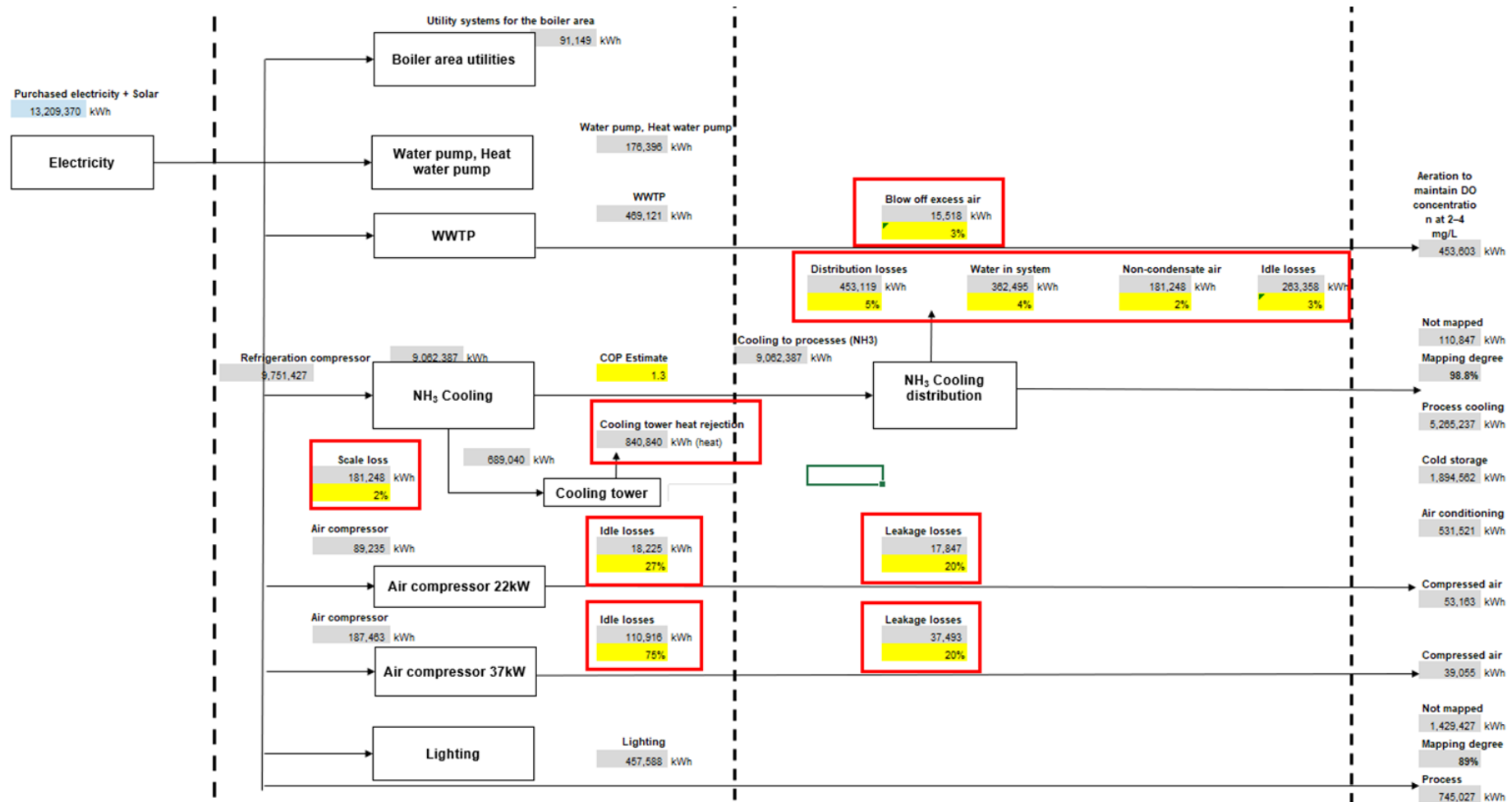


Figure 1.6. Schematic diagram of electrically powered utility systems

Based on the results of the energy balance analysis of the electrically powered utility systems, it can be observed that several major loads, including the WWTP blowers, the compressed air system, and the refrigeration compressor system, are associated with significant energy losses that still have potential for reduction. Specifically, in the wastewater treatment system, losses mainly arise from excessive aeration; in the refrigeration compressor system, losses are related to pipe scaling and the presence of non-condensable gases or water; while in the compressed air system, losses are primarily caused by air leakage and compressor no-load operation. Addressing these sources of loss would contribute to improving the overall energy efficiency of the utility systems.

In addition, during operation, a considerable amount of heat from the refrigerant in the refrigeration compressor system is rejected to the environment through the cooling tower, which represents a potential source for heat recovery.

1.3.1 Lighting system

The factory's lighting system uses 100% LED lamps, mainly LED tube lights in 0.6 m and 1.2 m sizes, with a total of more than 3,600 units installed throughout all areas.

The factory has implemented various energy-saving measures for this system, such as utilizing natural light through windows, doors, and translucent roofing sheets in workshops and warehouses; therefore, many areas do not require additional lighting during the daytime. In addition, the factory strictly turns off lights in areas that are not in use or already have sufficient natural light. Employees have been regularly informed and trained, resulting in high awareness of electricity saving.

To evaluate the effectiveness and suitability of the lighting system, the audit team conducted surveys and measured actual illuminance levels in several main working areas. The measurement results at representative positions were summarized and compared with the standards specified in QCVN 22:2016/BYT, as shown in the table below:

Table 1.1. Evaluation of illuminance at the factory according to QCVN 22:2016/BYT

Areas/Workshops	Measured illuminance (lux)	Required illuminance (QCVN 22:2016/BYT)
Catfish fillet conveyor	320	150

Areas/Workshops	Measured illuminance (lux)	Required illuminance (QCVN 22:2016/BYT)
Shrimp conveyor	300	150
Cold storage	150	100
Corridor	113	100
Office	310	300

The survey results show that the factory's lighting system operates effectively, with overall lighting quality meeting requirements and adequately supporting employees' working conditions. In areas with access to natural light, the measured illuminance (Lux) values were relatively high. The factory should maintain regular cleaning, maintenance, and replacement of lamps, and frequently clean reflectors and lamp housings to ensure optimal lighting efficiency.



Figure 1.7. Lighting system at the factory

1.3.2 Compressed air system

The factory's compressed air system consists of 02 screw air compressors with capacities of 37 kW and 22 kW, respectively, which supply compressed air to all production and utility areas. The compressors are operated alternately, with one unit running while the other remains in standby mode to ensure system continuity and stability. Both compressors operate under load/unload control mode, with the working

pressure set between 6.5 and 7.5 barG. The technical specifications of the compressors are presented in the table below:

Table 1.2. Technical specifications of the air compressors

Type	Status	Manufacturer	Rated power (kW)	Set pressure (barG)	Regulation method	Purpose of use
GA22	On	Atlas Copco	22	6.5 – 7.5	Load/Unload	Valve control, raw material washing (5.0 - 6.0 barG)
GA37+	Standby	Atlas Copco	37	6.5 – 7.5	Load/Unload	

Some pictures of the compressed air system:



Figure 1.8. Compressed air system

The layout of the compressed air system is illustrated below:

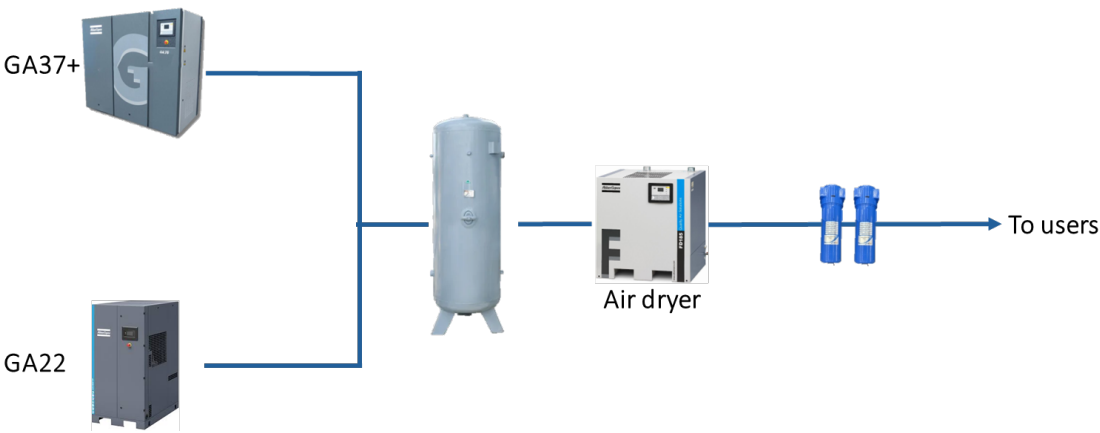


Figure 1.9. General layout of the compressed air system supply side

1.3.3 Refrigeration system

The factory is currently operating 09 GEA screw-type refrigeration compressors using ammonia (NH₃) as the refrigerant. These compressors provide cooling for a wide range of production and auxiliary systems, including chilled water supply for production processes (such as weight gain control, cutting, and product cooling), flake ice production for intermediate handling to prevent product spoilage, block freezing, IQF freezing, and IQF spiral freezing systems, as well as freezing and ice storage facilities. In addition, the refrigeration system also serves cold storage areas and air-conditioning systems for working areas within the factory.

Table 1.3. Summary of Refrigeration Compressors at the Factory

Refrigeration Compressor	Power (kW)	Area / System
No. 1 (High stage)	450	Integrated refrigeration system: - IQF 1 – 2 and Refreezer 1 – 2. - IQF 3 – 4 and Refreezer 3 – 4. - IQF 5 – 6 and Refreezer 5 – 6. - Spiral IQF freezer. - IQF fish balls and shrimp 7 – 8 Refreezer. - Flake ice machines (3x 25 ton + 1x15 ton). - Contact freezer 1 – 3. - Cold storage 2,000 ton. - 02 chill rooms and 01 dispatch room;
No. 2 (High stage)	450	
No. 3 (High stage)	450	
No. 4 (Single stage)	400	
No. 5 (Single stage)	400	
No. 6 (Low stage)	160	
No. 7 (Low stage)	200	
No. 8 (Low stage)	200	
No. 9 (Low stage)	200	



Figure 1.10. Screw-type refrigeration compressor and condenser system

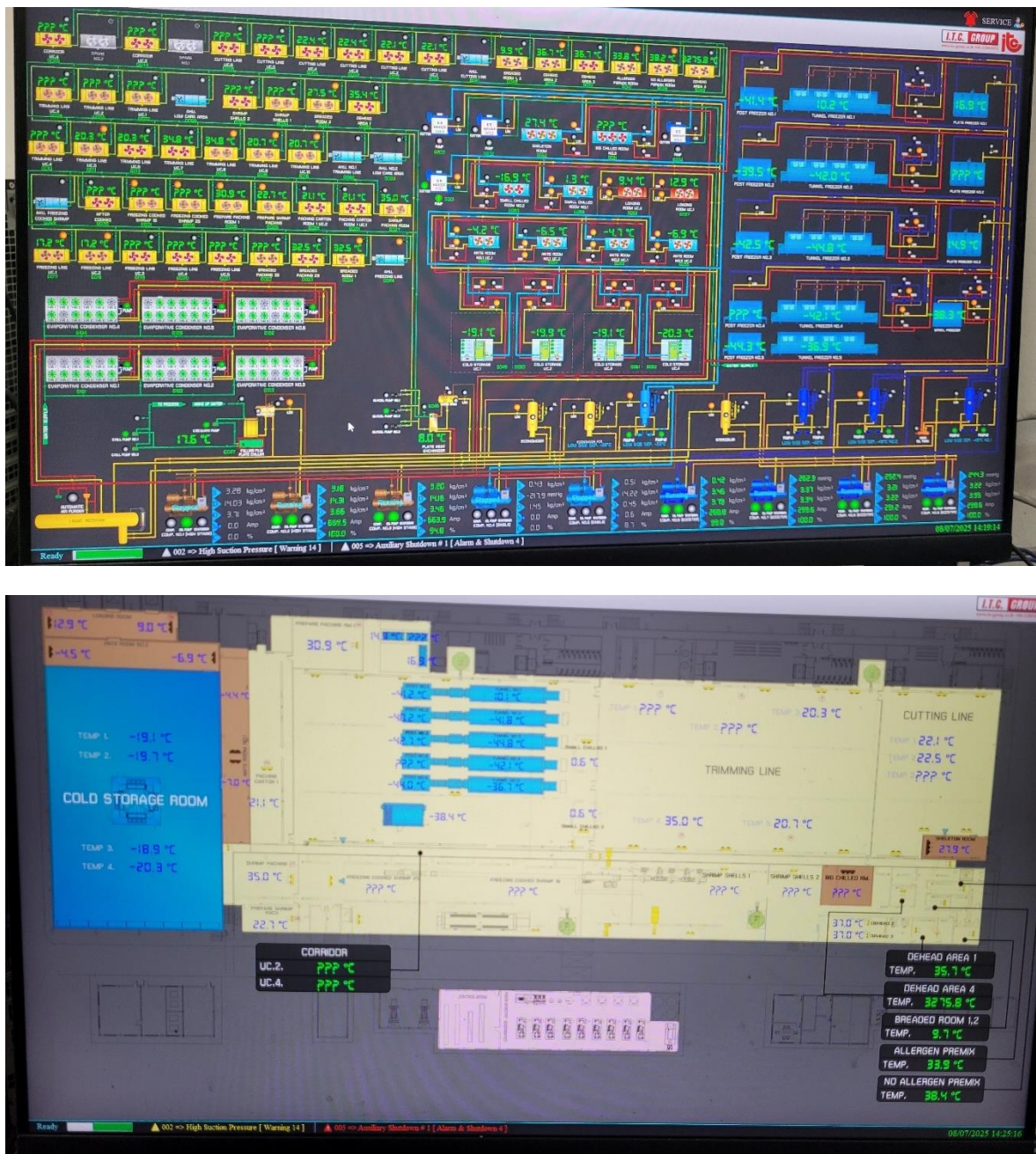
The factory's refrigeration system is designed as a two-stage compression cycle. In the low-pressure stage, the refrigerant (NH_3) vaporized at the heat exchangers is drawn into the low-stage compressors, compressed, and then sent to an intercooler for intermediate cooling before entering the high-stage compressors.

The refrigerant discharged from the high-stage compressors, which is at high temperature and pressure, is sent to 06 water-cooled condensers where it is fully condensed and collected in the high-pressure receiver. From this receiver, a portion of the refrigerant is directed through an economizer to cool the refrigerant during high-stage compression, helping reduce discharge temperature and compressor power consumption.

The condensed refrigerant is then divided into two streams. One stream passes through an expansion valve to reduce its pressure and temperature, exchanging heat with glycol in a heat exchanger. The chilled glycol is then circulated to cooling coils in production areas and air-handling units. The other stream is directed to the intercooler, where part of the refrigerant is used to cool the low-stage discharge gas (reducing the suction temperature of the high-stage compressors), and the remainder passes through

expansion valves to provide low-temperature, low-pressure refrigerant to the freezing equipment.

After completing the heat exchange processes, the refrigerant vapor is returned to the low-stage compressors, completing the closed refrigeration cycle. All system operating parameters such as pressure, temperature, and flow rate are monitored and displayed on the central control panel, ensuring stable operation and effective performance management of the system.



Efficiency of the existing refrigeration system was evaluated based on site observations, interviews with operating staff, and equipment inspection. Due to the limited availability of complete historical operating data, several key parameters were estimated using reasonable engineering assumptions and typical operating conditions observed at the site.

Based on the site survey results, the overall coefficient of performance (COP) of the refrigeration system is estimated to be approximately 1.3. This value is considered relatively low compared to typical industry benchmarks for industrial ammonia (NH₃) refrigeration systems.

For reference, the COP of ammonia-based industrial refrigeration systems commonly ranges from 2.5 to 4.0 for medium-temperature applications such as cold storage (around –20°C) or chill rooms, and from 1.0 to 2.5 for low-temperature applications such as IQF freezers (around –40°C) or contact freezers.

The relatively low COP may be attributed to factors such as system operating conditions, load fluctuations, compressor staging strategy, and overall system control practices. These aspects were therefore considered in identifying potential energy conservation measures (ECMs) presented in the following sections of this report.

1.3.4 Thermal oil heater and boiler system

The factory currently operates a thermal oil heater using FO with a rated capacity of 600 kW, which supplies heat for the breaded fish frying process. The heater operates an average of 18-19 hours per day. After being heated, the thermal oil is pumped to the consuming equipment through two circulation pumps of 7.5 kW each, with the oil flow rate adjusted by controlling the valve opening at the pump outlet.

Detailed parameters for these oil pumping related evaluations are tabulated below:

Table 1.4. Design of the oil pumping system for the thermal oil heater

No.	Motor rated power (kW)	Pole	Frequency (Hz)	Efficiency class	Efficiency based on IEC 60034-30-1 (%)
#1	7.5	2	50	IE2	88.1
#2	7.5	2	50	IE2	88.1



Figure 1.12. Thermal oil heater and oil pumping system

The factory also operates a steam boiler using FO with a capacity of 2 TPH and a working steam pressure of 5 barG. It is used in fish steaming and for producing 60°C hot water for floor and equipment cleaning. The boiler operates only about 2–2.5 hours per day, divided into two shifts of approximately 1 hour each.

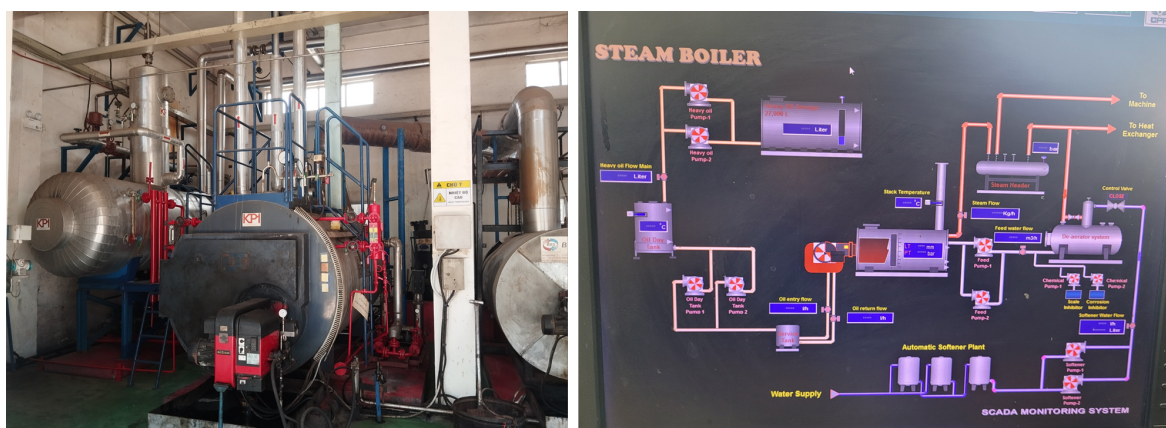


Figure 1.13. Steam boiler system

According to the survey, the flue gas temperature of the thermal oil heater is quite high, fluctuating above 430°C. The indirect efficiency of the thermal oil heater, as estimated during measurement, is around 75.9%. For the steam boiler, due to its short operating duration, the overall system efficiency is estimated at about 75%. Both boilers are not equipped with flue gas heat recovery systems (economizer or air preheater).



Figure 1.14. Measurement results of thermal oil heater flue gas

1.3.5 Water supply and wastewater treatment system

The factory uses raw water pumped from the river through two alternating pumps, supplying a storage tank with a capacity of 400 m³. From this tank, the river water is treated through a filtration system and then pumped to an elevated water tower before being distributed to various usage areas within the factory. Water is mainly used for production, domestic purposes, and equipment cooling.

The pumps are automatically controlled based on the water levels in the storage tank and the water tower. At the time of the survey, the system was operating normally, with one pump drawing water from the river and another transferring water from the tank to the tower.



Figure 1.15. Factory's water storage tank and water tower system

The factory's wastewater treatment system receives wastewater generated from production processes and treats it to meet environmental standards before discharge. The treatment capacity of the system is approximately 2,000 m³ per day. The aeration blowers in the wastewater treatment system are equipped with inverters, allowing the airflow to be adjusted according to the actual treatment load, thereby saving energy during low-load operation.



Figure 1.16. Wastewater treatment system

2 Methodology used to identify EE projects

2.1 How EE projects have been identified and developed

A thorough understanding of energy saving potentials in a specific company necessitates a good initial data collection and a series 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.

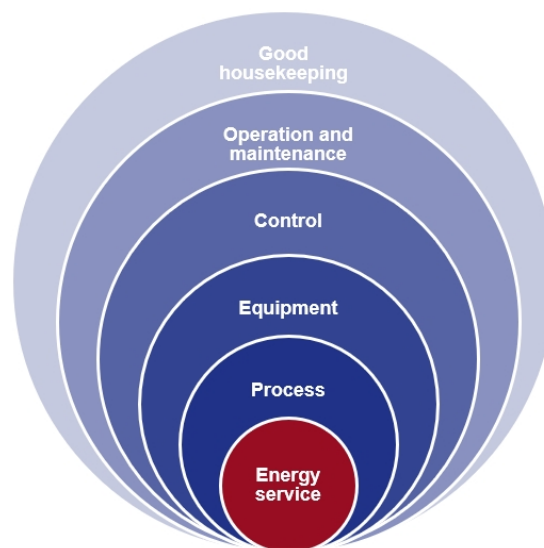


Figure 2.1. The “Onion diagram” for advanced understanding of energy consumption

- **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 named 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 ΔT , 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 (O₂-% 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, it 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 Potential for energy savings through energy mapping

Several key findings based on the energy mapping is identified:

- Understanding of the energy consumption structure or purpose of using energy in the specific processes.
- Overview of the distribution of heating, cooling and electricity consumption for the entire process and make it easy to identify the main energy consumers at the site.
- Energy input/output and energy losses at each stage in the production process
- Current status of technology equipment used in the production process

Electricity Consumption:

The factory mainly uses electricity for two-stage ammonia refrigeration compressors. These compressors generate the necessary cooling capacity for the freezing process, cold water production, flake ice, refreezing, and ice reserving. Additionally, electricity is

also used for the factory's utility systems such as water supply pumps, lighting, WWTP, office, and warehouse.

Table 2.2. Electricity consumption at the factory

Process	Measurement (kWh)	Share (%)
Process	745,027	5.4%
Water pump, Heat water pump	176,396	1.3%
WWTP	469,121	3.4%
Boiler area	91,149	0.7%
Refrigeration system	9,751,427	70.6%
Air compressor	89,235	0.6%
Lighting	457,588	3.3%
Laundry room	199,368	1.4%
Dormitory	35,300	0.3%
Office, Canteen	361,296	2.6%
Not mapped	1,429,427	10.4%
Total	13,805,333	100.0%

The share of electricity consumption in process at the factory in 2024 are as follows:

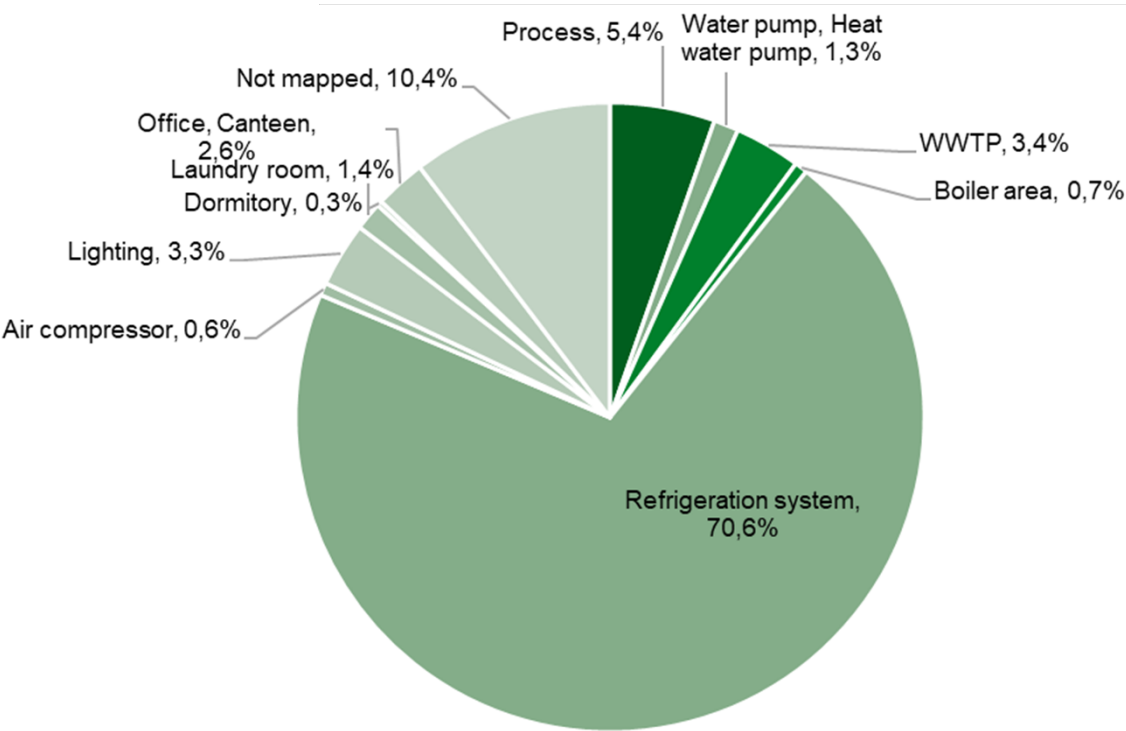


Figure 2.3. Share of electricity consumption in process

The largest proportion of electricity consumption at the factory is attributed to the refrigeration system used in the shrimp and catfish production process, accounting for approximately 70.6%. Following that, the process machinery and equipment, such as conveyor belts and boiling tanks used in production, account for 5.4%.

Thermal Energy Utilization:

a. Steam system

The steam boiler uses FO oil as fuel to produce saturated steam, which is supplied to the production processes. The steam is primarily used for the fish steaming process and for heating water for cleaning the factory floors and equipment.

Table 2.1. Energy consumption by main areas/ production lines using steam

Areas	Energy consumption (kWh) ⁴	Share (%)
Steamed fish cake	57,641	7.7%
Hot water for floor cleaning	428,235	57.0%
Basket washer	80,969	10.8%
Losses	184,341	24.5%
Total	751,187	100.0%

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

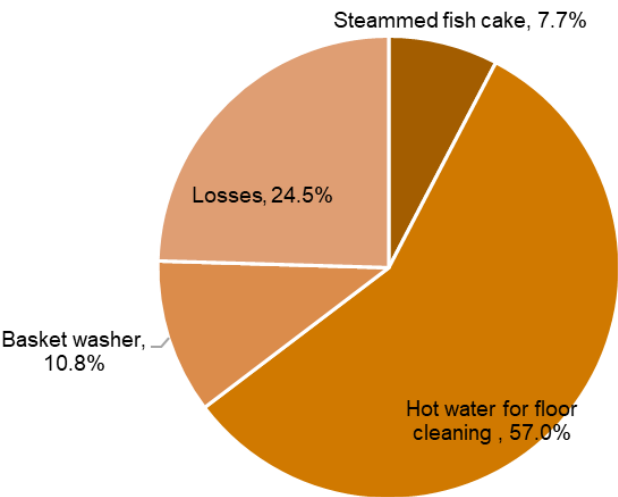


Figure 2.4 Primary energy consumption structure of steam-consuming equipment

⁴ Energy consumption in production processes, boiler converted to kWh

The chart shows that actual steam usage accounts for 75.5%, of which heating water for floor cleaning accounts for 57.0%, fish steaming for 7.7% and basket washer for 10.8%. Energy losses in the boiler and steam distribution system are significant, accounting for about 24.5% of the input energy. The major energy losses in the steam system are mainly due to the low operating time of the boiler and the uneven steam demand depending on the production schedule.

b. Thermal oil heater

The thermal oil heater also uses FO oil as fuel to generate heat, which is supplied to the production processes. The heat from the thermal oil is primarily used in the fish frying process.

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

Areas	Energy consumption (kWh) ⁵	Share (%)
Frying	848,399	70.7%
Losses	324,053	27.0%
Not mapped	26,792	2.2%
Total	1,199,243	100.0%

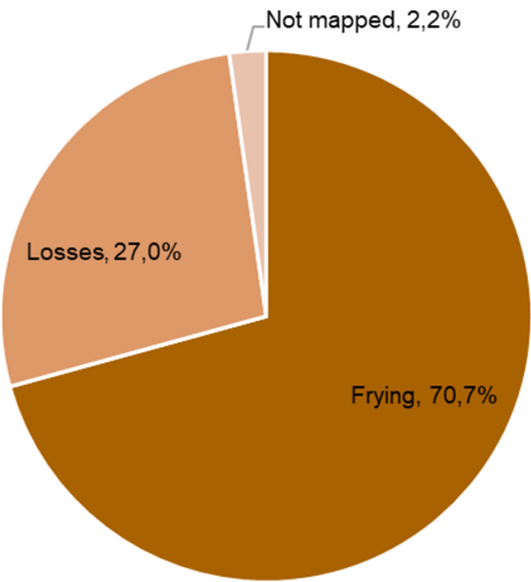


Figure 2.5 Energy consumption from thermal oil system share by main areas in 2024

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

The chart shows that energy losses in the thermal oil system are significant, accounting for 27.0%. The losses are mainly due to flue gas heat loss.

c. Cooling Systems

The cooling system is the most energy-intensive system in the factory. Electrical energy is converted into thermal energy through two-stage NH₃ compressors, providing the required cooling for production and utility systems.

Table 2.3. Cooling consumption in catfish process

Process		Measurement (kWh)	Share (%)
Catfish	Weight gain	176,197	1.6%
	Block freezing	28,000	0.3%
	IQF freezing	2,139,677	19.9%
	Flake ice making	737,000	6.9%
	Flaked ice	1,733,839	16.2%
	Cutting	52,859	0.5%
	IQF spiral freezing	621,622	5.8%
	Cooling	186,111	1.7%
Shrimp	Freezing	501,570	4.7%
	IQF freezing	435,609	4.1%
	Flaked ice	232,325	2.2%
General	Cold storage	2,462,931	22.9%
	Air conditioning	690,977	6.4%
	Losses	589,055	5.5%
	Not mapped	144,101	1.3%
Total		10,731,872	100.0%

The share of cooling consumption at the factory in 2024 is as follows:

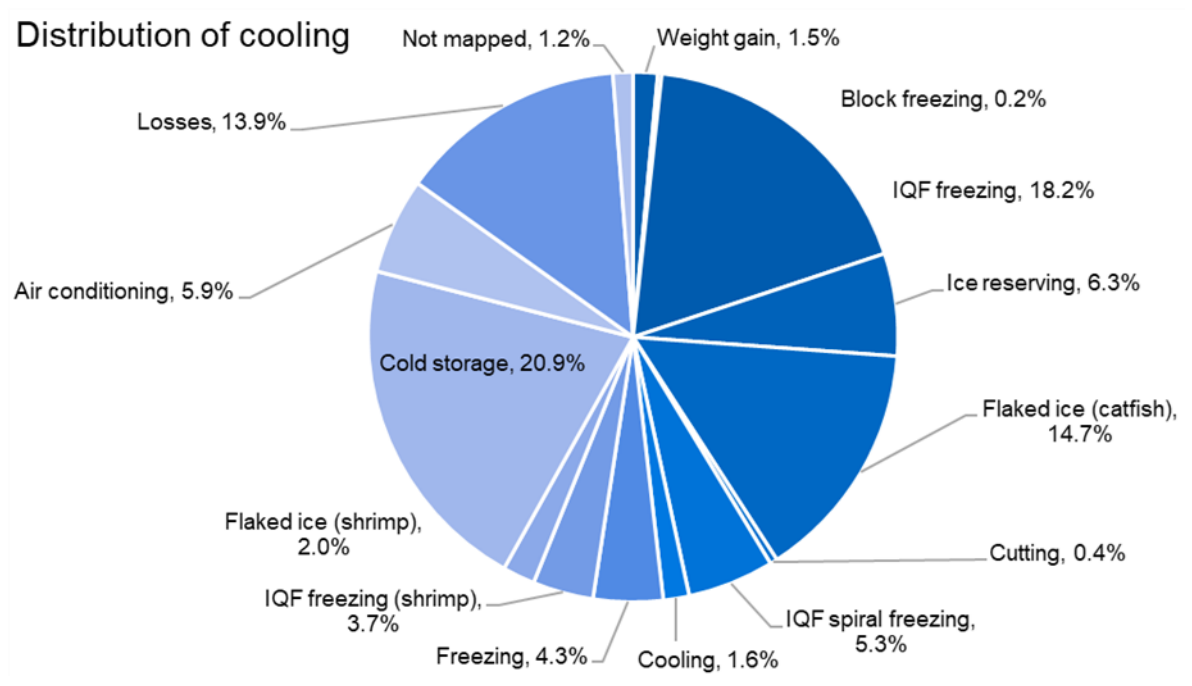


Figure 2.6. Share of cooling consumption

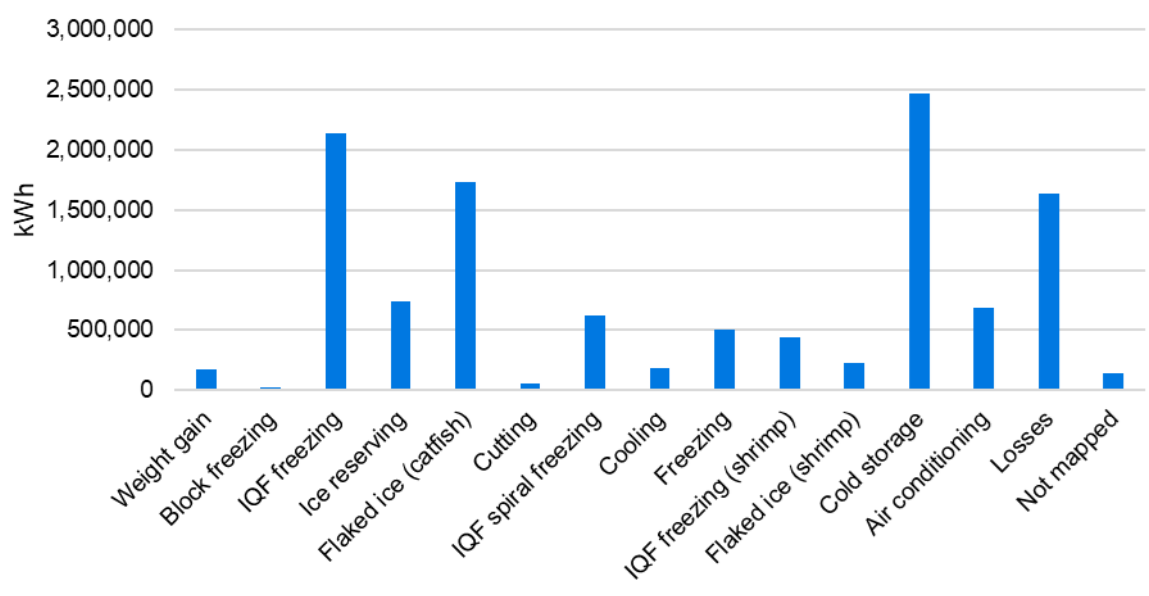


Figure 2.7. Distribution of cooling consumption in 2024

From the chart, cold storage represents the largest share of cooling demand, accounting for approximately 20.9%, followed by IQF freezing (18.2%) and the flaked ice process for the catfish line (14.7%). Other notable contributors include losses (13.9%), air conditioning (5.9%), IQF spiral freezing (5.3%), and ice reserving (6.3%). Energy consumption associated with shrimp processing remains relatively low, with IQF freezing

(3.7%) and flaked ice (2.0%). Minor contributions are observed in cooling (1.6%), block freezing (0.2%), weight gain (1.5%), cutting (0.4%), and unmapped loads (1.2%).

It is important to note that this distribution is not based solely on direct electricity consumption but is derived from an analysis of cooling capacity demand, including system losses. These losses encompass heat gains from distribution and transmission, water content within the system, air infiltration, and fouling or scaling within heat exchange equipment. As a result, categories such as “losses” represent inherent inefficiencies within the cooling system rather than specific end-use processes.

d. Heat Waste

The waste heat presented in this section were derived based on a combination of on-site measurements conducted during the assessment, operating data provided by the factory, and standard thermal efficiency calculation methods. Major sources of waste heat were identified from thermal oil heaters, steam boilers, distribution pipelines, and the frying process.

Waste heat quantities were estimated by evaluating system efficiency losses, including flue gas losses, radiation and standby losses, and heat dissipation during energy transmission.

Waste heat from manufacturing processes is presented as follows:

Table 2.4. Waste heat by main areas/ production lines

Areas/ production lines	Waste heat (kWh)⁶	Share (%)
Frying	17,861	1.3%
Thermal oil heater efficiency loss	287,966	21.1%
Heat loss during thermal oil transmission	18,226	1.3%
Boiler efficiency loss	187,797	13.8%
Heat loss in the steam distribution line	11,568	0.8%
Hot temperature refrigerant	840,840	61.6%

⁶ Waste heat sources in production processes converted to kWh.

Areas/ production lines	Waste heat (kWh)	Share (%)
Total	1,364,258	100.0%

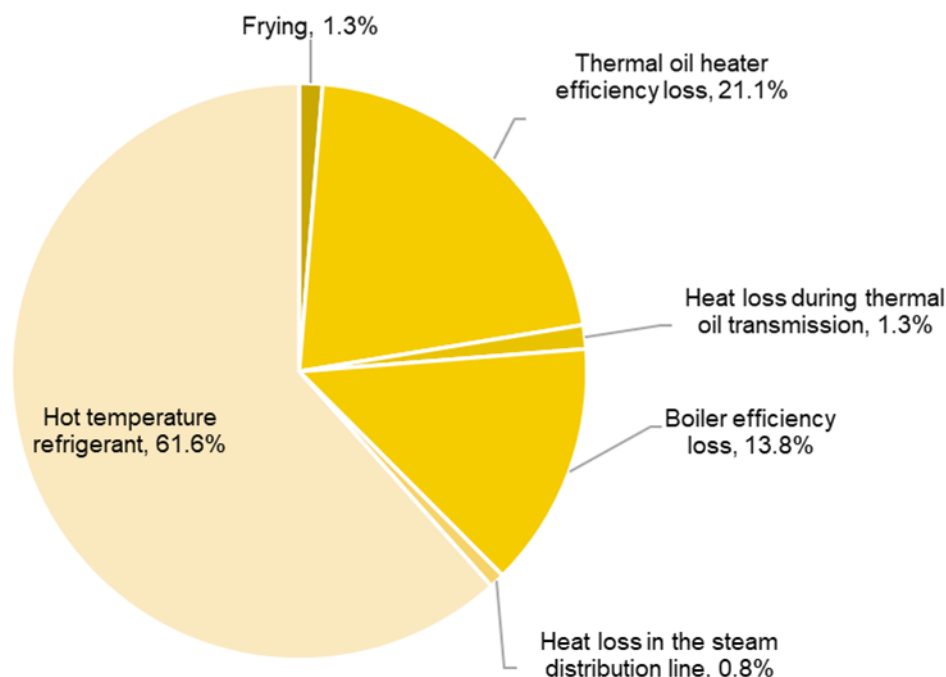


Figure 2.8 Waste heat by main areas

Based on the waste heat assessment results presented above, the main sources of waste heat in the factory are described as follows:

- **High-temperature refrigerant from the refrigeration compressors (61.6%):** The largest source of waste heat originates from the refrigeration system, where the refrigerant leaves the compressors at a high discharge temperature before being cooled in the condenser. This heat is normally rejected through the condenser and cooling tower system. Due to its relatively high temperature and concentrated nature, this waste heat represents the most significant opportunity for heat recovery, particularly for hot water generation.
- **Thermal oil heater efficiency loss (21.1%):** Losses from the thermal oil heater mainly occur due to combustion inefficiencies and heat losses through the flue gas, as well as radiation losses from the heater casing. These losses were estimated based on the operating characteristics of the thermal oil heater and typical combustion efficiency calculations.
- **Boiler efficiency loss (13.8%):** Boiler efficiency losses include flue gas losses, radiation losses, and blowdown losses during boiler operation. These losses

represent energy that is not effectively transferred to the steam system and therefore contribute to the overall waste heat potential.

- **Heat loss during thermal oil transmission (1.3%):** Heat is lost during the distribution of thermal oil from the heater to the end-use equipment through insulated pipelines. These losses are mainly caused by heat dissipation through pipe insulation and are distributed along the pipeline network.
- **Heat loss in the steam distribution line (0.8%):** Similar to thermal oil transmission, a small amount of heat is lost through the steam piping system during distribution to various processes in the factory.
- **Frying process (1.3%):** Waste heat from the frying process mainly originates from hot exhaust vapor released through the fryer exhaust system. However, this exhaust stream often contains oil vapor and grease, which makes direct heat recovery technically challenging due to potential fouling of heat exchange equipment.

Overall, the chart indicates that the largest share of waste heat originates from the refrigeration compressors, accounting for approximately 60.9% of the total waste heat potential, followed by losses from the thermal oil heater and boiler systems. These results highlight that heat recovery from the refrigeration system and flue gas streams could provide significant opportunities for improving the overall energy efficiency of the factory.

The chart below illustrates the temperature analysis at the factory:

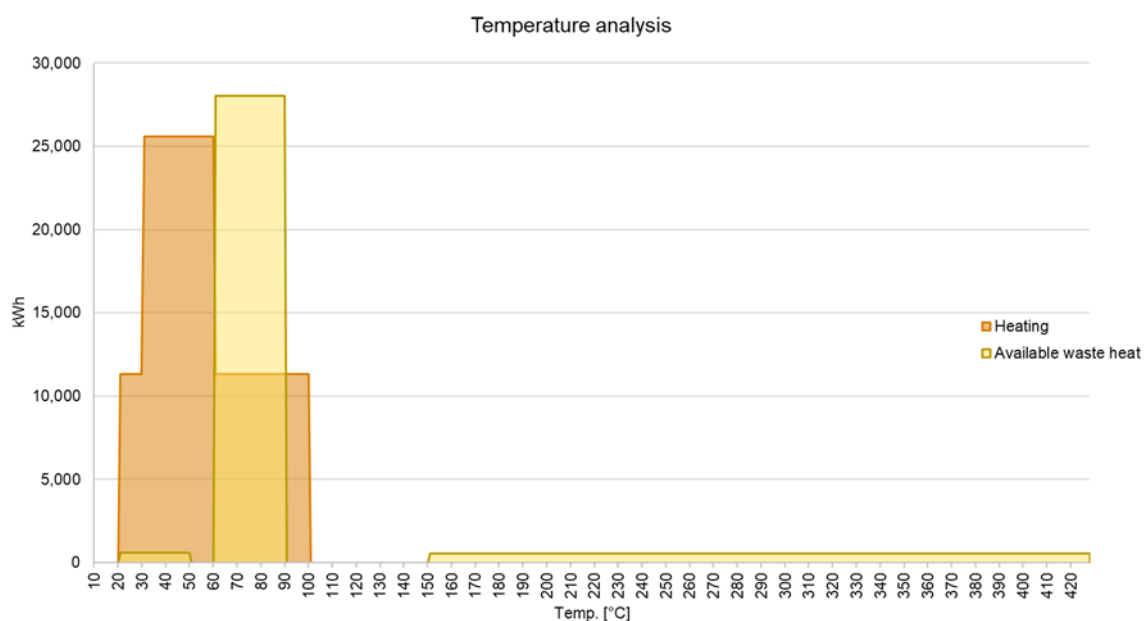


Figure 2.9 Temperature and energy relation analysis

Based on the temperature analysis presented in the chart above, the majority of the heating demand in the production process is concentrated in the temperature range of approximately 20–100°C, with the largest demand occurring around 60–90°C. This indicates that most thermal processes in the factory require low- to medium-temperature heat.

On the other hand, the available waste heat sources are mainly distributed in the temperature range of 60–90°C, which overlaps well with the temperature range required for heating processes. This suggests that a significant portion of the heating demand could potentially be supplied by recovered waste heat.

Although the frying process generates waste heat through exhaust vapor released from the fryer, the amount of recoverable heat from this source is relatively small. In addition, the exhaust vapor contains oil vapor and grease, which may cause fouling and operational issues in heat recovery equipment. Therefore, this source is considered technically difficult to recover and reuse.

In contrast, as discussed in the previous waste heat distribution analysis, the largest share of waste heat originates from the high-temperature refrigerant of the refrigeration compressors, followed by heat losses from the thermal oil heater and boiler systems. These sources provide a more stable and cleaner heat stream compared to the fryer exhaust, making them more suitable for heat recovery applications.

Overall, the temperature analysis confirms that the temperature level of the available waste heat matches well with the factory's heating demand, particularly for applications such as hot water generation for production processes. This indicates a strong potential for implementing waste heat recovery solutions to improve the overall energy efficiency of the facility.

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

Table 2.5. Screening of energy saving opportunities/projects based on the walkthrough assessment

No.	Energy saving opportunities
1.	Establish a compressed air leakage repair program
2.	Repair or use handheld DO meter, integrate inverter control based on DO signal
3.	Use high efficiency motor
4.	Recirculation of fish conveying flume water – fillet processing area
5.	Install VSD for air compressors
6.	Install non-condensate air purger for the freezing system of the fish processing line
7.	Use a scale prevention system for the cooling tower system
8.	Install water purger for the refrigeration system
9.	Install an air preheater to recover heat from the flue gas of the thermal oil heater
10.	Recover heat from the refrigerant of refrigeration compressors to produce hot water
11.	Use screw-type refrigeration compressors integrated inverters

After conducting an in-depth survey during the onsite assessment, data from the walkthrough assessment, the current situation, and the company's investment plans were reviewed. All potential energy-saving and efficiency projects were identified and agreed upon for further development and analysis.

2.1.2 Specific energy consumption

Based on the energy consumption and the number of products produced by the company, the energy consumption rate (kWh/ton) can be calculated. The energy consumption rate indicates the average energy consumed per product, used to compare the company's energy efficiency with the standard levels in order to assess the energy consumption status and propose savings for the following month and year.

For the industrial processing of catfish and shrimp products, the Ministry of Industry and Trade has issued regulations on energy consumption standards during the period that lasts until the end of 2025 (Circular No. 52/2018/TT-BCT).

No.	Process	Unit	Standard
1	Catfish product	kWh/ton	1,050
2	Shrimp product	kWh/ton	2,050

Below is the calculation of the SEC in 2024 for these two products:

Table 2.6. Specific energy consumption calculated for catfish product and shrimp product of the factory in 2024

No.	Process	Electricity consumption (kWh)	Production (ton)	SEC (kWh/ton)
1	Catfish product	7,552,198	7,985	946
2	Shrimp product	1,298,483	726	1,789

Table 2.7. Compare the factory's energy consumption rate for 2024 with the standards set by the Ministry of Industry and Trade.

Process	Unit	Standard	Specific energy consumption
Catfish product	kWh/ton	1,050	946
Shrimp product	kWh/ton	2,050	1,789

According to Circular No. 52/2018/TT-BCT issued by the Ministry of Industry and Trade regarding energy consumption standards for the industrial processing of catfish and shrimp products, the factory meets the energy consumption rate for catfish processing and shrimp processing.

2.1.3 Classification of projects 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 B and A project development:

Level B:

- Establish a compressed air leakage repair program
- Repair or use handheld DO meter, integrate inverter control based on DO signal
- Use high efficiency motor
- Recirculation of fish conveying flume water – fillet processing area
- Install VSD for air compressors
- Install non-condensate air purger for the freezing system of the fish processing line
- Use a scale prevention system for the cooling tower system
- Install water purger for the refrigeration system
- Install an air preheater to recover heat from the flue gas of the thermal oil heater
- Recover heat from the refrigerant of refrigeration compressors to produce hot water
- Use screw-type refrigeration compressors integrated inverters

Level A:

- Install an air preheater to recover heat from the flue gas of the thermal oil heater
- Recover heat from the refrigerant of refrigeration compressors to produce hot water
- Use screw-type refrigeration compressors integrated inverters

There is a total of 11 recommended energy-saving projects classified as Level B, representing opportunities identified at a preliminary stage of project development. Among these, three projects have been further defined and therefore classified as Level A, reflecting a more advanced level of project development. To ensure that the energy and economic saving potentials of the Level A projects are accurately assessed and properly realized, additional evaluation steps are required, including deep-dive pre-feasibility and feasibility studies

Table 2.8. Groups of ECMs

ECM group	Scope
Group I: Projects level B	Level B projects include all identified energy and resource efficiency opportunities at a conceptual level. At this stage, projects are defined based on preliminary technical assessment and indicative savings, without detailed engineering design or feasibility analysis. The Level B designation reflects the early stage of project development, rather than the level of investment or technical complexity.
Group II: Projects level A	Level A projects are selected from Level B projects and have been further developed with additional technical definition and data validation. These projects have clearer system boundaries, more refined assumptions, and higher confidence in savings estimates. The Level A designation indicates a more advanced stage of project development, suitable for further detailed analysis or decision-making.

2.2 EE Project evaluation

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)⁷.

Table 3.1. Gross list (level B mapping)

Gross list									
Project no.	Name of Project	Energy and Water Form	Investment Cost [mil VND]	Saving					Simple Payback [Years]
				Electricity [kWh]	FO [liter]	Water [m³]	CO ₂ [ton]	Financial [mil VND]	
1	Establish a compressed air leakage repair program	Electricity	20	13,835	-	-	9.1	26	0.8
2	Repair or use handheld DO meter, integrate inverter control based on DO signal	Electricity	30	15,518	-	-	10.2	29	1.0
3	Use high efficiency motor	Electricity	54	7,440	-	-	4.9	14	3.8
4	Recirculation of fish conveying flume water – fillet processing area	Water	None	-	-	21,600	-	233	Immediately
5	Install VSD for air compressor	Electricity	150	38,742	-	-	25.5	73	2.1

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

Gross list									
Project no.	Name of Project	Energy and Water Form	Investment Cost [mil VND]	Saving					Simple Payback [Years]
				Electricity [kWh]	FO [liter]	Water [m³]	CO ₂ [ton]	Financial [mil VND]	
6	Install non-condensate air purger for the freezing system	Electricity	500	181,248	-	-	119.5	342	1.5
7	Use a scale prevention system for the cooling tower system	Electricity	500	181,248	-	-	119.5	342	1.5
8	Install an air preheater to recover heat from the flue gas of the thermal oil heater	FO	550	-	14,126	-	43.0	181	3.0
9	Install water purger for the refrigeration system	Electricity	900	362,495	-	-	239.0	684	1.3
10	Recover heat from the refrigerant of refrigeration compressors to produce hot water	FO	780	-	46,150	-	140.6	592	1.3
11	Use screw-type refrigeration compressors integrated inverters	Electricity	1,733	263,358	-	-	173.6	497	3.5

4 Selected EE Projects for further supports

This section includes projects that has been chosen to be developed further (Level A)⁸.

4.1.1 Install an air preheater to recover heat from the flue gas of the thermal oil heater

Project information		
Project: Install an air preheater to recover heat from the flue gas of the thermal oil heater	Project no. 1	Date: 2025
Project description		
Current situation: The factory operates a fuel oil–fired thermal oil heater that supplies heat to the frying system, operating for approximately 17–18 hours per day. However, the exhaust gas temperature of the thermal oil heater is relatively high (around 430°C), indicating great potential for waste heat recovery and utilization.   <i>Figure 4.1 FO-fired boiler at the factory</i> <i>Figure 4.2 The exhaust gas temperature of the thermal oil heater</i>		
Proposed project: The factory can consider installing an air preheater at the exhaust outlet of the thermal oil heater to recover heat from the flue gas at approximately 430°C. The air preheater, which can be designed as a tubular or plate-type heat exchanger using heat-resistant and corrosion-resistant materials, will transfer the recovered heat		

⁸ Then project developed at level B is not described in a section for itself because it is included in gross list.

to the combustion air supplied to the thermal oil heater. This will increase the temperature of the combustion air, thereby improve combustion efficiency and reducing fuel consumption.

In addition, this measure helps reduce the flue gas temperature to below 180°C, contributing to lower CO₂ emissions and reduced FO fuel costs, while enhancing the overall energy efficiency of the system.

Project illustration

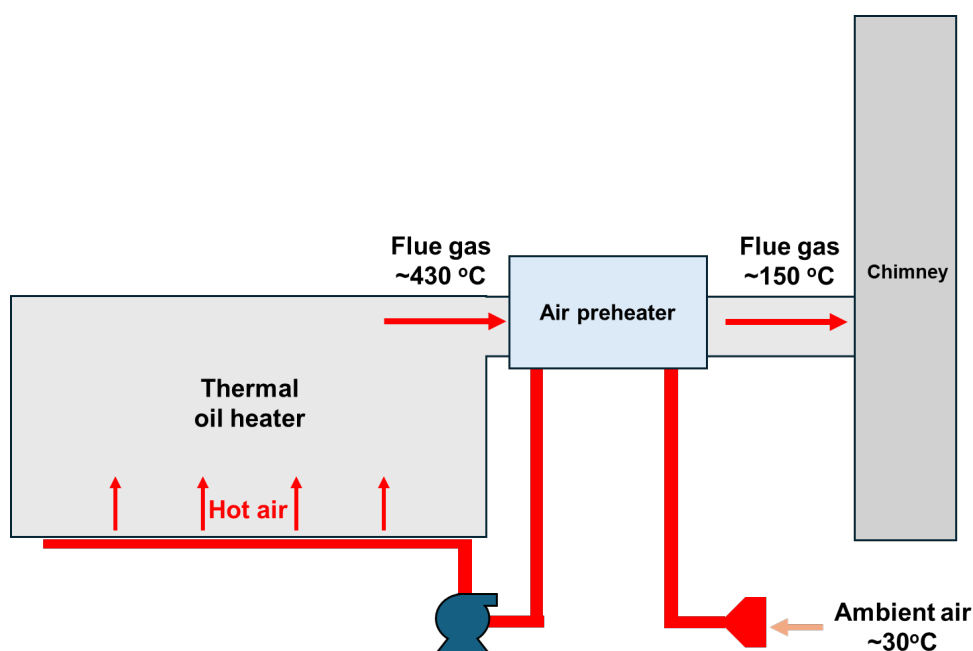


Figure 4.3 Schematic diagram of the proposed thermal oil heater

Project Budget

Element	Units	Unit costs (VND)	Costs (VND)
1. Air preheater	1	300,000,000	450,000,000
2. Construction cost	1	100,000,000	100,000,000
Total			550,000,000

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												
FO savings: 14,126 liter/year						Simple Payback: 3.0 years						
Financial savings: 181 million VND						GHG reduction: 43.0-ton CO ₂ e/year						
Risk Analysis												
Heat recovery efficiency depends on flue gas quality: High levels of dust or contaminants in the flue gas may cause fouling on the air preheater surfaces, reducing heat transfer efficiency and increasing maintenance requirements. Corrosion and high-temperature risks: The high flue gas temperature (≈430°C) may lead to material degradation or corrosion if improper materials are selected. Initial investment cost: Installation of an air preheater and associated ducting modifications may require moderate capital investment. Potential installation downtime: Integration with the existing thermal oil heater system requires careful planning to minimize disruption to production. Pressure drop impact: The addition of an air preheater may increase flue gas resistance, potentially affect fan performance and requiring system adjustment.												

– Maintenance requirement: Periodic cleaning of heat exchange surfaces is necessary to maintain efficiency and prevent performance degradation.
Non-Energy benefits
– Reduction of emissions: Lower flue gas temperature and improved combustion efficiency contribute to reduced CO₂ and NO_x emissions, supporting the factory's sustainability goals. – Improved combustion performance: Preheated combustion air enhances fuel burning efficiency, resulting in more stable and efficient boiler operation. – Improved working environment: Reduced waste heat release to the surroundings helps lower ambient temperature in the boiler area. – Lower operational costs: Improved combustion efficiency reduces fuel consumption, indirectly lowering operating costs. – Enhanced corporate image: Demonstrates commitment to energy efficiency and environmental responsibility, supporting ESG and CSR performance.

4.1.2 Recover heat from the refrigerant of refrigeration compressors to produce hot water

Project information		
Project: Recover heat from the refrigerant of refrigeration compressors to produce hot water	Project no. 2	Date: 2025
Project description		
Current situation: The factory uses screw refrigeration compressors in the central refrigeration system to support seafood processing and cold storage operations. During operation, the refrigerant leaving the compressor carries a significant amount of thermal energy, which represents a potential heat source that can be recovered for thermal applications within the factory. Under current operating conditions, the discharge temperature of the refrigeration compressors is approximately 90°C, while the condensing pressure of the system is around 14.5 bar. After leaving the compressor, the refrigerant is cooled in the condenser of the refrigeration system, where the condensing temperature is approximately 42°C, before continuing through the refrigeration cycle.		

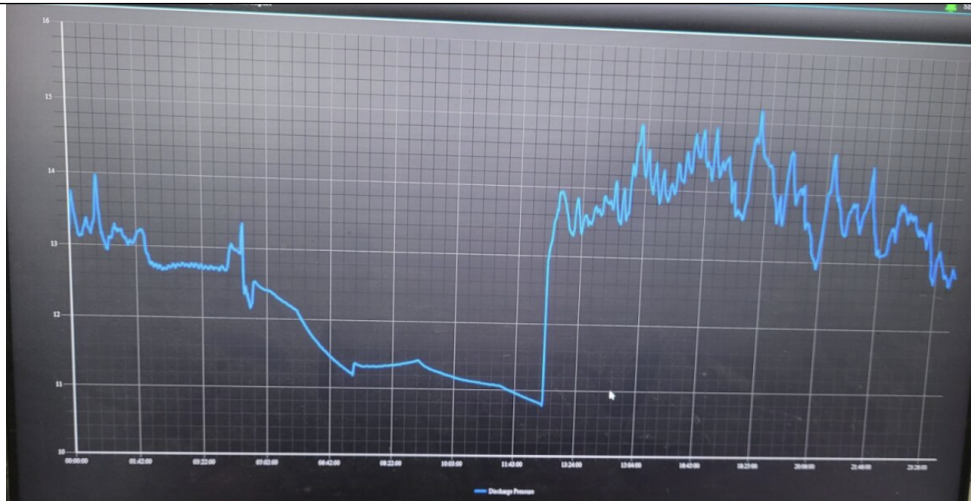


Figure 4.4 Discharge Pressure of Compressors

Proposed project:

The factory may consider implementing a heat recovery system to recover heat from the refrigerant and generate hot water for production processes.

In theory, heat from the refrigerant can be recovered from approximately 90°C down to the condensing temperature of about 42°C. However, in the proposed solution, the heat recovery system is designed to recover heat only from 90°C down to approximately 70°C, corresponding to the capability of supplying hot water at around 60°C for the factory's production needs.

The recovered heat will be used to heat the incoming water from approximately 25°C to 60°C through a heat exchanger. The heated water will then be stored in a hot water storage tank and subsequently supplied for hot water demand in the factory's production processes.

Recovering heat down to the condensation temperature (42°C) is not recommended due to the following technical reasons:

- To recover heat from 65°C down to 42°C, a heat exchanger with a very large heat transfer surface area would be required, which would significantly increase the investment cost of the system.
- When the refrigerant passes through a long heat exchanger or one with high flow resistance (in order to reduce the temperature close to 42°C), there is a risk of pressure drop in the piping system, which may negatively affect the stable operation of the refrigeration compressor.

- In addition, a safety temperature margin above the condensation temperature should be maintained to avoid premature condensation of the refrigerant inside the heat exchanger, which may result in liquid carryover returning to the compressor, potentially causing damage to the compressor.

Therefore, the proposed heat recovery system only recovers the superheat portion of the refrigerant at the compressor discharge, reducing the refrigerant temperature from 90°C to approximately 70°C before entering the condenser. This solution ensures stable operation of the refrigeration system, while still recovering a significant portion of high-grade thermal energy to produce hot water for the factory's operations.

Project illustration

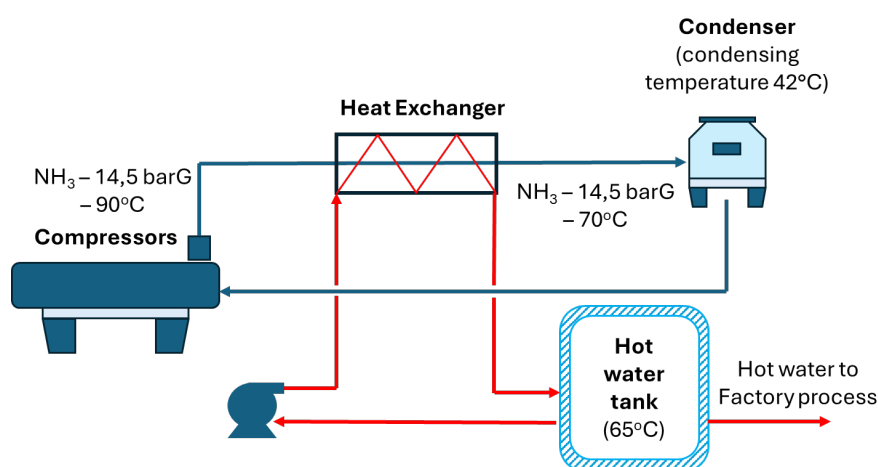


Figure 4.5 Schematic diagram of the proposed heat recovery system

Project Budget

Element	Units	Unit costs (VND)	Costs (VND)
3. Heat exchanger	1	400,000,000	400,000,000
4. Water pump, water pipe, insulation	1	200,000,000	200,000,000
5. Construction cost	1	180,000,000	180,000,000
Total			780,000,000

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												
FO savings: 46,150 liter/year						Financial savings: 592 million VND						
GHG reduction: 140.6 ton CO ₂ e/year						Simple Payback: 1.3 years						
Risk Analysis												
– Impact on refrigeration system operation: Installing a heat exchanger on the compressor discharge line may introduce additional pressure drop in the system. If not properly designed, this may affect the efficiency and stable operation of the refrigeration compressor. – Risk of premature refrigerant condensation: If excessive heat is recovered and the refrigerant temperature drops close to or below the condensing temperature, premature condensation may occur inside the heat exchanger. This could result in liquid carryover returning to the compressor, which may damage the compressor. – System integration risks: The heat recovery system must be carefully integrated into the existing refrigeration system to avoid disturbing the thermal and pressure balance of the refrigeration cycle.												

– Heat exchanger fouling and maintenance: Over time, the heat exchanger may experience scaling or fouling, particularly on the water side. This may reduce heat transfer efficiency if proper maintenance is not carried out.
Non-Energy benefits
– Reduction of CO₂ and NO_x emissions, supporting the factory’s sustainability and carbon reduction goals (ESG targets). – Reduced load on the condenser system: Recovering part of the heat from the refrigerant can reduce the amount of heat rejected at the condenser, thereby lowering the load on the cooling system such as cooling towers or condensers. – Reduced operating costs for water heating: The recovered heat can reduce the need for steam to produce hot water, thereby lowering the factory’s operating costs. – Enhanced corporate image: Promotes a green and energy-efficient brand reputation, improving ESG and CSR performance.

4.1.3 Use screw-type refrigeration compressors integrated inverters

Project information		
Project: Use screw-type refrigeration compressors integrated inverters	Project no. 2	Date: 2025
Project description		
Current situation: The factory’s refrigeration system consists of 12 ammonia (NH₃) compressors, divided into two refrigeration stations serving the fish processing line and the shrimp processing line. Among these, the fish line refrigeration system includes nine compressors. In 2024, the factory ceased operation of the shrimp line refrigeration system and began using the fish line refrigeration system to supply cooling for the entire plant. The fish line refrigeration system comprises nine screw compressors with rated capacities ranging from 180 to 450 kW, including:		

- Seven compressors (divided into two stages: four low-stage compressors and three high-stage compressors) providing cooling for the freezing lines and the workshop air-conditioning system;
- Two remaining compressors supplying cooling for the cold storage rooms used for product preservation.

All nine screw compressors have been installed and operating for approximately 13 years. The compressors are controlled by slide valves, and the start/stop operation is currently managed based on operator experience.

According to historical operating data, the compressors run on average at around 50% load. Due to the slide valve control mechanism, when the cooling demand fluctuates, the system faces difficulties in adjusting compressor capacity to match the actual load requirement, resulting in suboptimal operation and increased power consumption across the entire refrigeration system



Figure 4.6 Screw refrigeration compressors at the facility

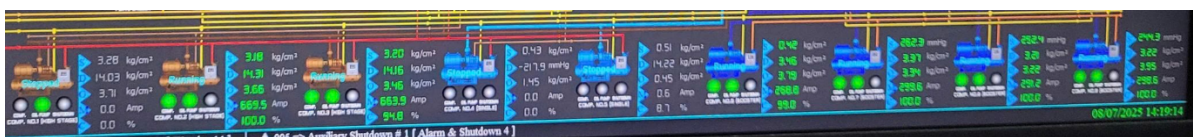


Figure 4.7 The facility's current refrigeration compressors

It is recommended that when the existing screw refrigeration compressors reach the end of their service life, or when the factory plans to purchase new units, it is recommended to consider investing in new screw compressors with integrated VSD. This technology helps reduce operational costs and energy consumption in the refrigeration system.

It is proposed that the factory prioritize the gradual replacement of one low-stage compressor and one high-stage compressor as the first step in the upgrade plan.

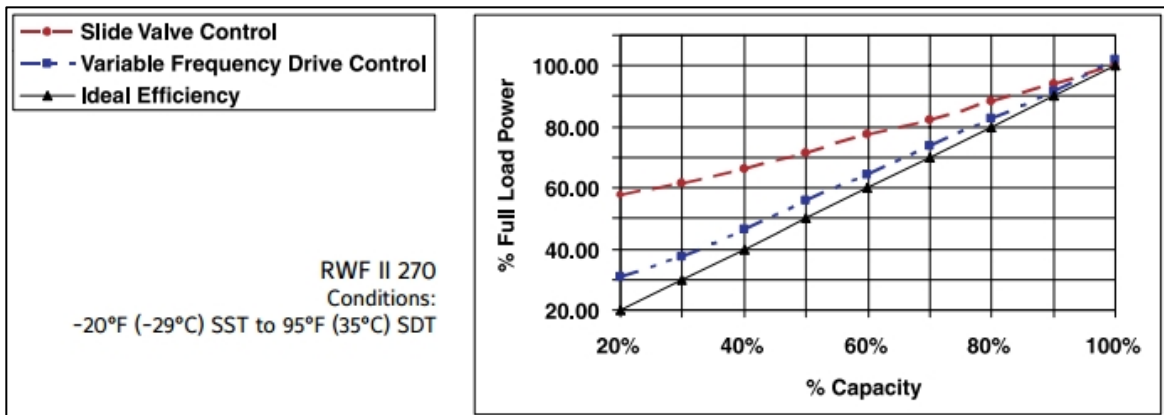


Figure 4.8 Comparison of power consumption by different regulation methods (screw compressor)⁹

Project illustration

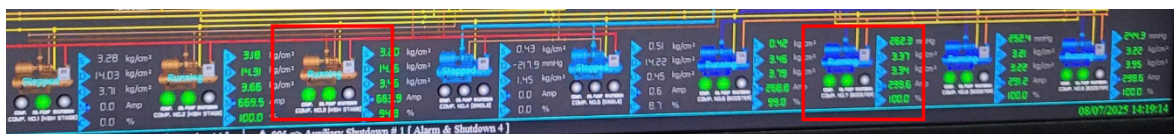


Figure 4.9 Proposal to replace compressor No. 3 (high pressure) and compressor No. 6 (low pressure) with inverter-integrated screw compressors.

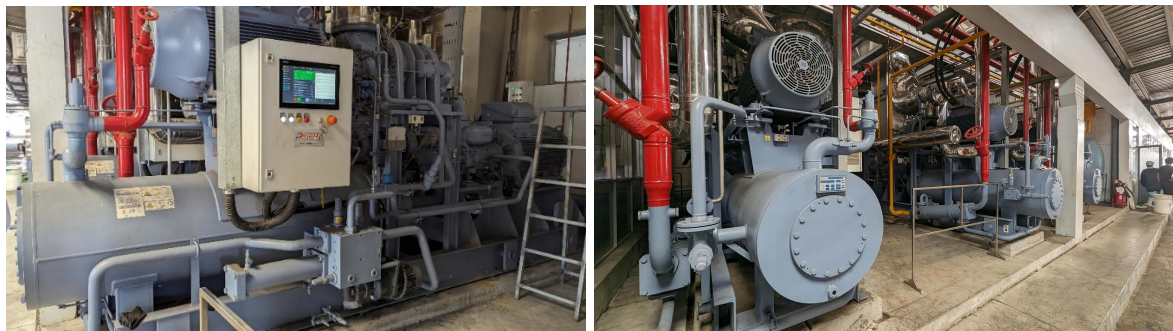


Figure 7.9 Screw compressors with integrated VSD (reference)

⁹ DEA & EESD, Energy Partnership Programme between Viet Nam and Denmark, "Catalogue for industrial cooling systems"

Equipment delivery												
Installation (depending on the production schedule, etc.)												
Testing, commissioning												
Trial run+ staff training												
Saving ¹¹												
Electricity saving ¹² : 263,358 kWh/year						Simple Payback: 3.5 years						
Financial savings: 497 million VND						GHG reduction: 173.6 ton CO ₂ e/year						
Risk Analysis												
– Technical compatibility risk: New VSD screw compressors may require adjustments to the existing refrigeration controls, sensors, and electrical system. – Installation downtime: Replacing the current compressors may require system shutdowns, affecting cooling supply and production continuity. – Uncertain load performance: Actual energy savings depend on real operating load, production patterns, and system tuning after installation. – Operator skill and training: Staff need training to properly operate and maintain VSD technology, especially during commissioning. – Higher initial investment: The upfront cost of VSD-integrated compressors is higher than standard units, potentially affecting project cash flow. – Potential harmonics issues: VSDs may introduce electrical harmonics if not properly filtered, impacting other equipment.												
Non-Energy benefits												

¹¹ Details of savings calculation is presented in Appendix 2: Detailed saving calculations of projects level A.

- **More stable cooling performance** due to smooth and continuous capacity control from VSD operation.
- **Extended compressor lifespan** thanks to reduced mechanical stress and fewer start/stop cycles.
- **Lower maintenance frequency and cost** as VSD compressors operate more efficiently and with fewer abrupt load changes.
- **Improved product quality** through more consistent temperature control in freezing, cold storage, and air-conditioning zones.
- **Reduced noise and vibration** because compressors operate at optimized speeds rather than full-load conditions.
- **Enhanced system reliability** due to improved control logic and reduced risk of overload conditions.
- **Better operational flexibility** allowing the system to adjust cooling output accurately to meet real-time demand.