DEMONSTRATION ENERGY AUDITS

Cement industry

Date 21/4/2026

Consulting firm:

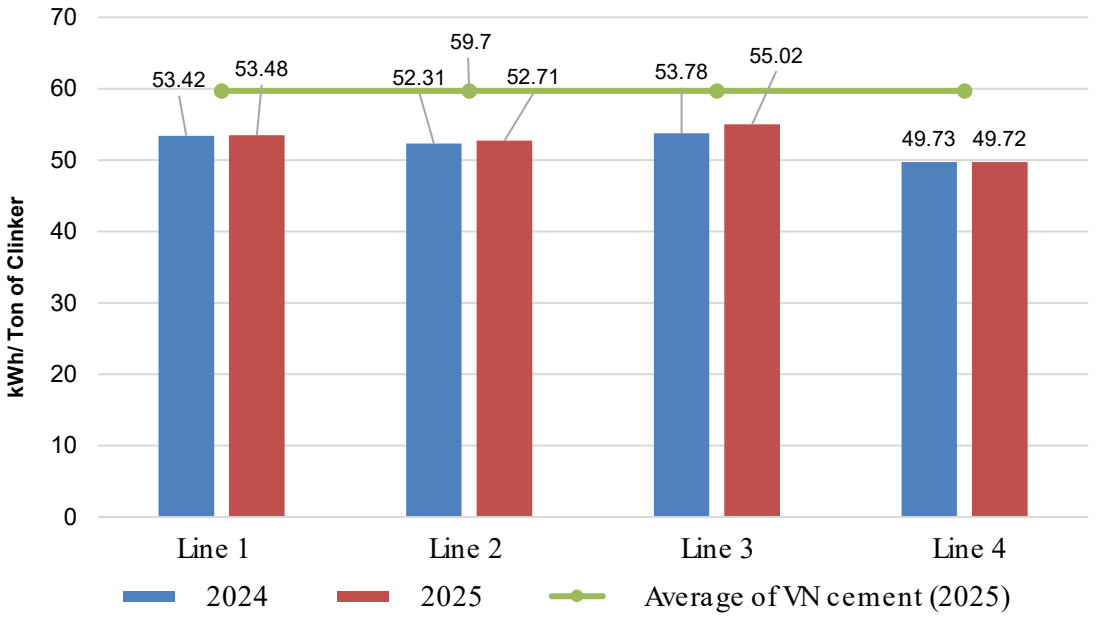
Case Overview

- **Sector:** Cement production
- **Establishment year:** 2016
- **Main materials:** Limestone, pure limestone, clay
- **Adjusting materials :** Iron ore, silt ore, silica sand
- **Additives:** Artificial gypsum and mineral additives (fly ash, steel slag, blast furnace slag, black clay, etc.)
- **Capacity:** 10.5 (million tons/year)

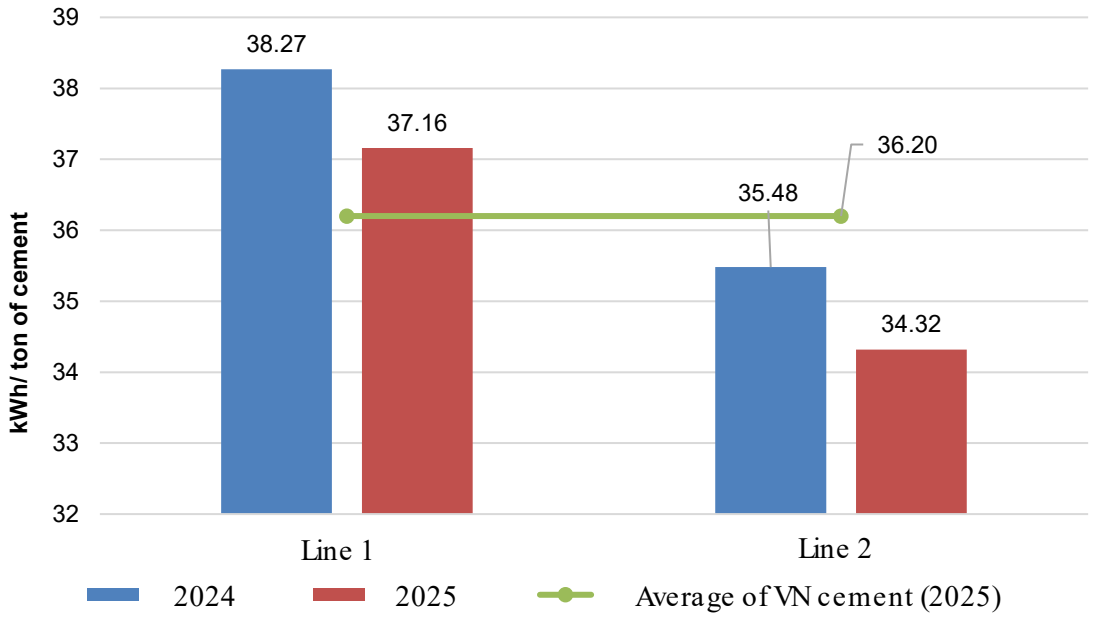


Factory image

Case Overview

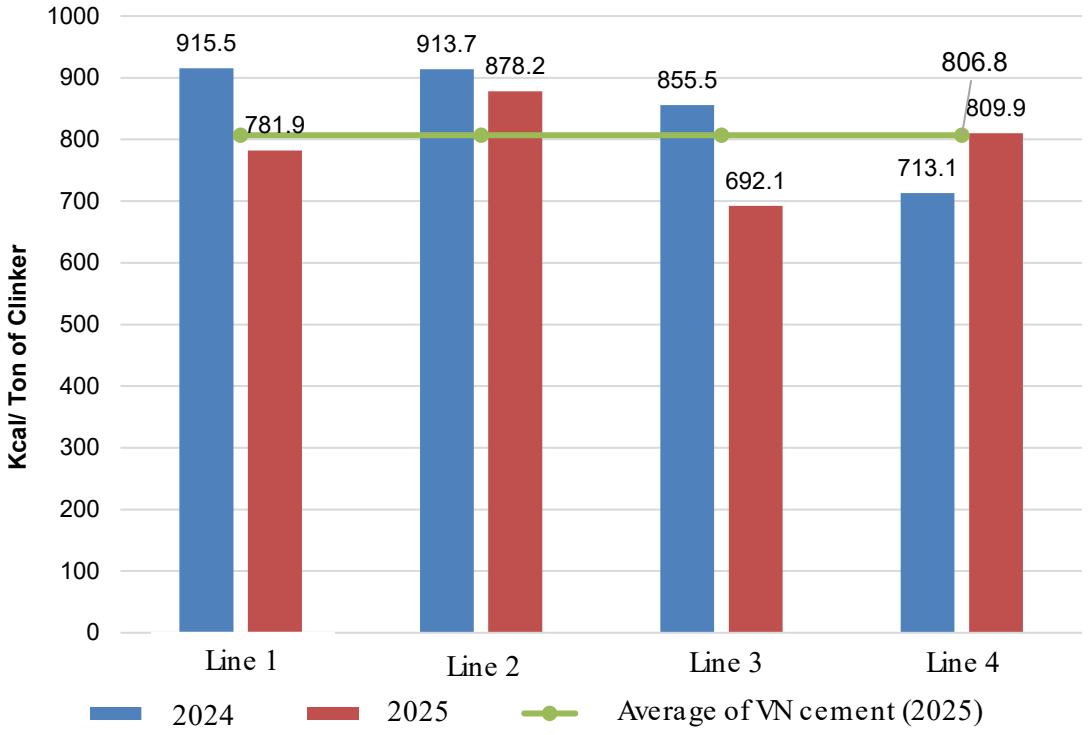


The chart compares the electricity consumption rate for clinker production between different production lines in the factory and the current average of the Vietnamese cement industry statistics

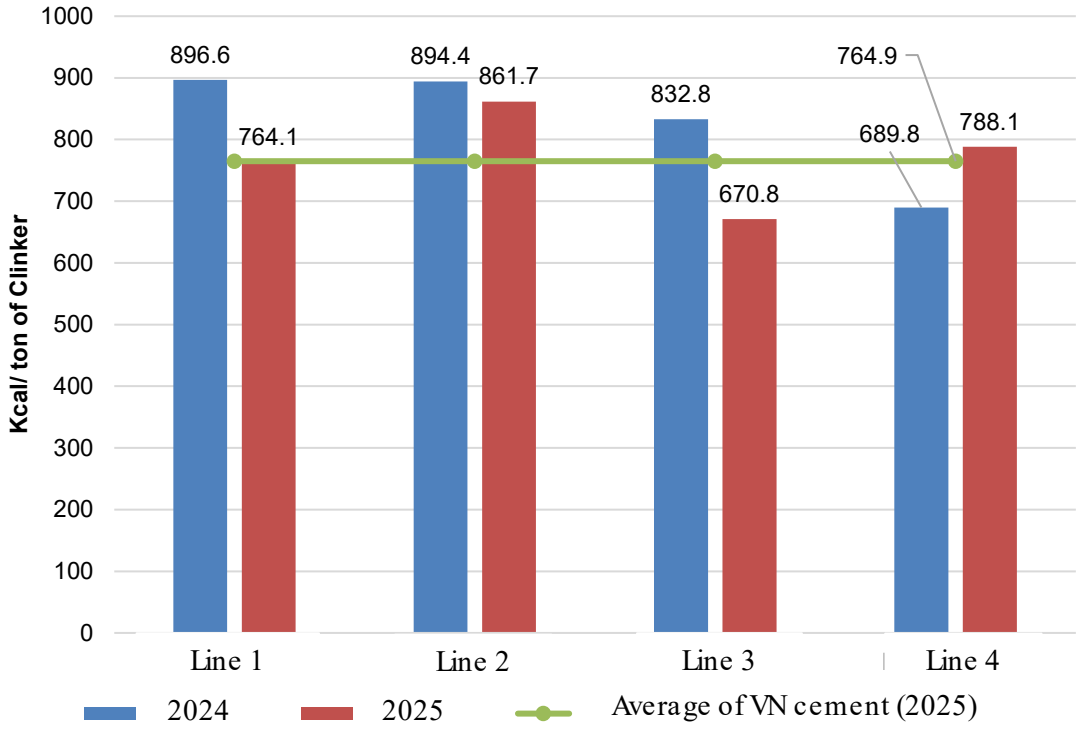


The chart compares the electricity consumption rate for cement grinding operations among different production lines in the factory and the current average of the Vietnamese cement industry statistics

Case Overview



This chart compares the thermal energy consumption rate for clinker production between different lines in the factory and the current average of the Vietnamese cement industry statistics



The chart compares the thermal energy consumption rate for clinker production between different lines in the factory and the current average of the Vietnamese cement industry after heat compensation from the WHR system

Case Overview



Material grinding machine



Heat exchange tower



Rotary kiln system

Machinery system at the factory

Case Overview



Cooling grate system



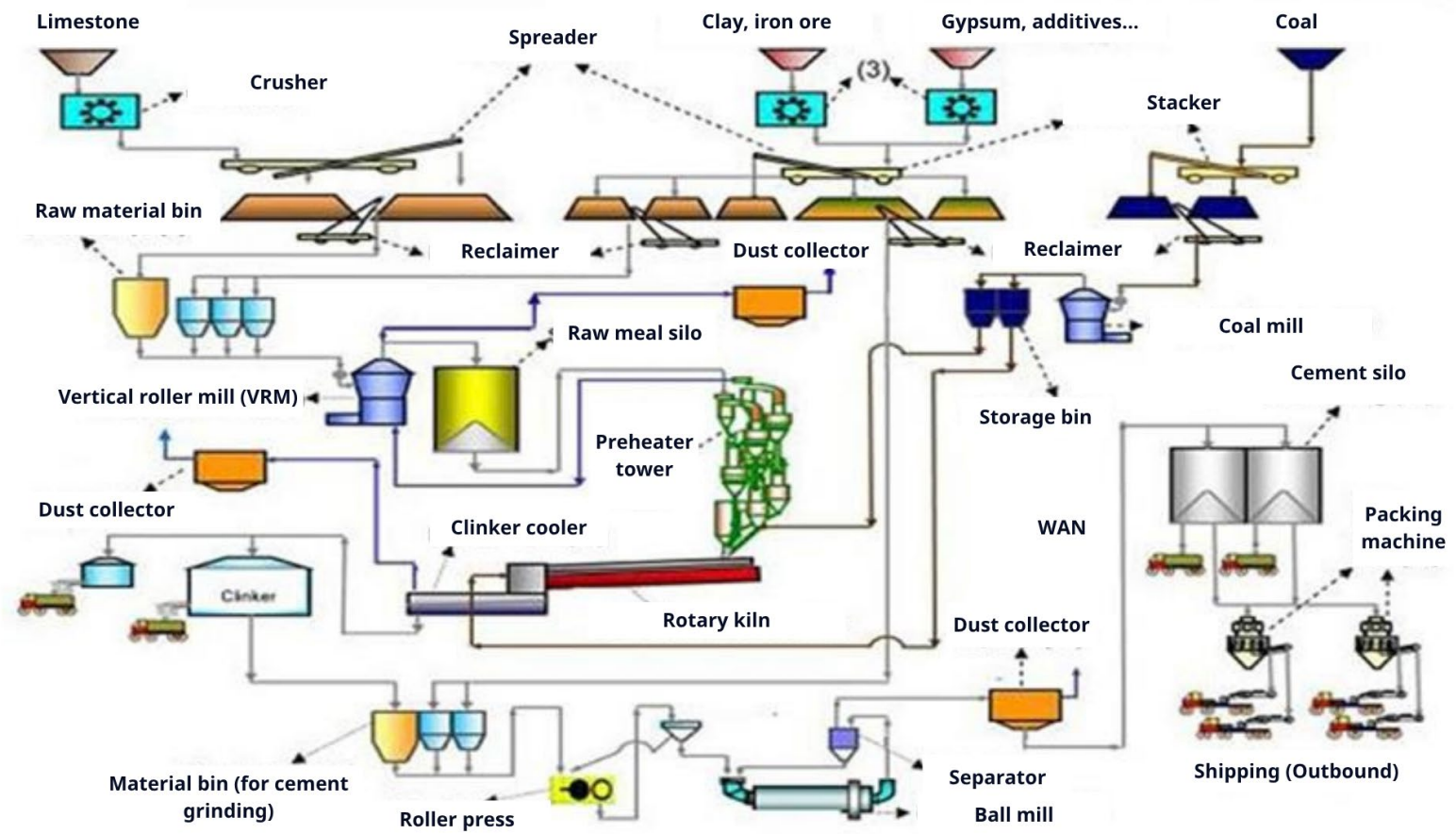
Cement grinding machine



ID Fan

Machinery system at the factory

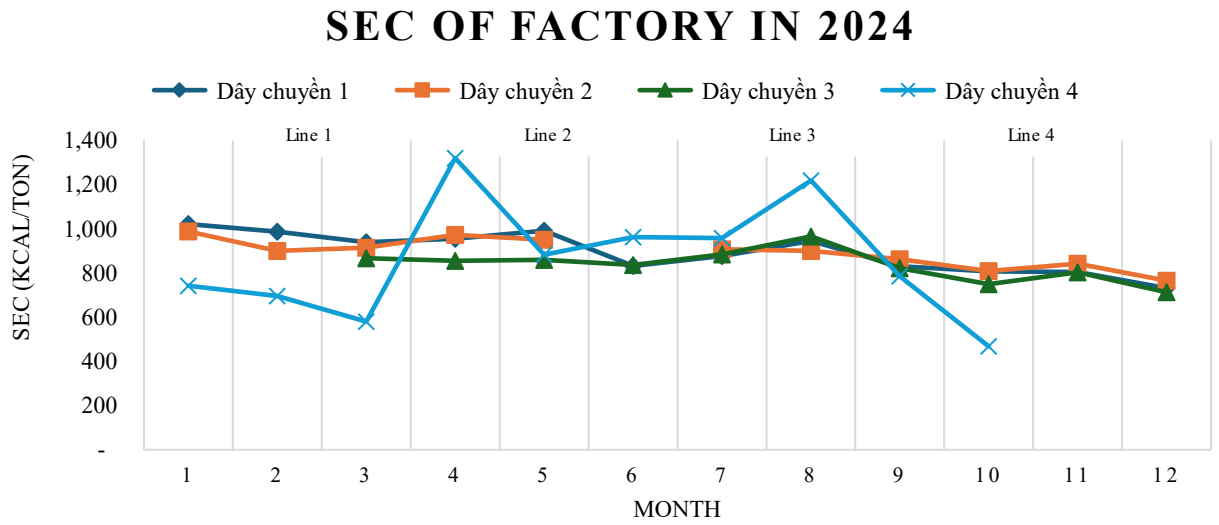
Production process



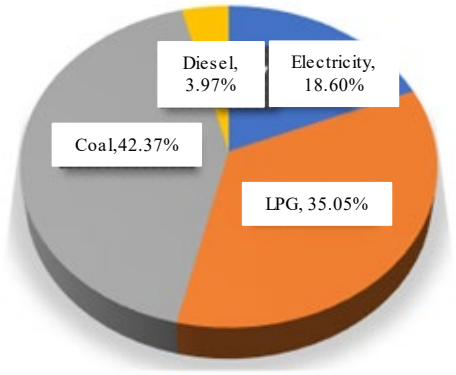
Factory's technological process

Annual energy total consumption

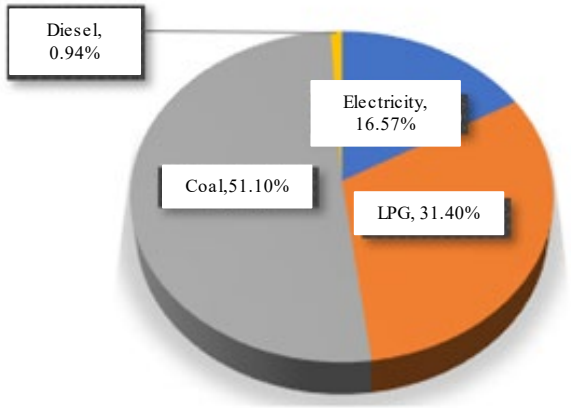
No	Energy type	Unit	Amount	CO2 emissions (Tons of CO2)	TOE Conversion (TOE)
1	Electricity (EVN)	kWh	433,979,656	286,079	66,963
2	Coal	Ton	1,224,438	3,024,362	734,663
Total			**649,726,897**	**3,310,441**	**801,626**



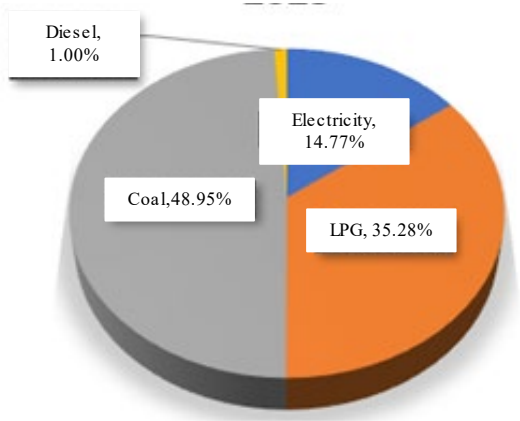
Energy consumption in 2021



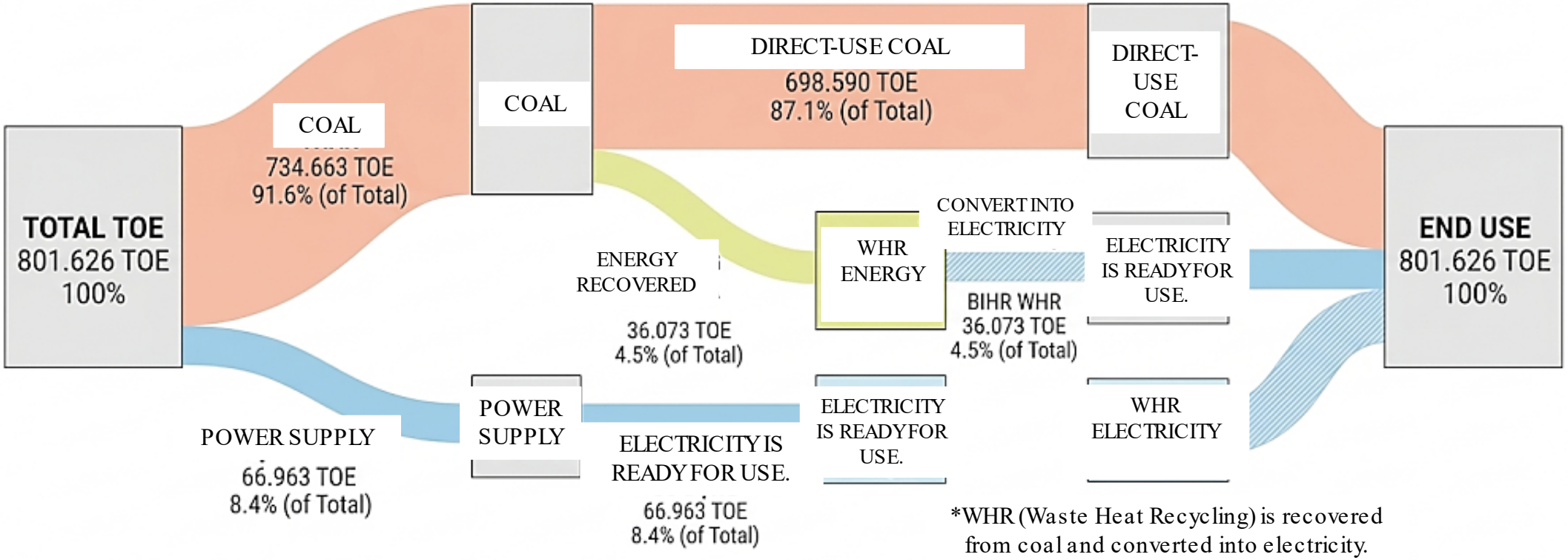
Energy consumption in 2022



Energy consumption in 2023



Breakdown energy flow



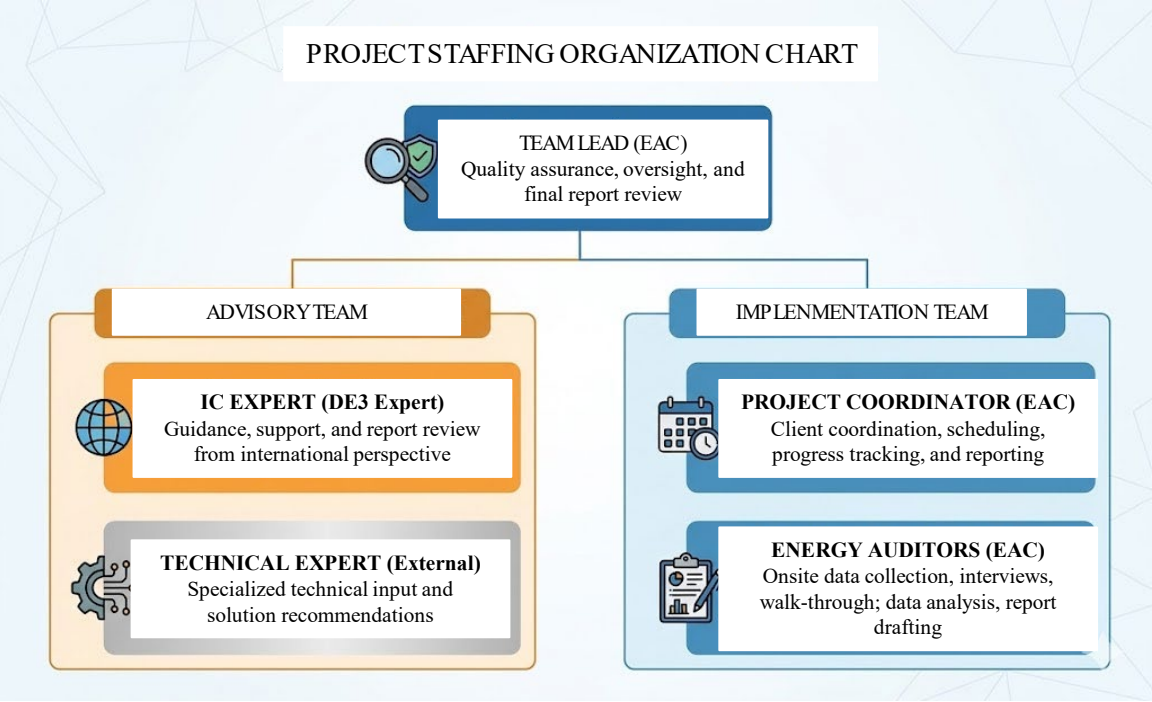
*WHR (Waste Heat Recycling) is recovered from coal and converted into electricity.

Total energy consumption after implementing energy saving solutions

No	Type of energy	Unit	Energy consumption	CO2 Emissions (Tons of CO2)	TOE Conversion (TOE)
1	Electricity	kWh	399,398,464	263,283	61,627
2	Coal	Ton	1,203,623	2,972,948	722,174
Total				**3,236,231**	**783,801**

Energy Audit Team and Equipment

List of energy audit team



List of equipment





Power quality analyzer



Electric power meter



Thermal camera



Liquid flow meter



HIOKI Lux Meter



Air pressure equipment



Emission analysis equipment



Wind speed measuring equipment

Level B List– Classified By Impact Level and Innovation

➢ Group 1: Main solutions (High-impact / Strategic)

No	Solutions	Esimated savings		Amount saved (Million VND/year)	Investment cost (million VND)	Payback (years)
		Electricity (kWh)	Coal (ton)			
1	Machine Learning solutions for optimizing production operations	12,966,543	18,366	71,175	116,600	1.64
2	Waste heat recovery solution (>100oC) using organic Rankine cycle (ORC) for air conditioning systems serving the loads in the control room and power station or generator area (DC1 - DC4) –Let's take the HVAC system, Line 1	1,296,480	-	2,525	9,000	3.56
3	Solar power system installation solutions - using a typical example of a 10MWp solar power system without storage	14,134,437	-	30,944	172,250	5.57
4	Install a variable frequency drive (VFD) for the air compressor system combined with a central controller for the compressed air system	590,357	-	1,150	3,600	3.13
5	Pipeline renovation: "Installation of pressure distribution piping for the compressed air system"	836,437	-	1,629	4,500	2.76

Level B List– Classified By Impact Level and Innovation

➢ Group 2: Support solutions (Conventional / Best Practice)

No	Solutions	Estimated savings		Amount saved (Million VND/year)	Investment cost (million VND)	Payback (years)
		Electricity (kWh)	Coal (ton)			
1	Establish, implement, and certify an Energy Management System according to ISO 50001:2018 standards	1,296,654	2,448	8,648	3,000	0.35
2	Continue to regularly and periodically implement propaganda, education, and dissemination of knowledge about energy saving to employees in the Company	Recommended solution				
3	Regularly inspect and repair any compressed air leaks	182,732	-	355	120	0.34
4	Equipped with a flow measurement system to monitor compressed air load	Recommended solution				
5	Installing a HydroBall automatic cleaning system, electronic descaling device, and automatic controller for the circulating water pump and cooling tower fan based on condenser vacuum pressure –A typical example for Production Line 1	2,447,672	-	4,768	3,000	0.6
6	Replace 70W and 150W halogen bulbs with high-efficiency LED bulbs	744,045	-	1,449	2,841	1.96
7	Replace low-efficiency IE1 motors with high-efficiency motors (IE3-IE4) whenever possible	85,833	-	167	1,090	6.52

Energy audit results

1. **A total of 12 solutions have been identified.**
2. **These solutions cover multiple areas, including:**

- *Compressed air system:* Air compressors, monitoring systems
- *Thermal systems:* Heat recovery, cleaning
- *Electrical systems:* Motors
- *Lighting system:* Lamp upgrades
- *Process control & automation:* Variable frequency drives (VFDs), timer relay installation
- *Management systems:* Machine learning software
- *Renewable energy & standards:* Solar PV installation, ISO 50001

In particular, key solutions such as Machine Learning, ORC, and Air compressor system optimization contribute significantly to the potential savings, while also demonstrating a digital transformation and operational optimization strategy in line with international trends.

3. Energy and Cost Savings Impact:

- Total electricity savings: ≈ **34,581,192 kWh/year**
- Total coal savings**: ≈ 20,815 kWh/year**
- CO_2 emission reduction**: ≈ 74,210 tCO_2/year**
- Total estimated financial savings**: ≈ 122,813 million VND/year**
- Payback period: Ranges from **0.22 to 6.5 years**, with many solutions **under 3 years.**

Application of Machine Learning (ML) in optimizing cement production operations

OVERVIEW OF THE SOLUTION & BENEFITS

1. Principles & Solutions for Digital Transformation



- Application of AI/ML for real-time analysis of operational data.
- The biggest impact: energy savings of approximately 55-60%.
- Digital transformation, currently being implemented in practice (e.g., ABB, FLS, Schneider).

2. Energy/Operational Benefits and Value



- Energy efficiency ~3-5% saving on heat/electricity
- Reduced temperature SEC variability
- Standardized operation

ML SOLVES PROBLEMS DIRECTLY IN STAGES

KILN & CALCINER



- Kiln load, O2, CO
- Temperature
- Air flow rate

COOLER (Cooling clinker)



- Airflow
- Clinker temperature
- Air 2/3

CEMENT GRINDING (Line 1)



- Crushing load
- Separation
- Air flow

FAN SYSTEM



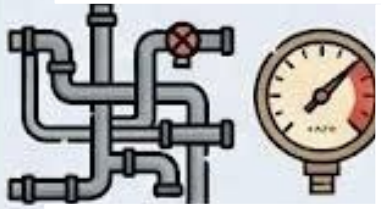
- Pressure
- Flow Rate
- VFD Status

👉 *Machine Learning is a key solution that helps factories approach near-BAT (Best Available Technology) in line with international trends.*

High-pressure – Low-pressure system solutions

CURRENT STATUS AND PROBLEM

OPERATION NOT OPTIMIZED



- Pressure: 0.60 – 0.75 MPa (~6–7.5 bar)
- The air compressor stations operate independently, without centralized coordination

CORE PROBLEM

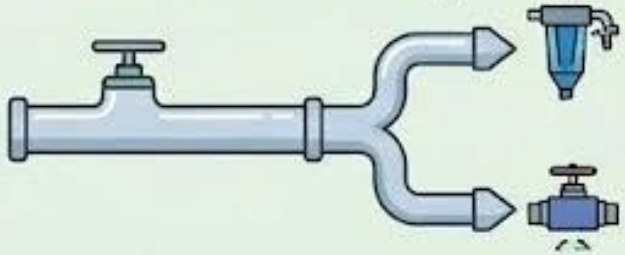
- All loads are using the same high pressure level.
- While in reality: 40–65% of loads only require low pressure (<0.55 MPa).
- **Current issues:**
  - Throttle loss through pressure reducing valves.
  - Increased compressed air leakage.
  - Increased "false compressed air".



SOLUTION & EFFICIENCY

PROPOSED SOLUTION:

Separate the system into 2 levels.



HIGH PRESSURE (> 0.55 MPa)

- Dust filters, air guns, air hammers

LOW PRESSURE (< 0.55 MPa)

- Instrument air
- Control valves
- Air slide, cleaning

EFFECTIVE SAVINGS

Low system pressure reduction

- **0.66 -> 0.45 Mpa (~4.5 bar)**

Savings:

- **~4-5%** of total system electricity
- **~836,000** kWh/year
- **~1,630,000** VND/year

The solution leverages existing infrastructure, is cost-effective, delivers sustainable results, and aligns with international best practices (BAT).

IMPLEMENTATION ROADMAP & KEY RECOMMENDATIONS

SHORT TERM (0-12 MONTHS) – OPTIMIZED & QUICK WINS

PROJECT

- ✓ Immediately implement no/low CAPEX solutions (kiln, cooler, fan, grinder)
- ✓ Conduct pilot projects for high-potential solutions (cooler/ML)
- ✓ Update financial performance (NPV/IRR) based on actual data

MANAGEMENT

- ✓ Establishing energy KPIs by process stage (kWh/t, kcal/kg clinker)
- ✓ Standardizing data collection and verification
- ✓ Adding sub-metering in key areas
- ✓ Establishing an internal energy team

LONG TERM (1-5 YEARS) – INVESTMENT AND TRANSFORMATION

PROJECT



- ✓ Implementation of large CAPEX projects (coolers, WHR, IE3/IE4 motors)
- ✓ Application of APC/ML for operational optimization
- ✓ Integration of solutions for system-wide optimization

MANAGEMENT



- ✓ Implementing an energy management system according to ISO 50001
- ✓ Building an Energy Data Platform
- ✓ Applying data analytics & ML in operations
- ✓ Training and enhancing the capacity of the team

Key messages:

The implementation roadmap should proceed from **operational optimization -> technology investment -> digital transformation**, in order to ensure sustainable efficiency and reduce energy costs across the entire plant.

Energy methodology

a. Data collection and analysis

b. System survey implementation

c. Preliminary assessment and determination of energy saving potential

d. Building an energy mapping

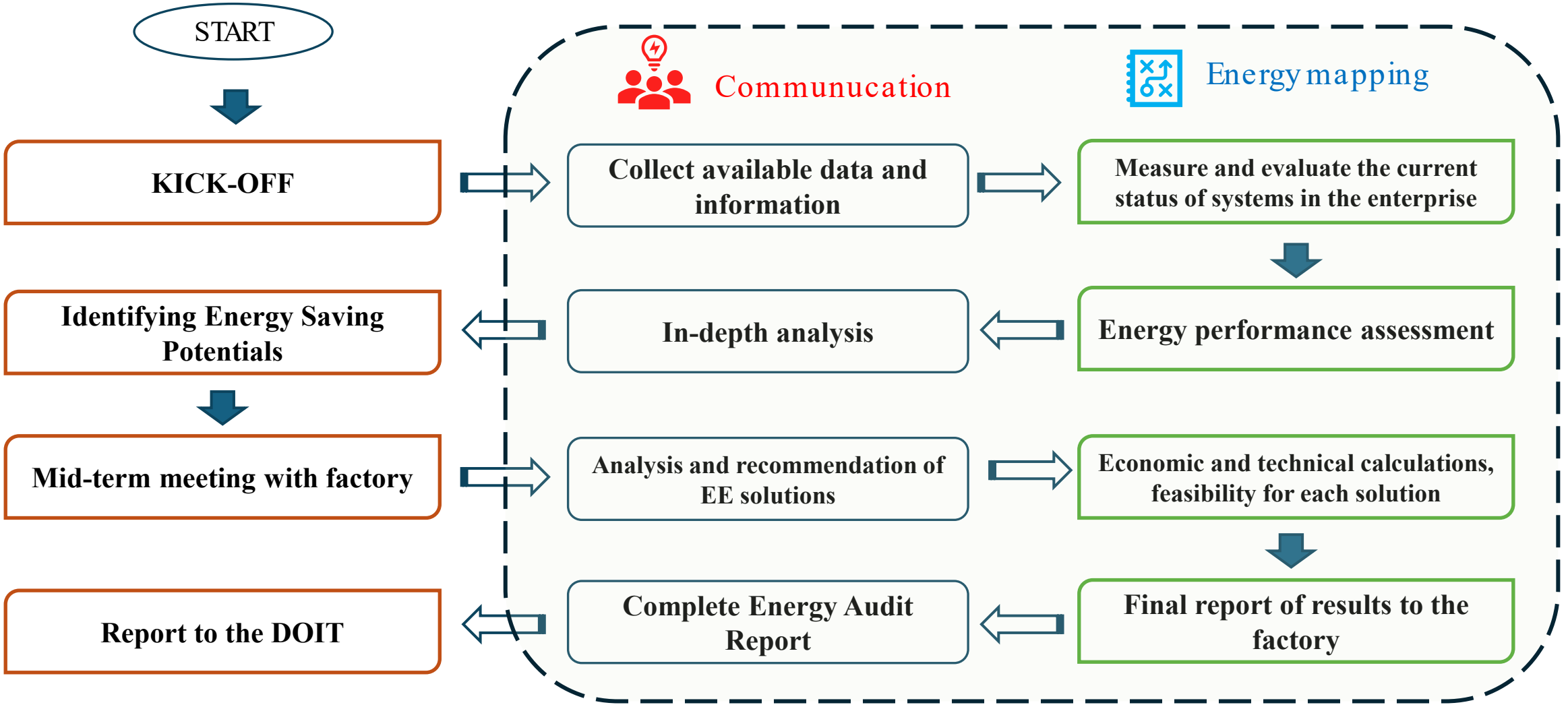
e. Energy performance assessment

f. Detailed analysis and evaluation

g. Identify energy saving opportunities and options

- The energy audit process follows the instructions of Circular 25/2020/TT-BCT dated September 29, 2020.

Energy audit process



Energy mapping

Legend:

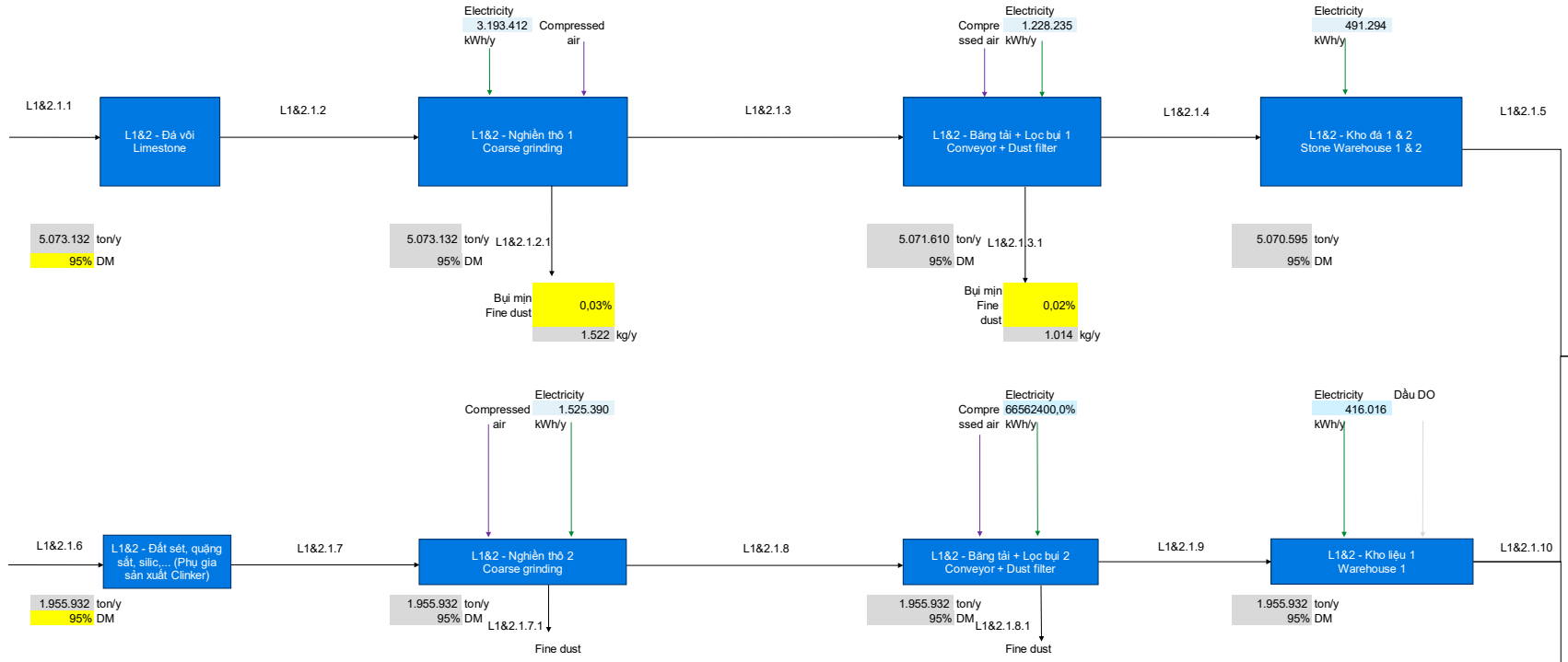
- Steam
- Trục cơ khí/Mechanical shaft
- Water
- Cooling Water
- Dầu DO/DO oil
- Product
- Electricity
- Hot air
- Compressed air
- Khí thải/ Exhaust gas
- Fresh air

Production line 1 & Production line 2

Dây chuyền chính 1&2 - Main product line 1&2

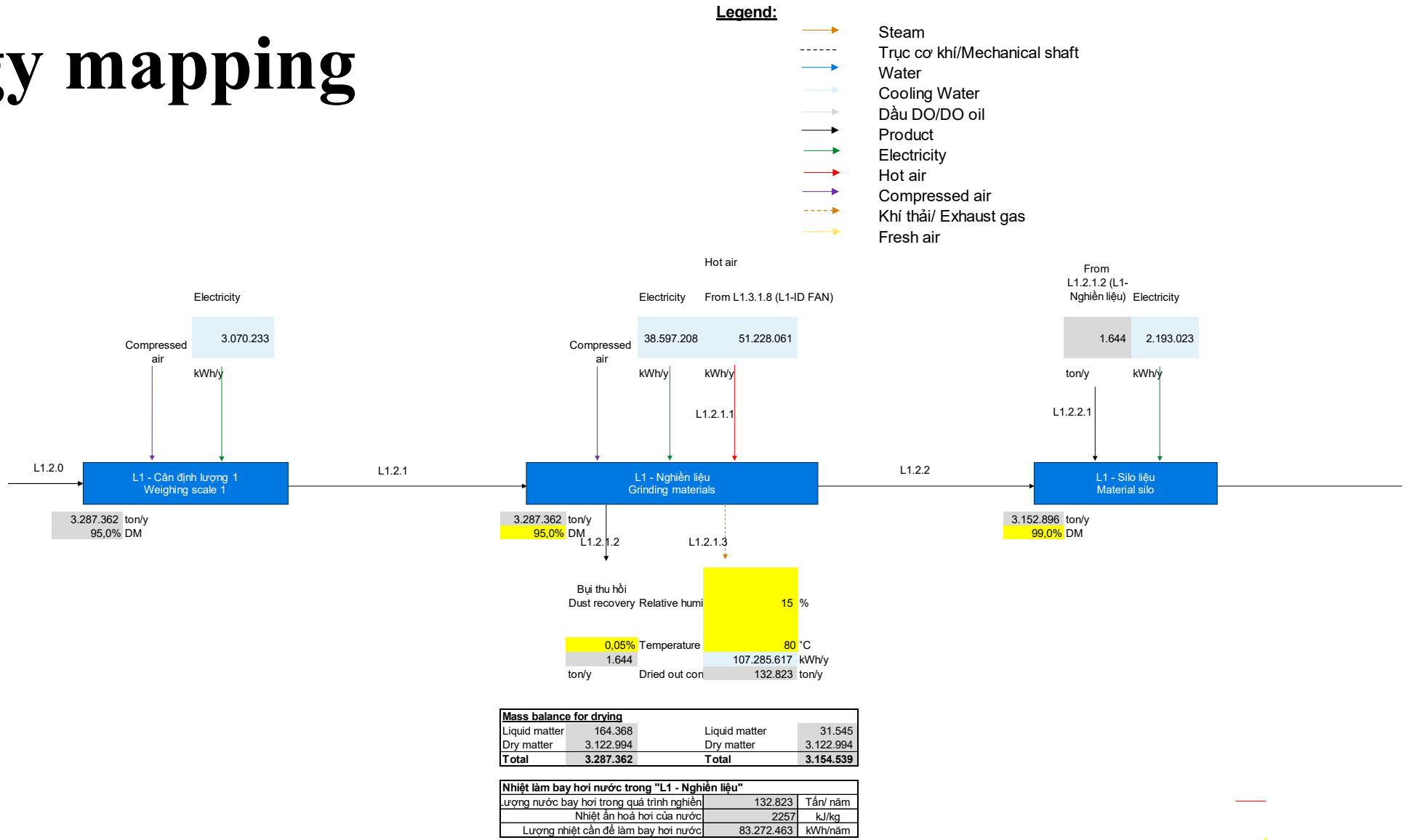
Raw materials

		Tota Line 1&2	Line 1	Line 1 - %	Line 2	Line 2 - %
Đá vôi Limestone	ton/y	5.073.132	2.596.013	51,2%	2.477.118	48,8%
Đất sét, quặng sắt, silic,... Clay, iron ore, silicon,...	ton/y	1.955.932	692.535	46,8%	1.263.397	53,2%
Phụ gia tổng hợp, thạch cao,... Synthetic additives, gypsum,...	ton/y	1.290.944	986.538	1	304.406	0
Than Coal	ton/y	625.958	321.601	51,4%	304357	48,6%
Total	ton/y	8.945.966				



Preparation, receipt of raw materials and preliminary processing (1)

Energy mapping

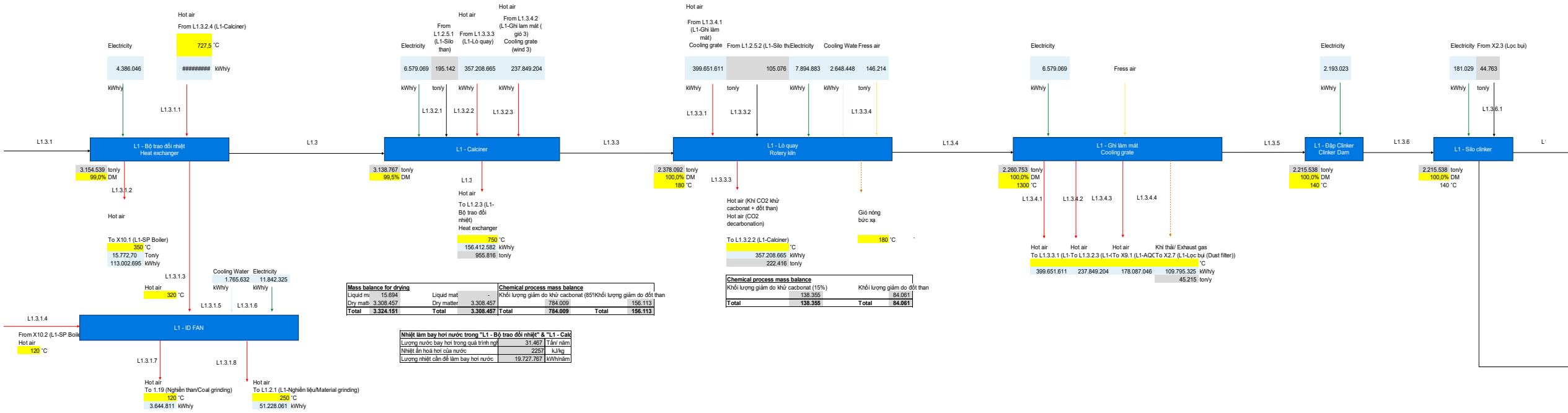


The process of grinding and homogenizing raw materials.

Energy mapping

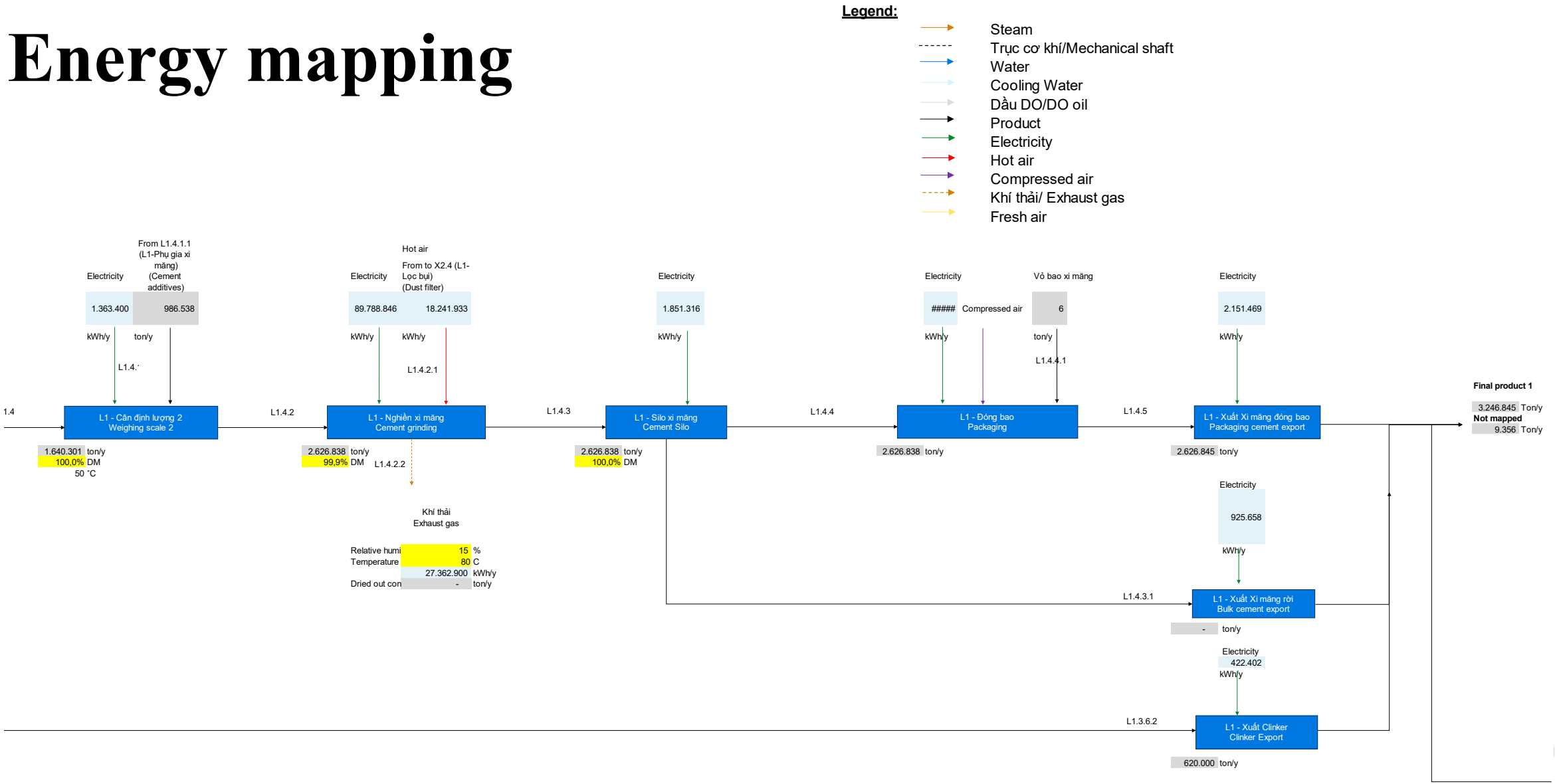
Legend:

- Steam
- Trục cơ khí/Mechanical shaft
- Water
- Cooling Water
- Dầu DO/DO oil
- Product
- Electricity
- Hot air
- Compressed air
- Khí thải/ Exhaust gas
- Fresh air



Clinker burning and cooling process

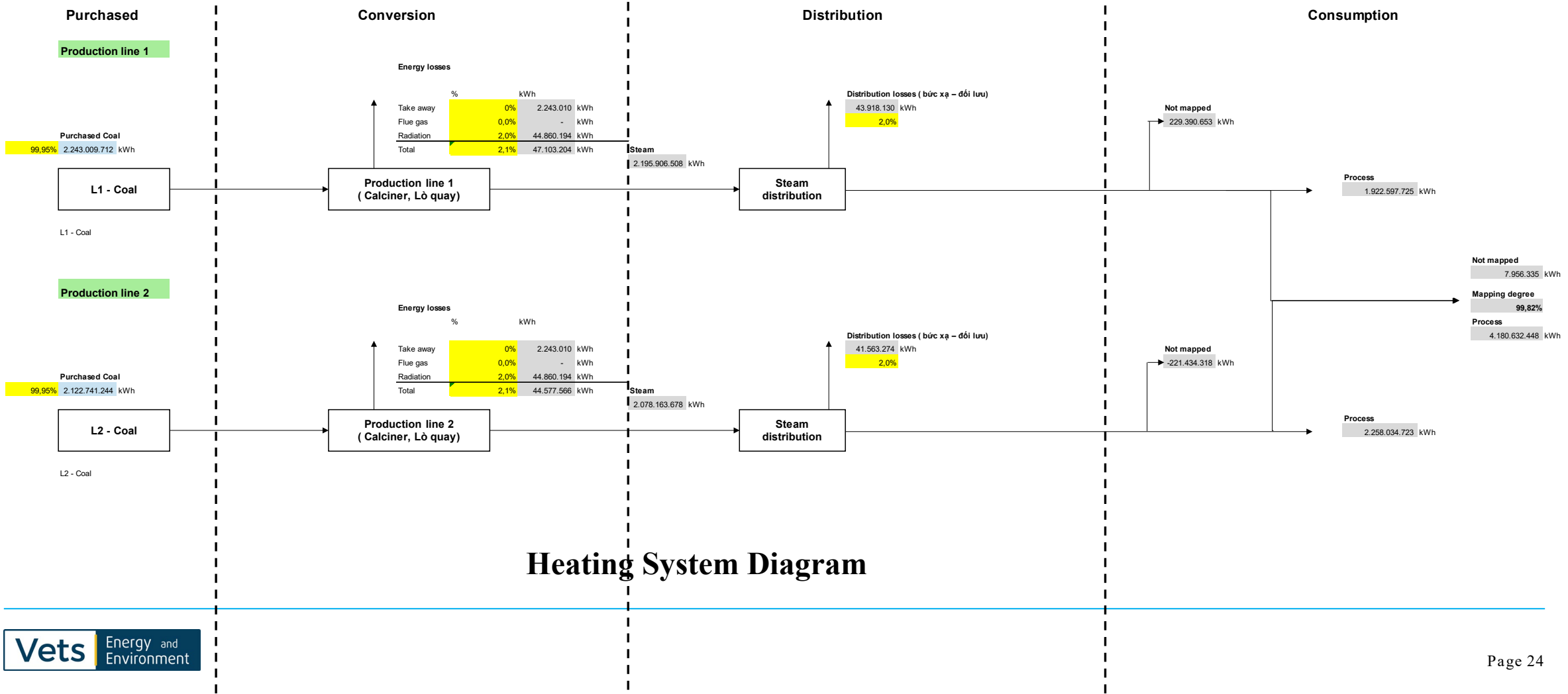
Energy mapping



Cement grinding, cement storage, and packaging processes.

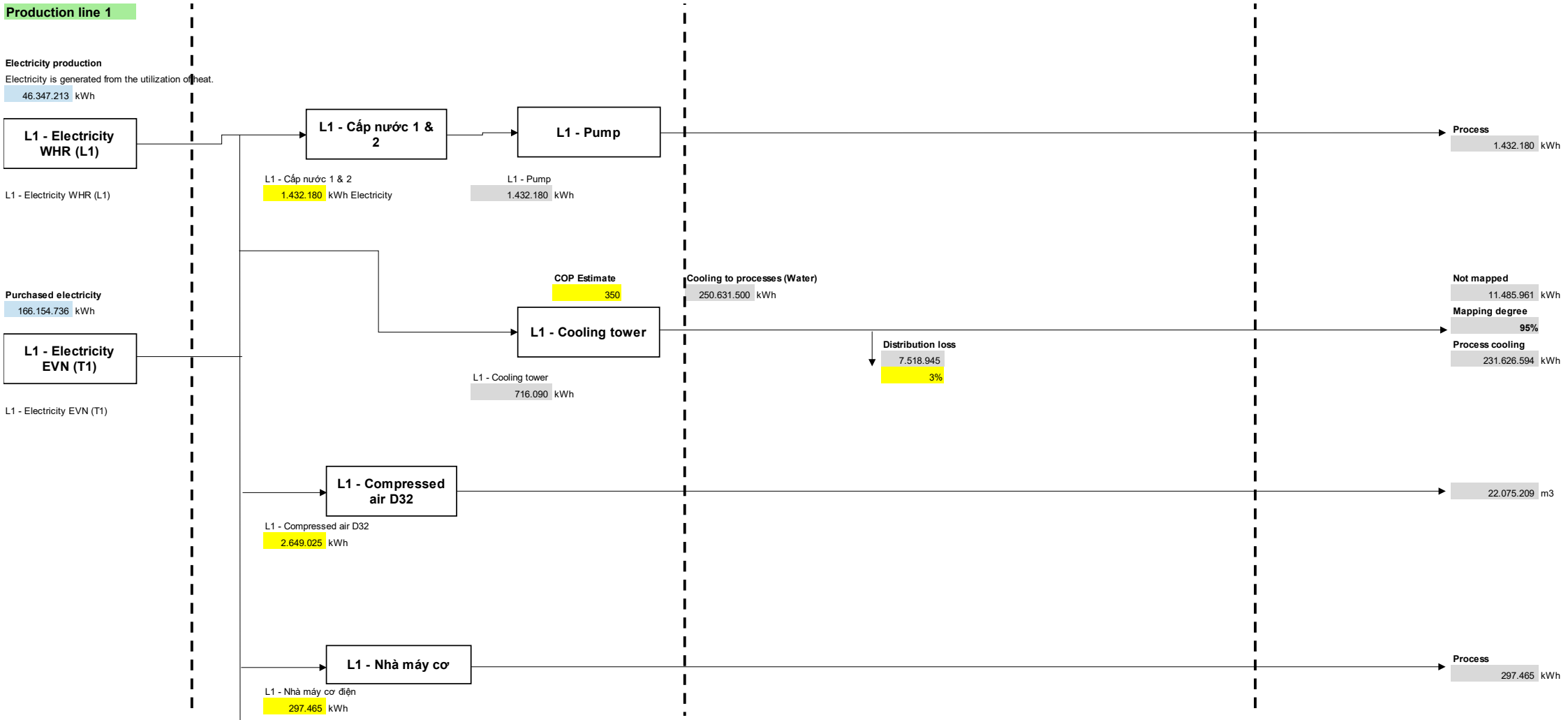
Energy mapping

Utility mapping



Heating System Diagram

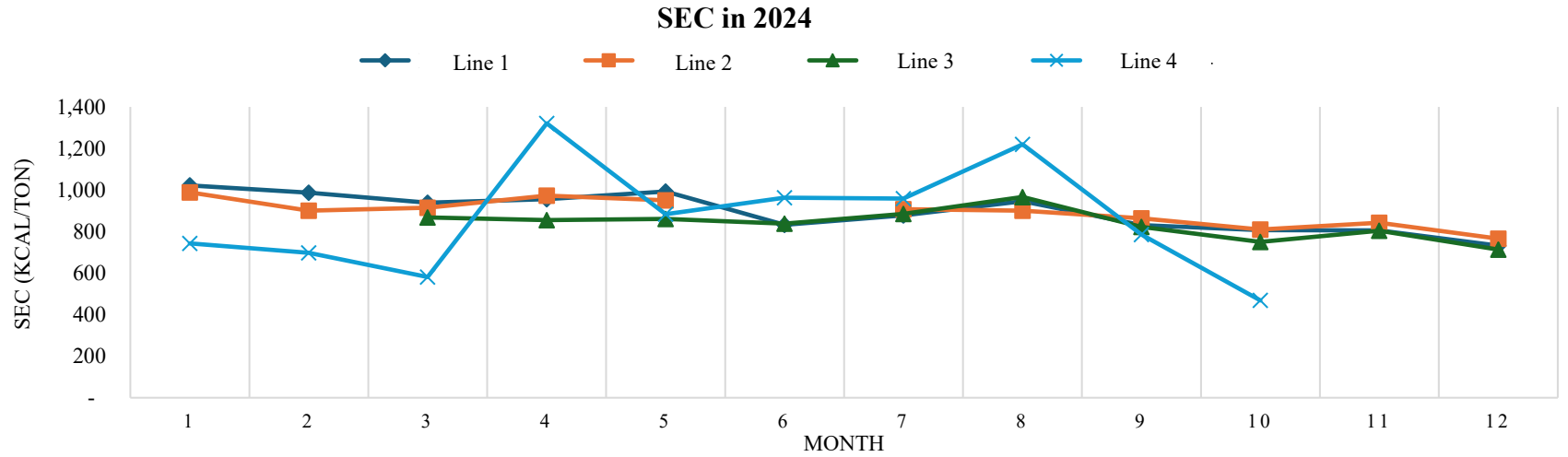
Energy mapping

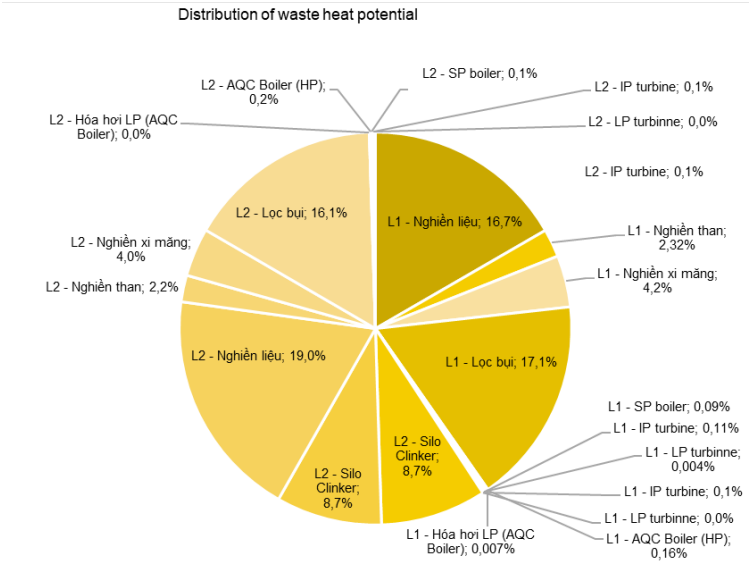


Vets Energy and Environment

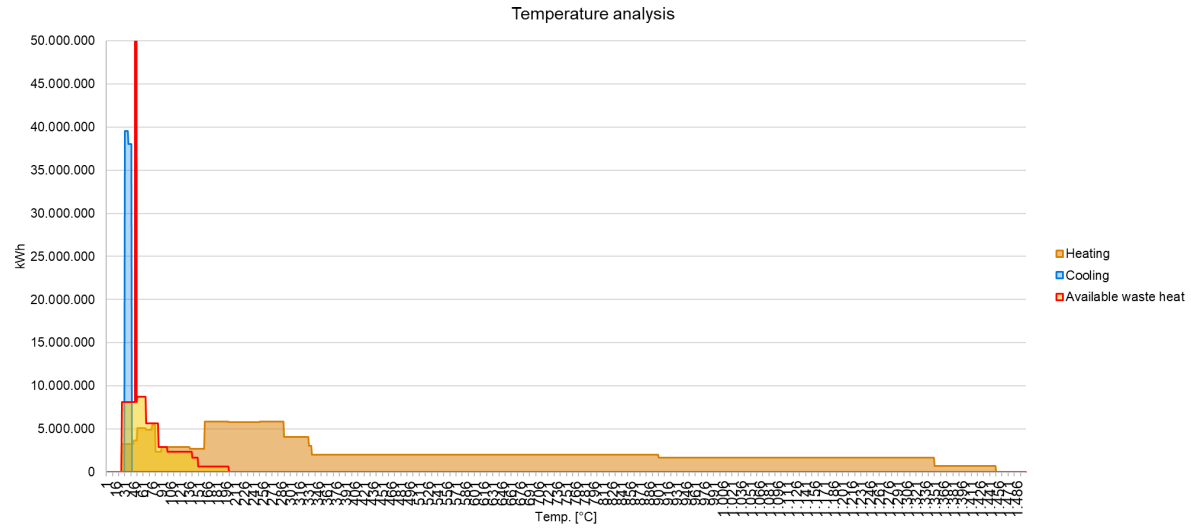
Diagram of the power supply system and auxiliary systems

Energy saving potentials



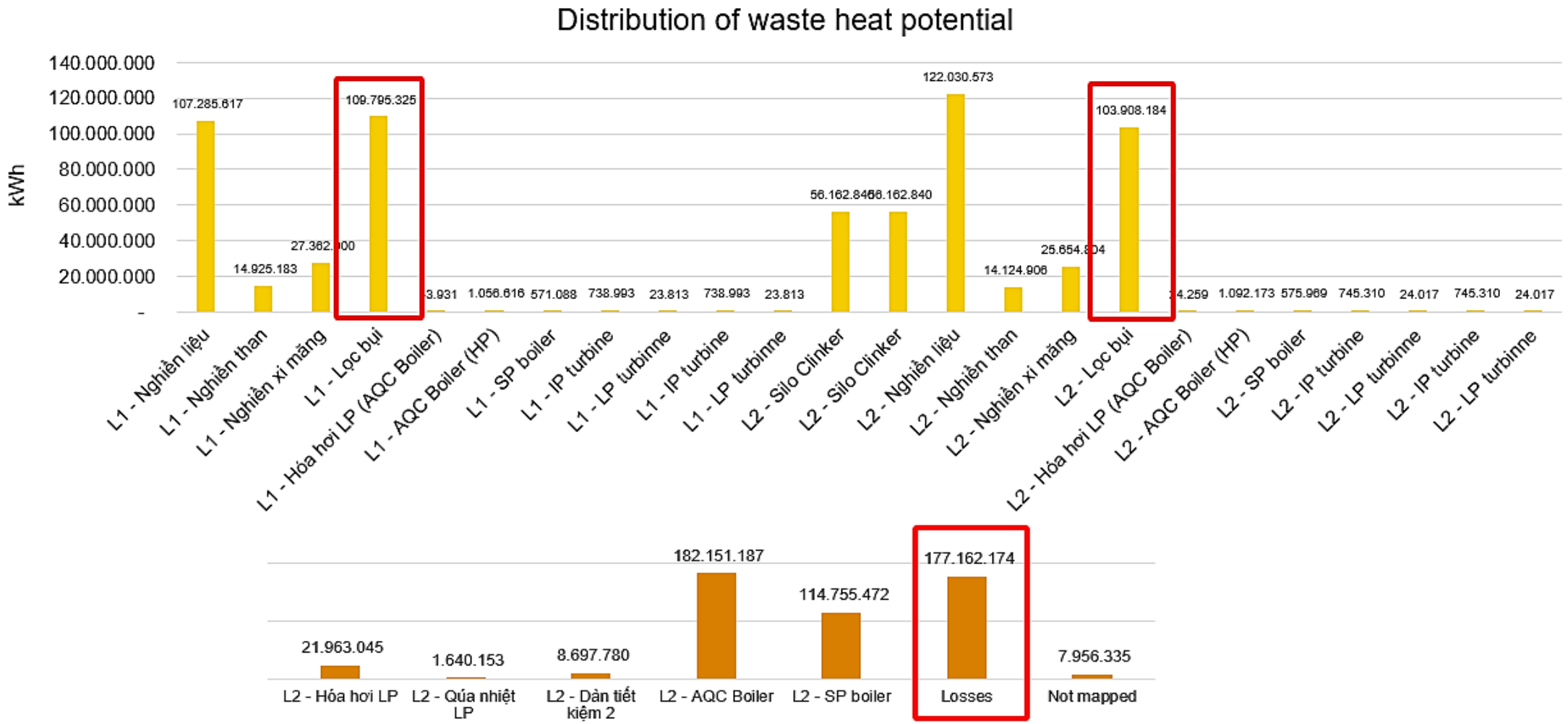


Distribution of waste heat potential



Identifying the potential for waste heat recovery and optimizing inter-process heat utilization.

Energy saving potentials



Identifying energy saving potential from energy mapping

Advantages

PROJECT SUPPORT FLOWCHART

SUPPORTS FROM FACTORY

- Provides information on raw materials; fuel and electricity consumption; finished products and losses at each stage.
- Develop a material balance table.
- Support in detail energy mapping
- Equipment list: Name, location, and design capacity
- Facilitate the work of VETS and international experts in conducting measurements at the factory.
- Expressing interest in implementing the proposed solutions and willingness to invest if the solutions are feasible.

SUPPORTS FROM INTERNATIONAL EXPERTS

- Guide to energy mapping
- Developing solution ideas
- Instructions for calculating solutions







Challenges

- Heat exchange and recovery flows (WHR) are complex and difficult to quantify accurately during energy mapping
- Challenges in standardizing data due to the use of multiple measurement units
- Difficulty in disaggregating energy consumption by process → requires interpolation/estimation
- Energy allocation across processes is assumption-based and requires validation
- Variations in operating conditions (load, raw materials) lead to fluctuations in KPIs
- Significant time is required for coordination across departments to collect and verify data

Lessons learned: optimizing data collection and analysis

- Develop industry-specific data models and make adjustments after the survey
- Estimate intermediate data when there is a lack of measurement and verification with the factory's engineering team.
- Combining actual measurement data and engineering assumptions for complex systems (WHR)
- Multi-departmental collaboration is key to ensuring complete and accurate data.



- KPIs fluctuate depending on the operating mode; representative operating conditions need to be selected.
- Develop and standardize guidelines for energy data management.
- Consider investing in a sub-metering system for energy measurement and monitoring.
- Expedite the review and approval process for energy-saving solutions.
- Strengthen coordination between all parties (factory - consultant - expert) right from the start.

Proposed strategies to improve efficiency

- Develop and standardize guidelines for energy data management.
- Consider investing in a sub-metering system for energy measurement and monitoring.
- Expedite the review and approval process for energy saving solutions.
- Strengthen coordination between all parties (factory - consultant - expert) right from the start.



Why is quantifying WHR potential complicated?

Waste heat is highly dependent on the furnace operating conditions (load, O2, combustion stability).	Large fluctuations
Lack of direct measurement points makes it difficult to determine gas/vapor flow rate and enthalpy.	Estimate required
System efficiency depends on many stages (boiler-turbine-condenser-cooling).	Nonlinear interaction
Environmental conditions (coolant temperature, vacuum) can affect the results.	





Thank you for listening!

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