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EMBASSY OF DENMARK
Hanoi

Danish Energy Agency



Energy Audit Report

Brick and Ceramic Industry Anonymous Enterprise

Energy Audit Report

Brick and Ceramic Industry
Anonymous Enterprise

Office/department
Global Cooperation

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Develop in collaboration with:
Ministry of Industry and Trade of Vietnam
Danish Energy Agency
...

The Danish Energy Agency

Audit report from auditing a quartz sand processing company

EAC: TUV NORD Vietnam Limited Co.,LTD

….. Aug, 2025

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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 anonymous summary of a specific energy audit report conducted as a part of the DEPP3 program. The audit has been conducted on a quartz sand processing production plant, by TUVNORD Vietnam, in collaboration with an international expert from Viegand Maagøe.

SUMMARY

1. About the enterprise

The high quality energy audit has taken place in Hue city which is in the middle region of Vietnam. The audited company is among one of the largest quartz sand processing enterprise in Vietnam, it has been established since 2016, and has been operated for 07 years until now.

1.1. Description of the company

Sector	: Quartz sand processing
Production input	: Quartz sand
Production output	: Cristobalite
Production capacity	: around 92,600 tons/year
Number of shifts	: 3
Working days per year	: 335 days
Energy sources	: Electricity (from grid and from solar system), LPG, Diesel oil.
Annual energy consumption	: around 61,600 MWh/y

Energy Data	Year 2022		Year 2023		Year 2024	
Purchased Electricity (*included solar root top*)	5,607,200	kWh/y	4,989,952	kWh/y	5,041,760	kWh/y
Produced Electricity					4,803	kWh
Purchased Natural Gas Rotary Kiln oven	58,049,210	kWh/y	57,100,690	kWh/y	56,129,657	kWh/y
Purchased DO	521,641	kWh/y	426,518	kWh/y	464,216	kWh/y
Total Purchased Energy	**64,178,051**	**kWh/y**	**62,517,159**	**kWh/y**	**61,640,436**	**kWh/y**

Figure 1.1.1. Annual energy consumption

Final product data	Year 2022		Year 2023		Year 2024	
Final product 1(Production of Cristobalite grains)						
Grains 01-04	38,816.20	Ton/y	45,514.6	Ton/y	45,069.2	Ton/y
Grains 01-05	10,219.30	Ton/y	7,943.0	Ton/y	6,058.0	Ton/y
Grains 03-07		Ton/y	1,092.0	Ton/y	4,859.4	Ton/y
Other Grains		Ton/y		Ton/y	1,441.8	Ton/y
Sub-Total Production of Cristobalite grains	**49,035.50**	**Ton/y**	**54,549.60**	**Ton/y**	**57,428.40**	**Ton/y**
Final product 2 (Production of Cris powder, Cris mix powder)						
Powder Cris	36,247.20	Ton/y	29,565.6	Ton/y	13,770.6	Ton/y
Powder Cris mix		Ton/y	1,366.3	Ton/y	7,614.1	Ton/y
Sub-Total Production of Cris powder, Cris mix powder	**36,247.20**	**Ton/y**	**30,931.90**	**Ton/y**	**21,384.70**	**Ton/y**
Final product 3 (Production of Quartz powder, Quartz mix powder)						
Powder Quartz	9,552.00	Ton/y	5,544.0	Ton/y		Ton/y
Powder Quartz mix		Ton/y	2,699.4	Ton/y	13,833.1	Ton/y
Sub-Total Production of Cris powder, Cris mix powder	**9,552.00**	**Ton/y**	**8,243.40**	**Ton/y**	**13,833.10**	**Ton/y**
Final product 3 (Production of Quartz grains)	1,485.94	Ton/y	65.0	Ton/y		Ton/y
Sub-Total Production of Quartz grains	**1,485.94**	**Ton/y**	**65.00**	**Ton/y**	**-**	**Ton/y**
Total final product	**96,320.64**	**Ton/y**	**93,789.90**	**Ton/y**	**92,646.20**	**Ton/y**

Figure 1.1.2. Production capacity

Through the results of energy mappings analysis, there are 04 main types of energy that are used in the company:

a) Heating

Table 1.1. Process mapping results of heating

Heating consumption

Section	Proces	Medium	Stream no	Utility system	Temp. In	Temp. Out	Mass flow	Dry matter	Cp	KPI	Flow approach	KPI approach	Measurement	Total	Share of total
					°C	°C	t/yr	%	kJ/KgK	kWh/ton	kWh	kWh	kWh	kWh	
Production line 2 - Cristobalite grain production	Receiving and mixing raw materials	Raw Material	4	Bucket and Chain							-			-	0.0%
Production line 2 - Sản xuất hạt Cristobalite	Pre -Drying	Product	5	Heat	31	116	86,806	95.00%	1.32		2,705,442			2,705,442	5.4%
Production line 2 - Sản xuất hạt Cristobalite	Drying	Product	6	Heat	116	614	119,523	69.07%	0.75		12,400,513			12,400,513	24.7%
Production line 2 - Sản xuất hạt Cristobalite	Firing	Product	7	Heat	614	1,470	83,355	100.00%	1.70		33,694,086			33,694,086	67.1%
Production line 2 - Sản xuất hạt Cristobalite	Firing (for 1Phase Transformation Energy)	Product	7	Heat	870	1,470	83,355	100.00%			944,645			944,645	1.9%
Support System 4	Avaporator	LPG	7.3	Heat	31	80					-		496,243	496,243	1.0%
	TOTAL										49,744,687	-	496,243	**50,240,930**	100%

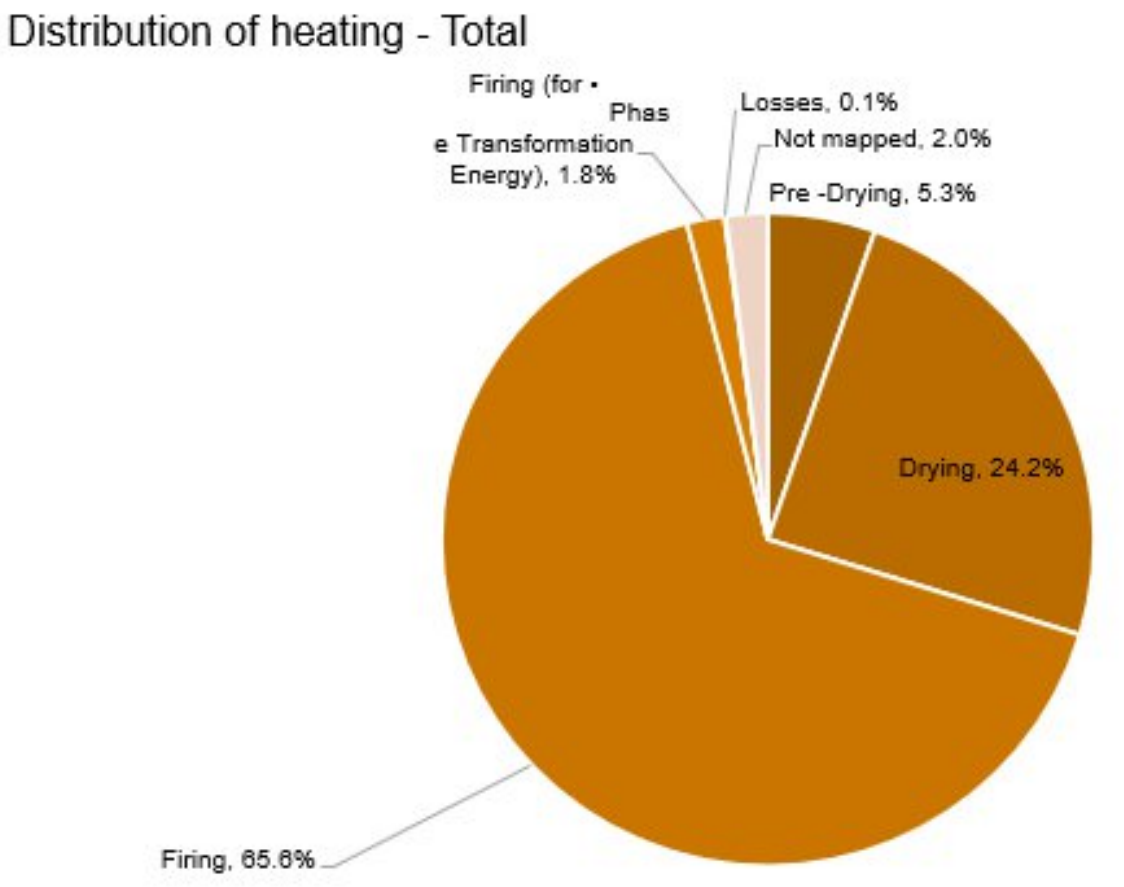


Figure 1.1.1. Pie chart of heating distributrion

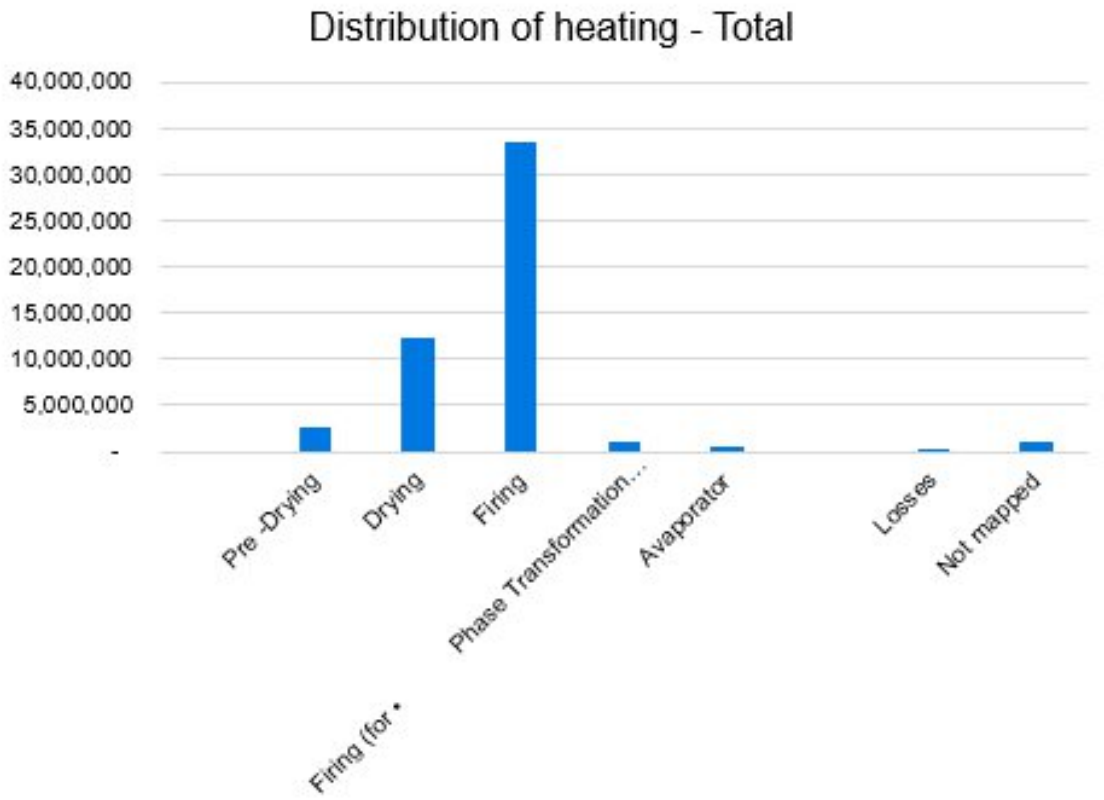


Figure 1.1.2. Bar chart of heating distribution

According to the result showed on above table, the drying process and the firing process are the two activities with the highest thermal energy consumption, accounting for 24.2% and 65.6% respectively, with a total contribution to the entire heat use process of up to 89.8%. Therefore, the Company needs to ensure strict control of heat

use in these two processes by minimizing losses and optimizing heat utilization.

b) Cooling

Table 1.2. Process mapping results of cooling

Cooling consumption																
Section	Proces	Medium	Stream no	Utility system	Temp. In	Temp. Out	Mass flow	Dry matter	Cp	KPI	Flow approach	KPI approach	Measurement	Total		Share of total
					°C	°C	t/yr	%	kJ/KgK	kWh/ton	kWh	kWh	kWh	kWh		
Production line 2 - Sản xuất hạt Cristobalite	Receiving raw materials	Raw Material	4								-			-		
Production line 2 - Sản xuất hạt Cristobalite	Mixing raw materials and Additives and feedback materials	Product	5								-	-		-		
Production line 2 - Sản xuất hạt Cristobalite	**Drying**	Product	6								-	-		-		
Production line 2 - Sản xuất hạt Cristobalite	**Firing**	Product	7								-			-		
Production line 2 - Sản xuất hạt Cristobalite	**Fluid bed Cooler** (product)	Product	8	Water cooler + Air cooler	1,470	750	83,320	100.0%	1.70		28,328,859			28,328,859		62.8%
Production line 2 - Sản xuất hạt Cristobalite	**Moving bed Cooler** (product)	Product	9	Water cooler	750	55	82,696	100.0%	1.05		16,763,145			16,763,145		37.2%
Production line 2 - Sản xuất hạt Cristobalite	Transfer to Storage System (Silo No. 1-No. 6)	Product	10													
Production line 2 - Sản xuất hạt Cristobalite	Storing in Silo No. 1-No. 6	Product	11													
	TOTAL										**45,092,004**	0	0	**45,092,004**		100%

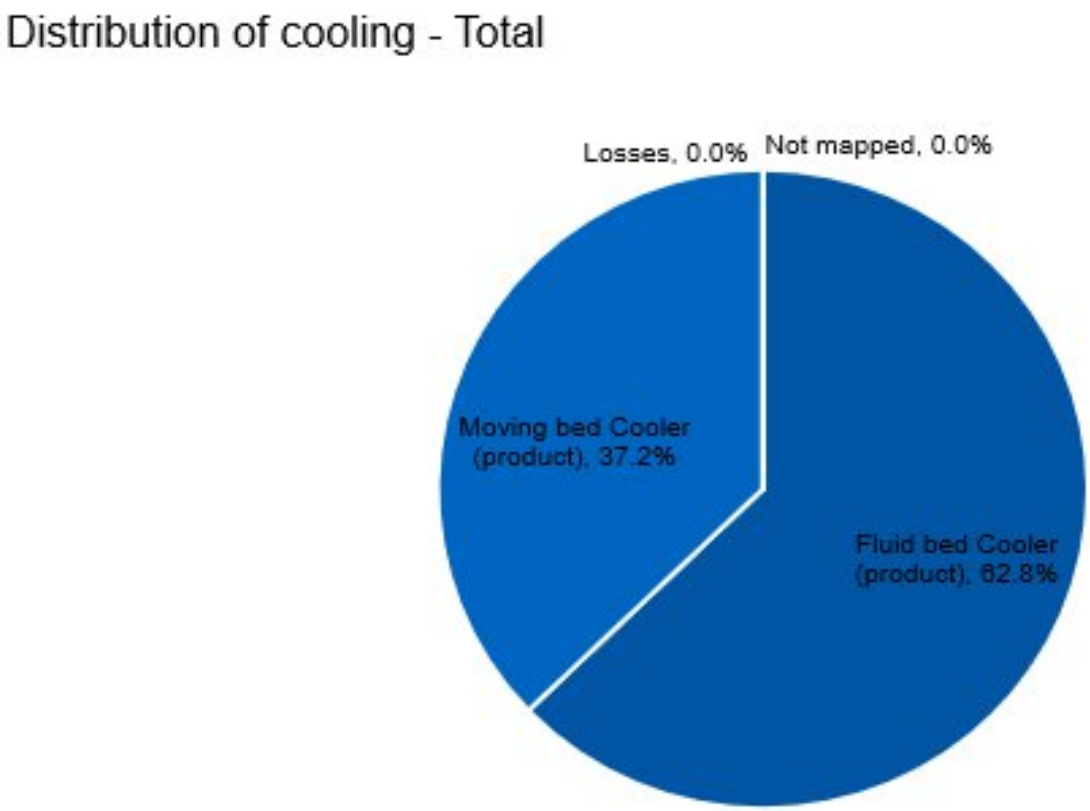


Figure 1.1.3. Pie chart of cooling distribution

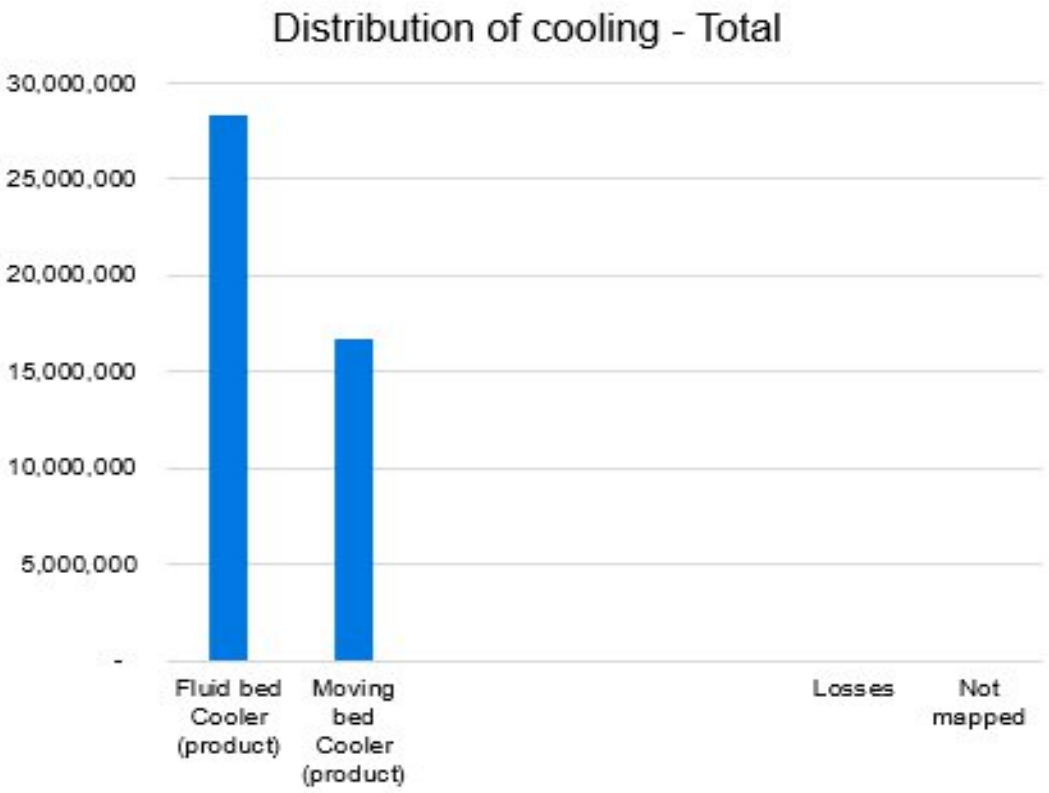


Figure 1.1.4. Bar chart of cooling distribution

The processes of cooling semi-finished products at the Fluid bed, moving bed and water cooling at the moving bed of auxiliary system 3 are the 3 processes that have the greatest impact on the efficiency of using cooling, accounting for 30.2%, 29.1% and 27.7% respectively.

c) Waste heat

Table 1.3. Process mapping results of waste heat

Waste heat potential

Section	Proces	Medium	Stream no	Utility system	Temp. In °C	Temp. Out °C	Mass flow t/yr	Dry matter %	Cp kJ/KgK	KPI kWh/ton	Flow approach kWh	KPI approach kWh	Measurement kWh	Total kWh	Share of total
Production line 2 - Sản xuất hạt Cristobalite	Receiving raw materials	Raw Material	4								-			-	
Production line 2 - Sản xuất hạt Cristobalite	Pre -Drying and additing materials	Air	5.6	Hot Air	123	31	205,851		1.01		5,286,935			5,286,935	49.7%
Production line 2 - Sản xuất hạt Cristobalite	Drying Water in sand and Additives	Product	6	Heat	100	31	36,180	0.0%	4.18		2,898,603			2,898,603	5.8%
Production line 2 - Sản xuất hạt Cristobalite	Drying	Water	6	Steam Water	123	100	3,551		2,260		2,229,192			2,229,192	20.9%
Production line 2 - Sản xuất hạt Cristobalite	Fluid bed Cooler (Export)	Product	8	Export materials	**300**	31	568	100.0%	1.05		44,564			44,564	0.419%
Production line 2 - Sản xuất hạt Cristobalite	Dust from Dust Collecting Bag	Product	5.5												
Production line 2 - Sản xuất hạt Cristobalite	Pre-Drying	Product	5												
Production line 2 - Sản xuất hạt Cristobalite	Drying (dust)	Product	6	Dust (total including Pre-Drying ,Drying, Firing,...)	300	31	704	100.0%	1.05		55,205			55,205	0.519%
Production line 2 - Sản xuất hạt Cristobalite	Firing (dust)	Product	7												
Production line 2 - Sản xuất hạt Cristobalite	Fluid bed Cooler (dust)	Product	8												
Production line 2 - Sản xuất hạt Cristobalite	Moving bed Cooler (dust)	Product	9												
Production line 2 - Sản xuất hạt Cristobalite	Pre_Dryer and Drum Dryer	Heat loss		Heat loss	250	31					1,155			1,155	0.011%
Production line 2 - Sản xuất hạt Cristobalite	Kiln Oven	Heat loss		Heat loss	550	31					11,899			11,899	0.112%
Support system 4	Evaporator	LPG	7.3	Heat loss	80	30	4,064		2.10		118,536			118,536	1.113%
	TOTAL										10,646,091	-	-	**10,646,091**	79%

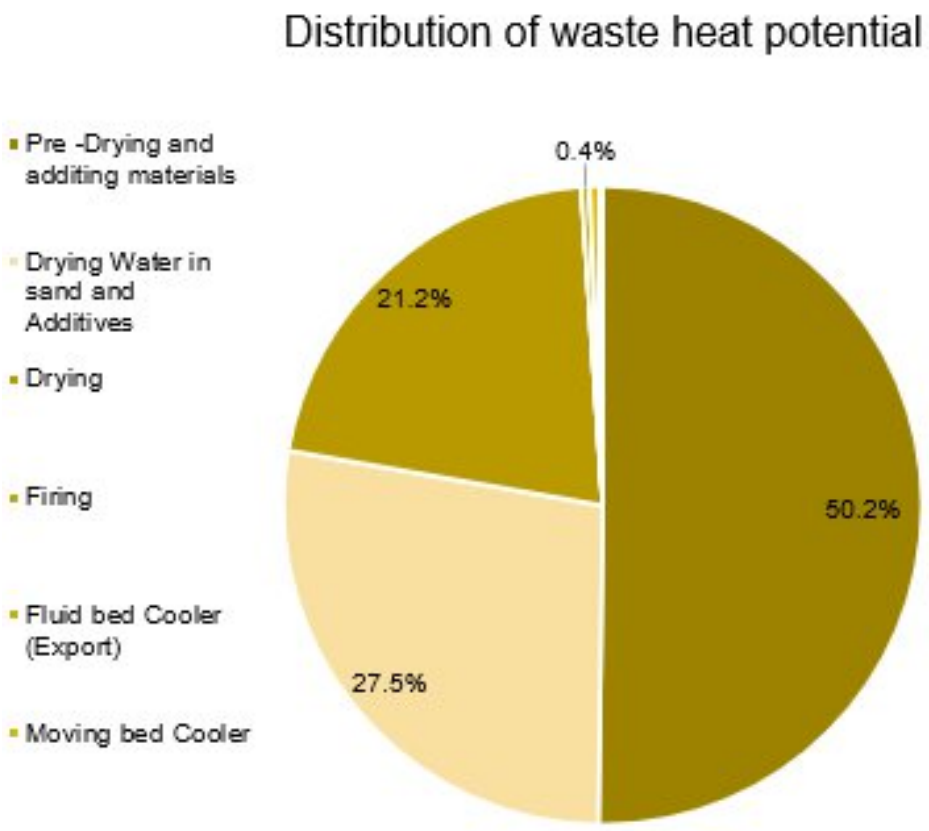


Figure 1.1.5. Pie chart of waste heat distribution

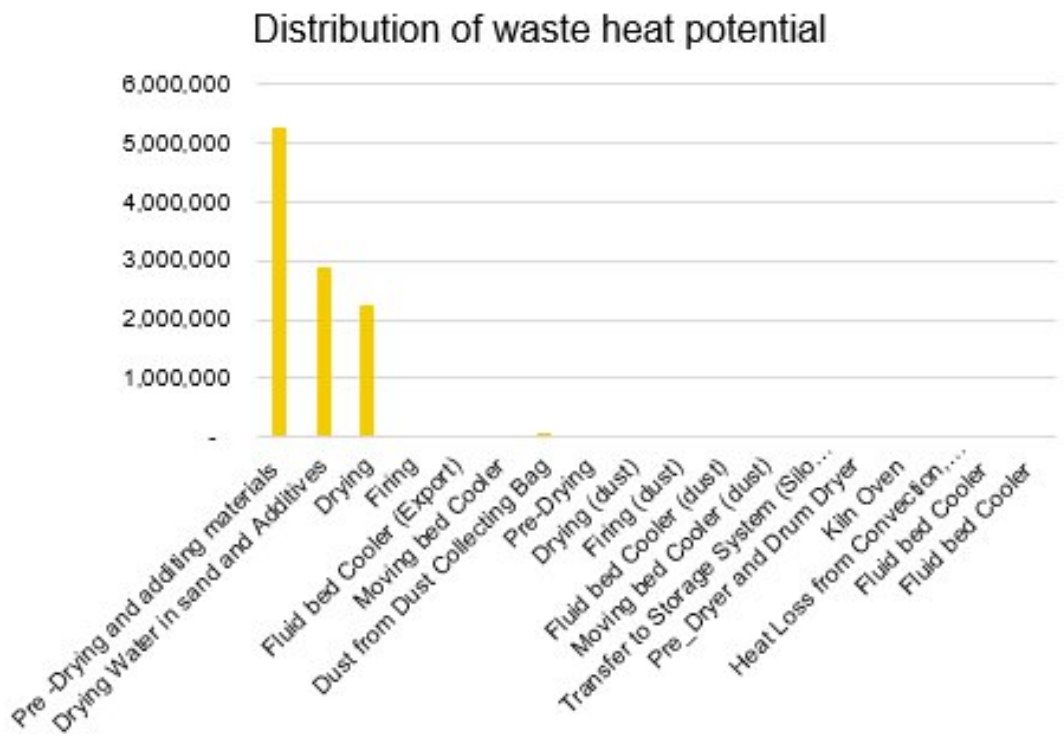


Figure 1.1.6. Bar chart of waste heat distribution

The assessment of waste heat source is approached to identify sources of excess heat that need to be controlled or optimized to avoid waste and energy loss, in which, it is necessary to mention the huge contribution to the waste heat source is hot air released from the pre-drying process and steam released from the raw material drying process with the proportions of 60.0% and 16.4% respectively. From there, the Company can identify measures or actions to control this waste heat source more optimally.

d) Electricity

Table 1.4. Process mapping results of electricity

Section	Proces	Medium	Stream No.	Effect	Operation hours	Mass flow	Load factor	KPI	Flow approach	KPI approach	Measurement	Total	Share of total
				kW	h/y	t/yr	%	kWh/ton	kWh	kWh	kWh	kWh	
Production line 2 - Sản xuất hạt Cristobalite	Production line 1 - Washing and Sorting Line/ Sand production line (Trial run from September, 2024)	Raw Material	3	249		-					32,952	32,952	0.653%
Production line 2 - Sản xuất hạt Cristobalite	Receiving raw materials	Raw Material	4	68	7,680		50.0%		261,120			261,120	5.175%
Production line 2 - Sản xuất hạt Cristobalite	Pre -Drying and additing materials	Product	5	1	7,680		50.0%		3,840	-		3,840	0.076%
Production line 2 - Sản xuất hạt Cristobalite	**Drying**	Product	6	140	7,680	-	50.0%		537,600			537,600	10.654%
Production line 2 - Sản xuất hạt Cristobalite	**Firing**	Product	7	157	7,680		60.0%		723,456	-		723,456	14.337%
Production line 2 - Sản xuất hạt Cristobalite	**Fluid bed Cooler**	Product	8	70								-	0.000%
	Air Fan of Fluild bed System			33.0	7,680	-	60.0%		152,064			152,064	3.013%
	Water Cooler of Fluid bed System			33.7	7,680	-	60.0%		155,290			155,290	3.077%
	Other Device in Fluid bed Cooler			3	7,680	-	60.0%		15,206			15,206	0.301%
Production line 2 - Sản xuất hạt	**Moving bed Cooler**	Product	9	76					-			-	0.000%

Cristobalite													
	Water Cooler of Moving bed System			72.4	7,680		60.0%		333,619			333,619	6.611%
	Other Device in Moving bed Cooler			4	7,680		60.0%		16,589			16,589	0.329%
Production line 2 - Sản xuất hạt Cristobalite	Transfer to Storage System (Silo No.1-No.6)	Product	10	1	7,680		60.0%		4,608	-		4,608	0.091%
Production line 2 - Sản xuất hạt Cristobalite	Storing in Silo No.1-No.6	Product	11	0	7,680		60.0%		-			-	0.000%
Production line 3 - Production of Crushing and screening line	Transfer from Silo No.1-No.6 to Screening	Product	11.1	1	6,580		50.0%		3,290			3,290	0.065%
	Screening 645-265 & 645-165	Product	12	143	6,580		50.0%		470,470			470,470	9.323%
	Packing into bags.	Product	12.2	1	6,580		50.0%		3,290			3,290	0.065%
	Optical separation MTQ-750-220 & MTQ-750-120	Product	14	21	1,030		50.0%		10,815			10,815	0.214%
	Packing into bags.	Product	14.1	1	6,580		50.0%		3,290			3,290	0.065%
	Magnetic separation	Product	15	1	6,580		50.0%		3,290			3,290	0.065%
	Grinding	Product	16	250	6,580		90.0%		1,480,500			1,480,500	29.339%
	Separing	Product	17	45	6,580		50.0%		148,050			148,050	2.934%
	Suction Fan and Bag filters	Product	18	127	6,580		50.0%		417,830			417,830	8.280%
Production line 4 - Production of Cris powder, Cris mix powder line -													
	Material Receiving Cris Powder,..			1	800		50.0%		400			400	0.008%

	Grinding Cris Powder			250	800		90.0%		180,000			180,000	3.567%
Production line 5 - Production of Quartz powder, Quartz mix powder line													
	Material Receiving Quartz Powder			1	230		50.0%		115			115	0.002%
	Grinding Quartz Powder			250	230		90.0%		51,750			51,750	1.026%
Production line 6 - Production of Quartz grains line													
	Material Receiving Quartz Grains			1	0		0.0%		-			-	0.000%
	Grinding Quartz Grains			250	0		0.0%		-			-	0.000%
Support system 1	Auxiliary for Production line 2, 3, 4, 5, 6			20	4,380		30.0%		26,280			26,280	0.521%
Support system 2	Auxiliary for Common			8	4,380		30.0%		10,512			10,512	0.208%
	TOTAL								5,013,274	-	32,952	**5,046,226**	100.000%

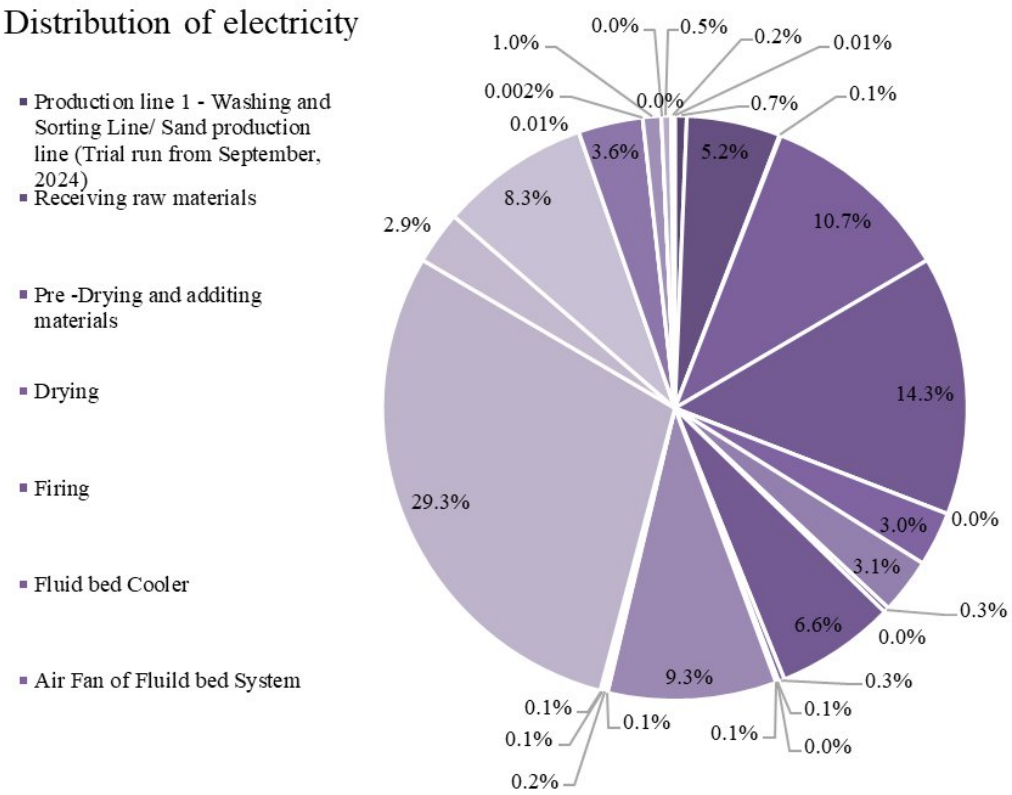


Figure 1.1.7 Pie chart of electricity distribution

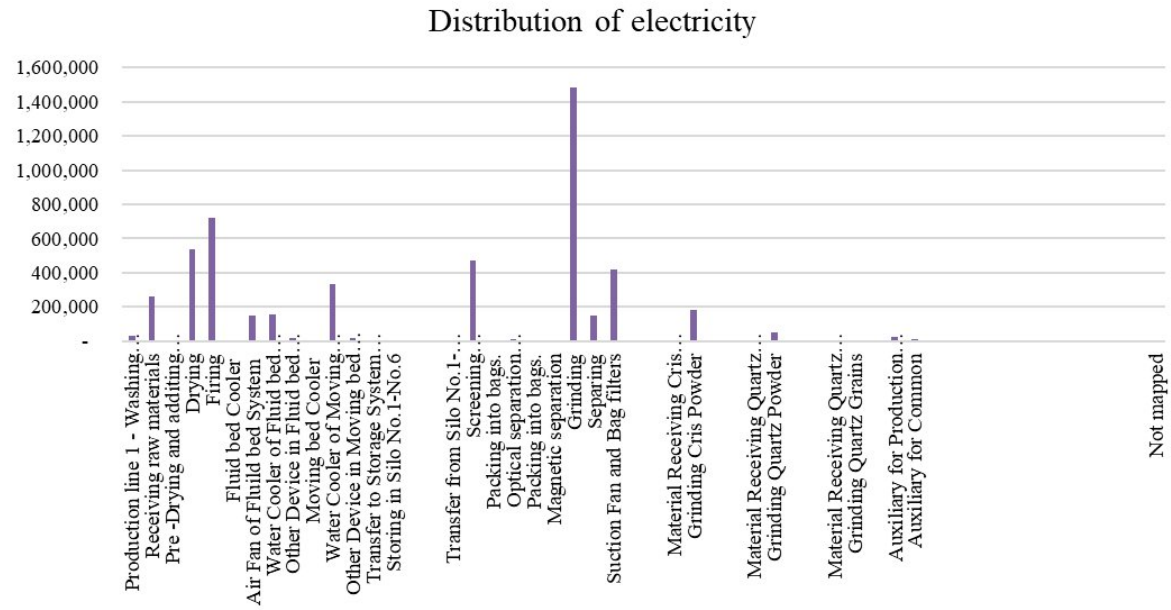


Figure 1.1.8. Bar chart of electricity distribution

Two systems that have a significant contribution to electricity consumption are the grinding system and the kiln line. Management activities on equipment operation and maintenance need to be established effectively to control these systems. The grinding system accounts for 29.34% and the killn line accounts for 14.34% of electricity consumption.

e) Result overview of energy distribution

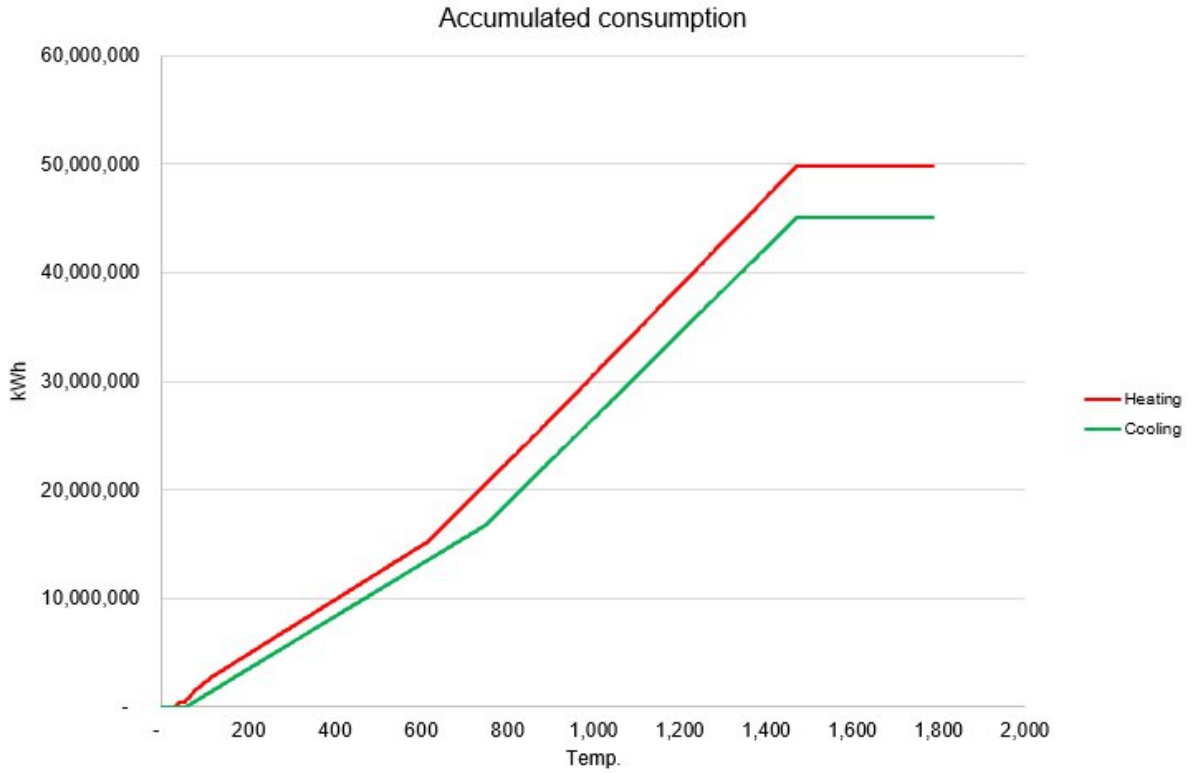


Figure 1.1.9. Dashboard of accumulated consumption

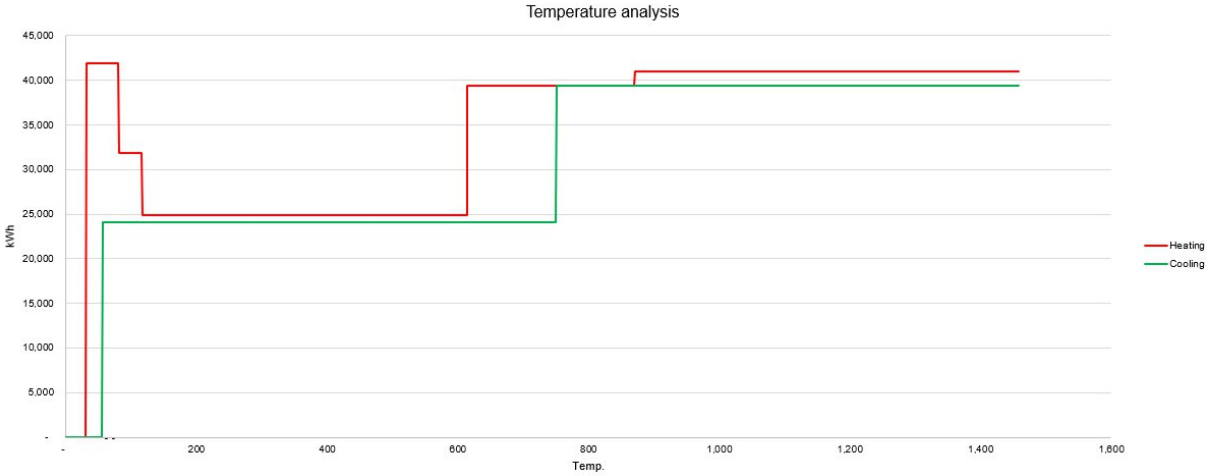


Figure 1.1.10. Dashboard of temperature analysis

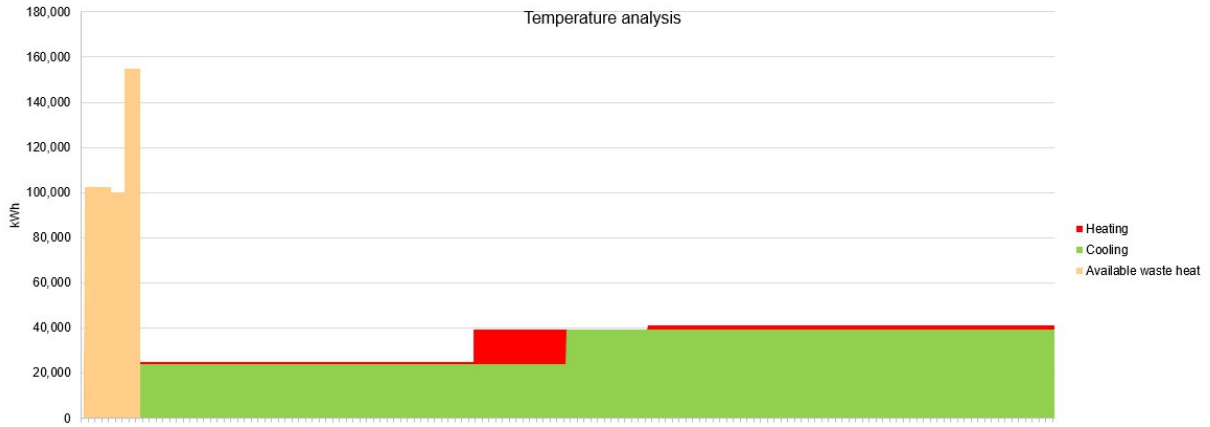


Figure 1.1.11. Temperature analysis of available waste heat

Based on the temperature profiles and actual kiln operation, the temperature difference between heating and cooling shows that below about 600 °C there is a large gap—heating energy is far higher than cooling energy—because this is the furnace's initial start-up phase. At this stage no feedstock has yet been added, and the kiln runs empty, heating from the gas input to raise and stabilize the furnace temperature without

transferring heat into any product. Cooling systems such as the Moving Bed and Fluid Bed operate minimally since there is no need to cool any output product at this stage, so cooling energy demand is low and the heating–cooling gap widens.

Conversely, above 1,000 °C the kiln is under load (with raw material entering and product exiting), so heating energy is transferred into the material during pre-drying, drying, and firing, and then the product is cooled to the required temperature. Here the difference between heating and cooling energy is small. This also demonstrates that the kiln control system—via SCADA and in-furnace thermal cameras—is working effectively, keeping heating and cooling demands closely matched.

Therefore, most heat losses occur below 600 °C, where heat escapes through the flue gas before any heat exchange with the product in waste-heat recovery stages (pre-drying). The auditor recommends that the company consider capturing this waste heat—by routing the hot gases through a heat exchanger to pre-dry the incoming sand feedstock—to reduce the latent heat required to evaporate moisture in the sand.

1.2. Description of the utility systems

According to the high-quality audit approach with system energy flow mapping ,EAC will divide the entire process from the input to the output of energy — starting from the purchase of energy or fuel (purchased), followed by the transformation processes of energy and fuel, such as the conversion of LPG gas from liquid to gaseous state, the supply of electricity to air compressors to produce compressed air for use, or the supply of electricity to pumps and fans in the cooling system to create temperature changes from hot to cold, and so on.

The entire supply and usage demands for the main forms of energy — Electricity (including rooftop solar power) and LPG gas — for all systems, including auxiliary systems such as air compressors, cooling fans, pumps, and the cooling tower of the Company's main Cristobalite production line, are outlined as follows:

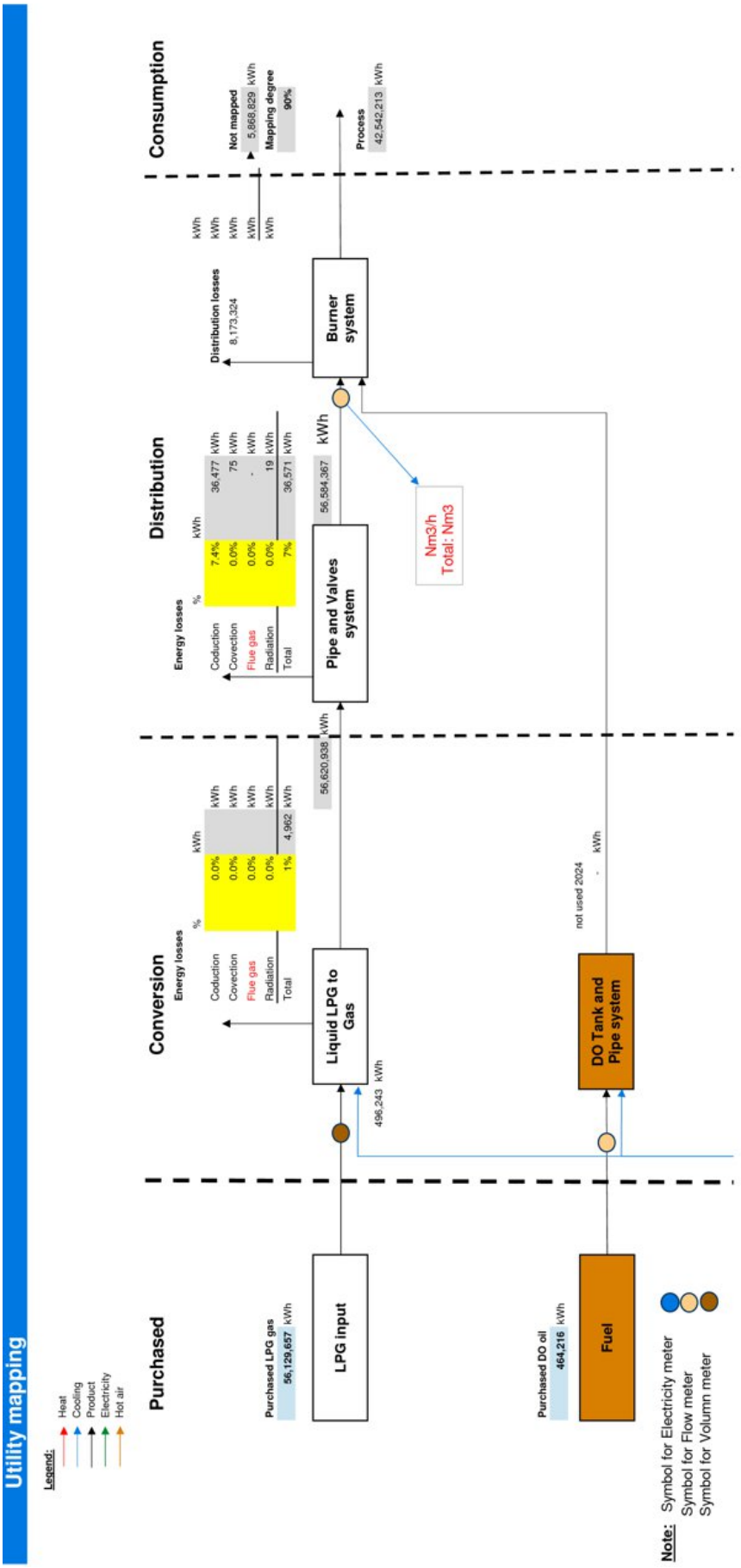


Figure 1.2.1. Utility systems of LPG energy type

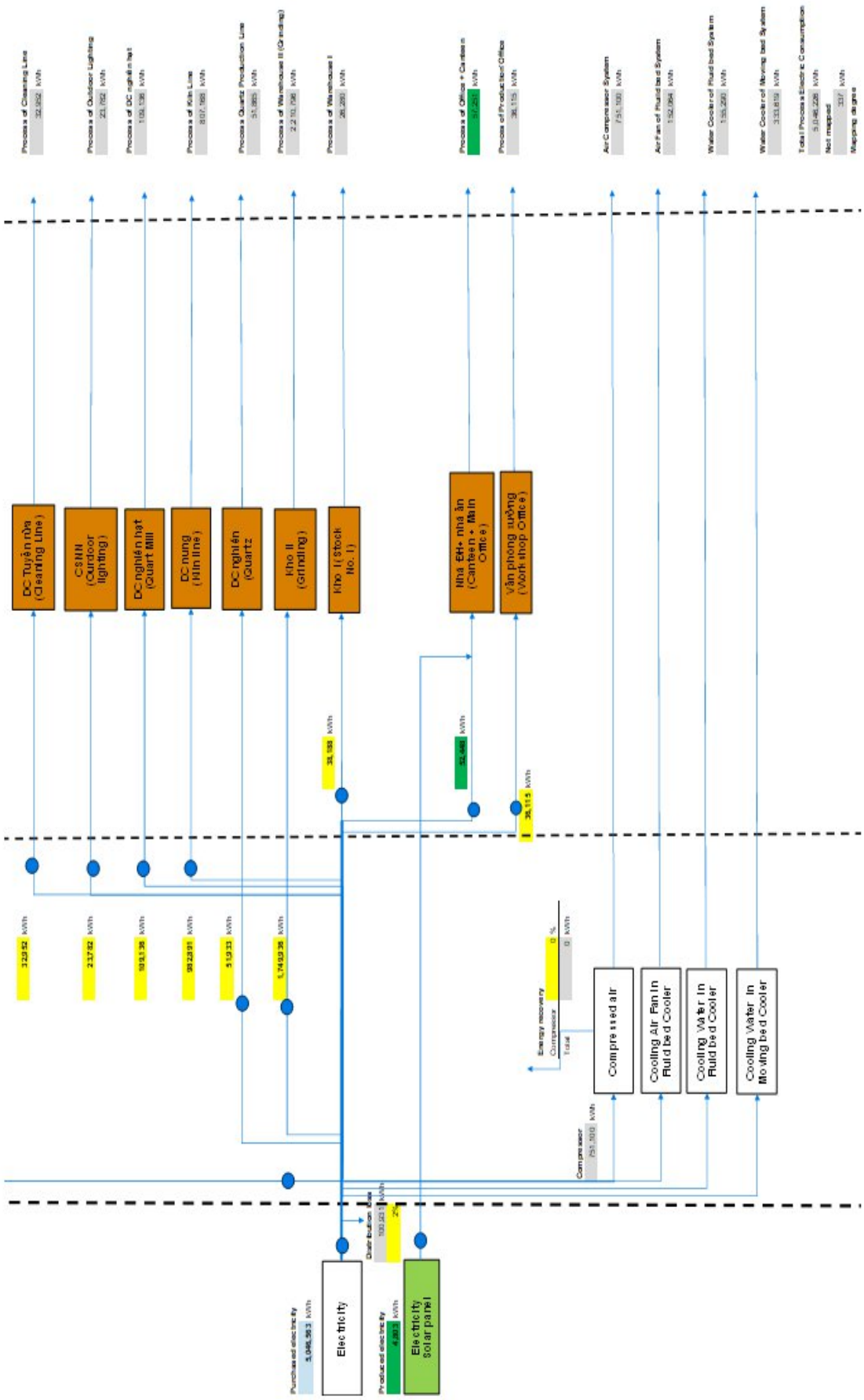


Figure 1.2.2. Utility systems with electricity energy type

Through energy flow mapping, it is shown that based on the baseline data, the amount of purchased LPG gas is equivalent to 56,200,000 kWh (1). This LPG, stored

in liquid form in tanks, is vaporized at the vaporizer machine installed at the station, consuming 500,000 kWh of electricity during the year (2).

During the vaporization process, electricity is supplied to the three-phase heating elements in the vaporizer, and the heat transfer from the electrical energy to the gas results in estimated heat losses of about 1%, equivalent to approximately 5,000 kWh per year (3). Thus, the amount of gas energy delivered to the distribution area — consisting of the LPG gas supply pipelines, valve systems, and the gas transportation route from the LPG station to the burner inlet — will experience losses due to convective and radiative heat transfer. These losses are calculated to be around 7%, equivalent to a total loss of 36,000 kWh (4).

The remaining amount of gas energy is (5) = (1) + (2) - (3) - (4), equivalent to 56,600,000 kWh, which is supplied to the LPG gas burners of the Kiln. Here, the LPG gas is mixed with air supplied to the burner by the burner air supply fan, and all the energy is exchanged with the product to facilitate the phase transformation of Silica into Cristobalite. The heat losses occurring here include flue gas losses, hot gas leakage losses inside the kiln, and thermal conduction, convection, and radiation losses across the kiln surfaces (6), totaling approximately 8,200,000 kWh.

Finally, the useful energy for the technological process is (7) = (5) - (6) = 48,400,000 kWh. Comparing this with the amount of LPG gas energy required for the technological process, (8) = 42,500,000 kWh, the energy balance achievement for the LPG gas energy type is 90%, with the remaining 10% of LPG gas energy unbalanced, corresponding to 5,900,000 kWh. The cause also lies in the amount of heat loss occurring at the transition areas between different kilns, such as from the burner zone to the kiln zone, and from the kiln zone to the drying and preheating zones. These losses occur because each kiln section operates independently, creating gaps through which heat escapes. Additionally, the calorific value of the gas was based on limited sampling, and there may have been times when LPG with lower heating value was used, leading to discrepancies in the gas energy balance calculations above.

Also shown clearly on the energy diagram, the Company purchased DO oil for storage in tanks to serve the purpose of fueling the Kiln burners in cases where LPG gas cannot be supplied during emergency combustion situations. The amount of DO oil energy purchased and stored by the Company is equivalent to 460,000 kWh. However, since there are no processes of transformation, distribution, or consumption, the subsequent branches resulting from the transformation of DO oil will have a value of "0" kWh.

For the type of energy that is electricity, including the electricity purchased from the grid and the self-produced electricity from the rooftop solar power system, the energy diagram shows that the solar electricity is measured by a separate meter and is supplied only to specific loads — namely the Administration Building and the Staff Canteen. The amount of electricity purchased from the grid by the Company was 5,050,000 kWh, and the electricity generated by the rooftop solar system was 5,000 kWh. According to the energy balance diagram, losses during the primary distribution process — such as transformer losses, transmission line losses, and other associated losses — are estimated to reach 2%, equivalent to 100,000 kWh.

As previously outlined, three types of energy are used in the main production process in the Cristobalite kiln area, including electricity (from the grid and rooftop solar power), LPG gas, and DO oil (used as backup fuel for the Kiln furnace), to provide a comprehensive energy balance picture through Utility Mapping.

In addition, several heat exchange processes based on specific technologies are employed in the Kiln area, as follows:

- Water Cooling System (Cooling Stage 1): Utilizes cooling water pumped from the cooling tower to a tubular heat exchanger located at the Fluid Bed Cooler area to reduce the product temperature from high levels in the Kiln to an intermediate cooling temperature.

- Air Cooling System (Cooling Stage 2): Uses air from fans to blow directly into the Kiln, cooling the product in the Fluid Bed Cooler area, before continuing the cooling process in the Moving Bed Cooler area.
- Water Cooling System (Cooling Stage 3): Uses cooling water in the Moving Bed Cooler area to perform final product cooling, ensuring the product reaches the appropriate target temperature.

The Energy Mapping diagram for the Cooling Stage 1 process using water in the Fluid Bed Cooler is as follows:

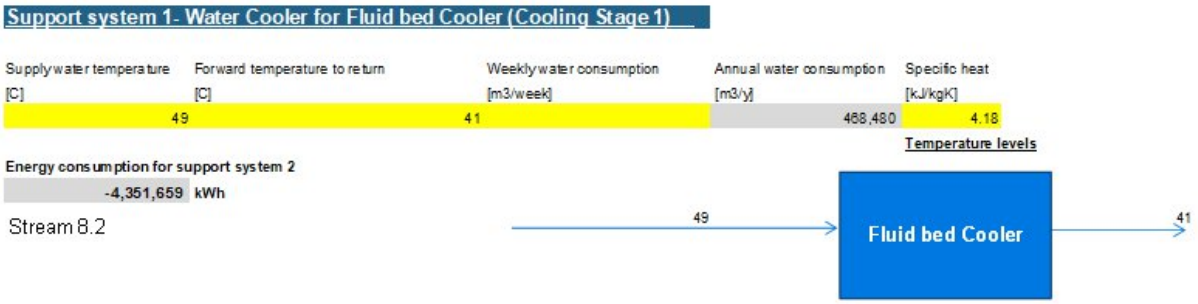


Figure 1.2.3. Energy mapping for Support system 1 – Water Cooler for Fluid bed

According to the energy balance diagram, the product is cooled by water, meaning that the thermal energy from the product is removed (dissipated) by the water. The inlet water temperature before cooling is 41°C, and the outlet water temperature after absorbing heat from the product is 49°C. The calculated energy balance is -4,400,000 kWh, with the negative sign ("-") indicating the amount of heat removed from the product.

Here, the cooling water flow rate supplied to the Fluid Bed Cooler is calculated based on readings from water flow sensors, as well as direct measurements at the water supply pipe entering the Fluid Bed Cooler and the return pipe to the cooling tower, using an ultrasonic flow meter.

The Energy Mapping diagram for the Cooling Stage 2 process using cooling air in the Fluid Bed Cooler is as follows:

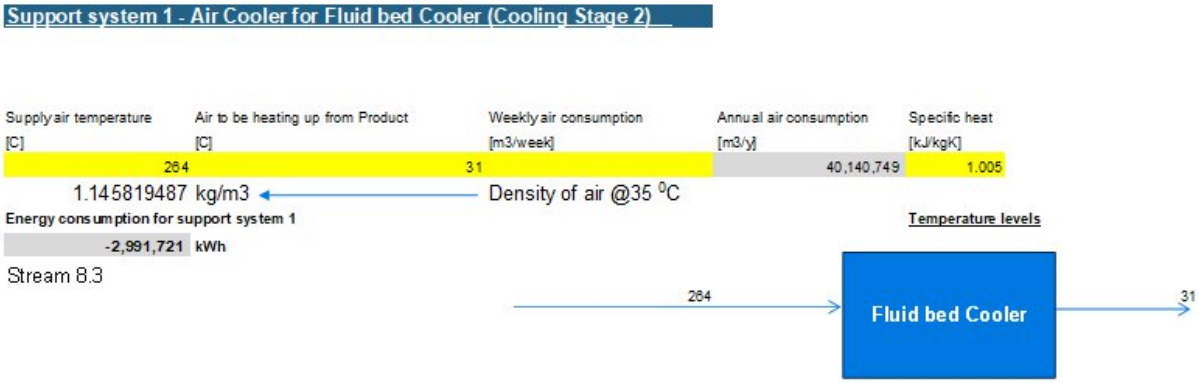


Figure 1.2.4. Energy mapping for Support system 1 – Air Cooler for Fluid bed

According to the energy balance diagram, the product is cooled by air supplied by fans that draw in ambient air into the furnace. This means that the thermal energy from the product is reduced (dissipated) by the air, as the air enters at 31°C and exits at 264°C after heat exchange. The calculated energy balance is -3,000,000 kWh, with the negative sign ("-") indicating the amount of heat removed from the product.

After the two cooling stages mentioned above, the product undergoes final cooling in the Moving Bed Cooler using water that is pumped from the cooling water system, which is chilled by a cooling tower. The inlet water temperature is 40°C and the outlet water temperature is 50°C. The energy balance calculation gives a value of

-11,800,000 kWh, with the negative sign ("-") indicating the amount of heat removed from the product.

Here, the cooling water flow rate supplied to the Moving Bed Cooler is calculated based on readings from water flow sensors and direct measurements at the water supply pipe entering the Moving Bed Cooler and the return line to the cooling tower, using an ultrasonic flow meter.

The Energy Mapping diagram for the Cooling Stage 3 process using cooling water in the Moving Bed Cooler is as follows:

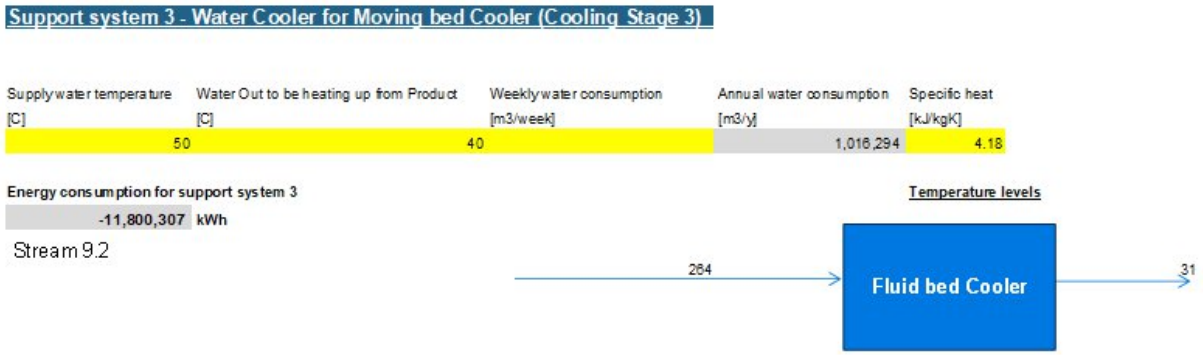


Figure 1.2.5. Energy mapping for Support system 3–Water Cooler for Moving bed

In addition, based on the identification of energy losses used for calculations in the Utility Mapping balance, at the LPG station area of the Company, electric vaporizers are used. The gas temperature measured by a thermal camera was compared with the set temperature of the vaporizers as well as the actual operating conditions of the three LPG vaporizers. These conditions are described in the following Energy Mapping diagram:

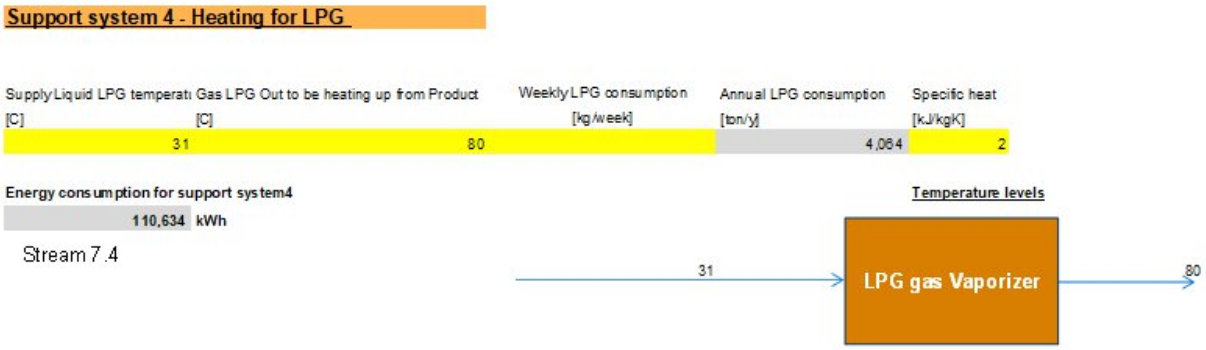


Figure 1.2.6. Energy mapping for LPG gas Vaporizer

The amount of energy used to raise the temperature of LPG gas from liquid to vapor state, as calculated from the above diagram, is 110,000 kWh/year. According to the actual audit, due to the gas pipeline being long and installed outdoors with bare steel pipes, the gas—although initially heated to around 80°C at the vaporizer outlet—experiences heat loss and drops back to approximately 31°C by the time it reaches the burner area. This is also a point of energy loss, and the audit team has recommended that the Company consider and implement improvements to reduce this heat loss.

1.3. Description of the process

The company produces cristobalite by using high heat to transform the structure of quartz sand. There are 03 main types of product: cristobalite grain, cristobalite powder and quartz powder along with 05 main processes to gain those products. These main processes are describe as follows:

a) Washing line:

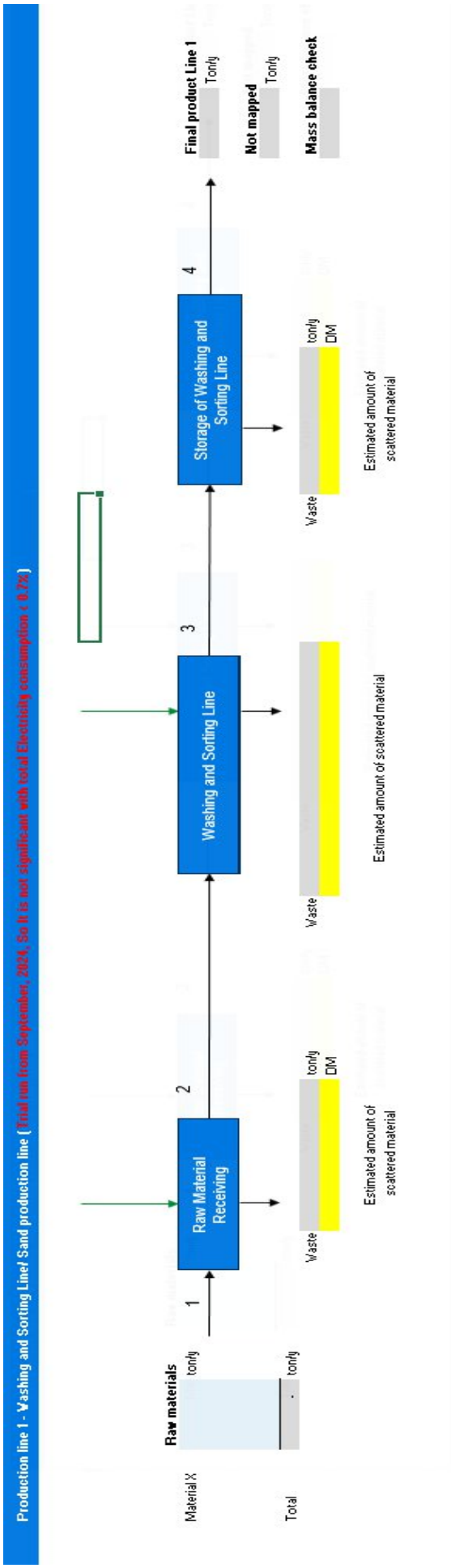


Figure 1.3.1 Flow chart of washing line

The washing line plays an important role in providing input materials for the Cristobalite production line, helping the Company reduce its dependence on suppliers and meet the needs of boosting the Company's production situation.

The washing line is located in the new factory area, along with the raw material storage warehouse and the refined material storage warehouse after washing. The entire washing process uses water washing technology, combined with vibrating screens to remove impurities (accounting for about 15% of the raw material volume) and classify materials by color to serve the Company's different production needs.

b) Kiln line:

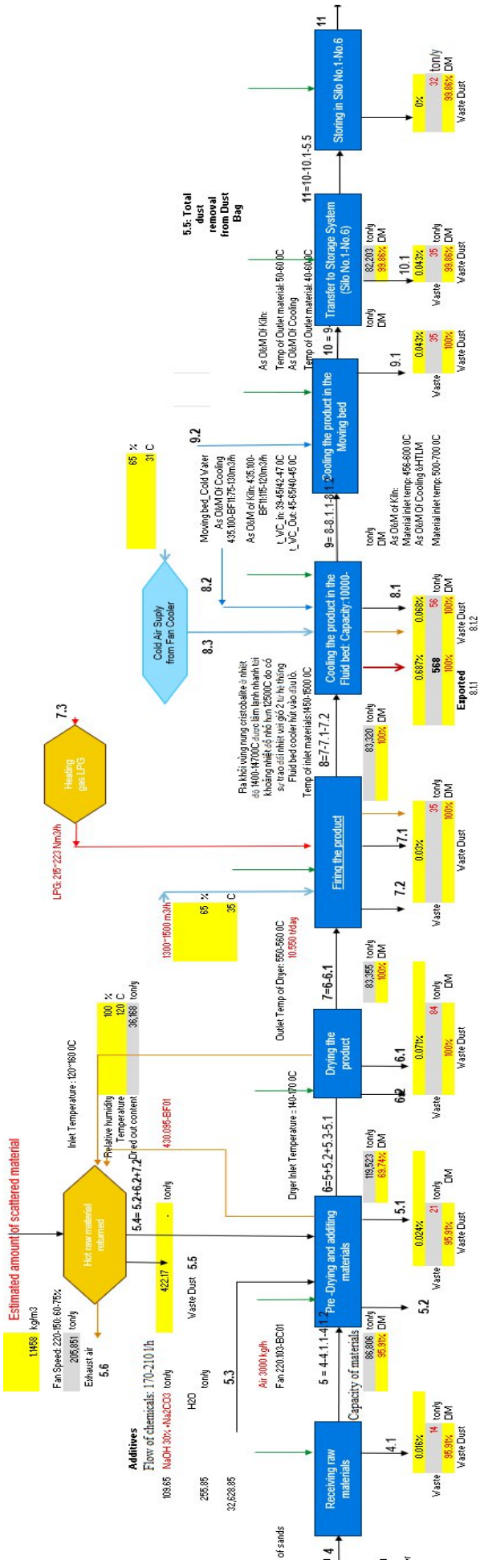


Figure 1.3.2. Flow chart of kiln line

The kiln line is the main production stage to convert quartz sand to Cristobalite, including 5 main stages with 8 steps as shown in the flow chart above.

- Material transportation stage from the gathering yard to the pre-drying furnace: Materials are brought into the intermediate silo by a wheel loader, from here the materials are fed through the bucket elevator system to the pre-drying furnace area, the material transportation process is pre-dried through heat exchange with the material after the pre-drying furnace returning to the feed line and chemicals are added at the last point of the bucket elevator before entering the pre-drying furnace.
- Pre-drying stage: Here the materials are pre-dried to a temperature of about 550 - 560°C with the heat source blown from the furnace.
- Calcination stage: At the end of the pre-drying stage, the raw materials are transferred to the kiln and the temperature is gradually raised to 1,500 ^{o}C, where the crystal phase transformation of quartz sand takes place and turns into Cristobalite. The main energy source of this process is the LPG gas combustion by 01 burner at the end of the kiln. In addition, this process also has an Export discharge door with lumpy materials.
- The cooling stage includes 02 cooling stages: Phase 1 cooling is the process of completing the phase transformation of quartz sand into Cristobalite by fresh air supplied to the kiln (the process of the material falling from the kiln to the Fluid bed) and by the circulating cooling water system (in the Fluid bed compartment), the output temperature of the semi-finished product is about 750 - 850 ^{o}C. Cooling by fresh air is both to cool the semi-finished product and to heat the fresh air supplied to the LPG gas burner. Next is the second stage of cooling, this is a rapid cooling process to stabilize the Cristobalite crystal structure of the semi-finished product with a cooling process from 750 - 850 ^{o}C to 60 - 70 ^{o}C, the semi-finished product after leaving the Fluid bed will continue to fall into the Moving bed and be cooled by a pipe-shaped circulating cooling water system.
- Semi-finished product transportation stage for storage: Semi-finished products after the Moving bed stage are transported by a conveyor system to the cluster of 6 storage silos and continue with the process of dividing the finished product by particle size or semi-finished product for the optical separation stage or the powder grinding stage.

The total input material to the line is about 86,800 tons/year and the output of semi-finished products is 82,100 tons/year, the loss is about 700 tons/year due to the loss from dust and the export of unqualified lumps of material.

c) Screening and Grinding line

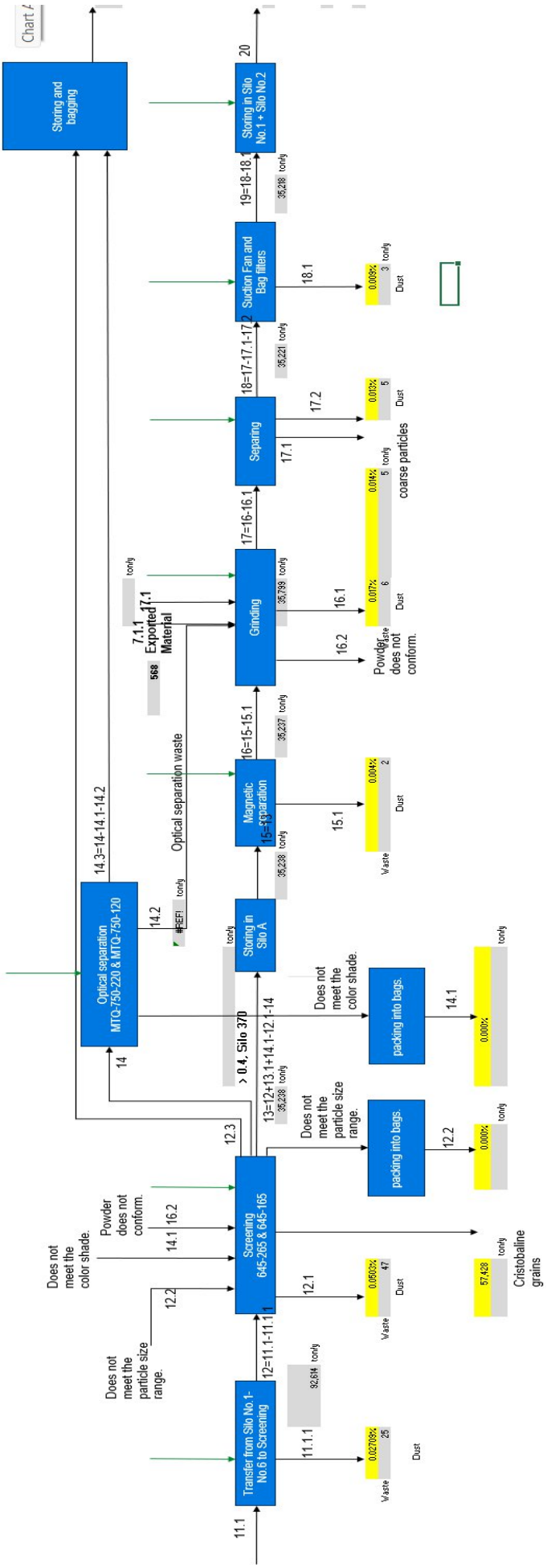


Figure 1.3.3. Flow chart of screening and grinding line

The screening and grinding line is the stage that separate products according to quality:

- Screening stage: Cristobalite semi-finished products after calcination will go through the screening system to separate according to particle size. The cristobalite particles that meet the required size and color will be sent to Silo 1, 2 for packaging and delivery to customers. The part of the particles that do not meet the quality or requirements will be divided into 02 types: meeting the particle size but not meeting the color and meeting the color but not meeting the particle size.
- Semi-finished products that meet the particle size but not meeting the color will be transferred to the optical separation line, here, the semi-finished products will have dark particles removed to ensure the color before being packaged and stored.
- Semi-finished products that meet the color but not meeting the particle size are transferred to the powder grinding line. Cristobalite semi-finished products will be mixed with quartz powder in a certain ratio (according to order) and put into a grinder to make fine powder before being packaged and stored

d) Cristobalite powder and mixed cristobalite powder line:

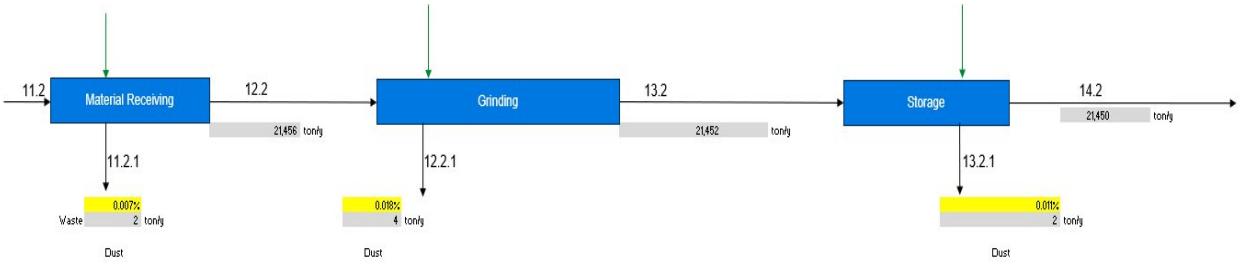


Figure 1.3.4. Flow chart of Cristobalite powder and mixed cristobalite powder line

Cristobalite powder production line is the process of producing finished powder products through grinding, Cristobalite powder or mixed Cristobalite powder is the process of mixing Cristobalite and Quartz powder (with a small proportion of Quartz powder) according to customer requirements. This whole process uses electricity to produce with an annual capacity of about 21,500 tons/year.

e) Quartz powder and mixed quartz powder line

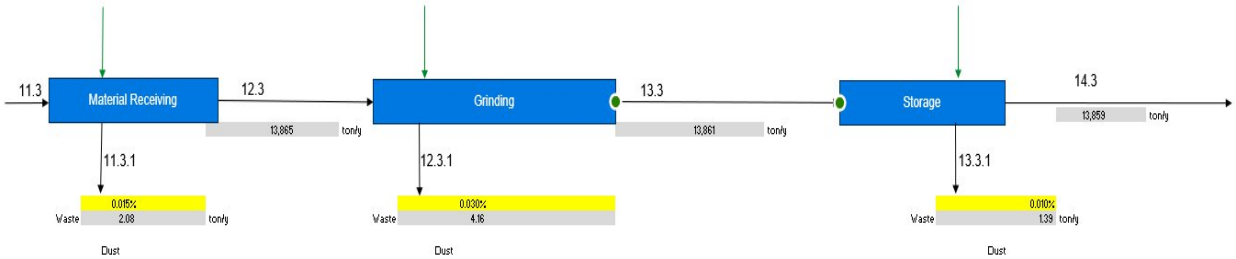


Figure 1.3.5. Quartz powder and mixed quartz powder line

Quartz powder production line is the process of producing finished powder products through grinding, Quartz powder or mixed Quartz powder is the process of mixing Quartz and Cristobalite powder (with a small proportion of Cristobalite powder)

according to customer requirements, Quartz powder raw materials are completely imported by the Company. This entire process uses electricity to produce with an annual capacity of about 13,900 tons/year.

2. Methodology used to identify projects

The energy audit process is carried out according to the instructions of Circular 25/2020/TT-BCT dated September 29th, 2020, specifically as follows:

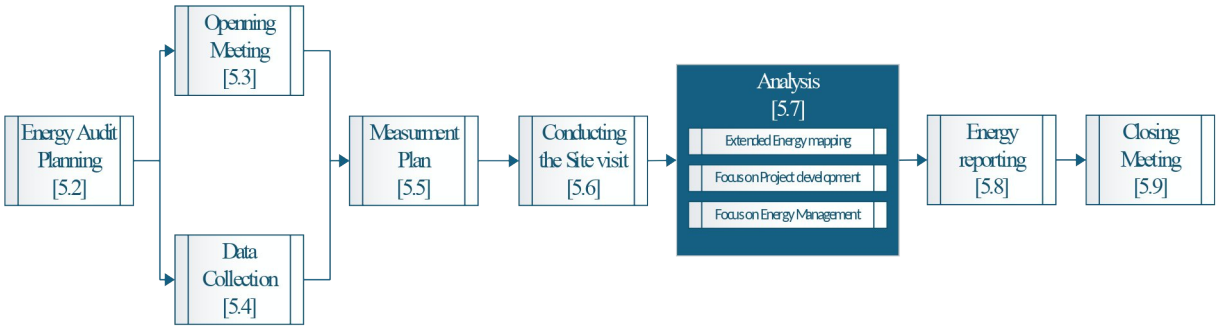


Figure 2.1 Procedures of conducting the energy audit

Besides, this project is also following the guidelines of DEPP3 program for carrying out high quality energy audit which includes energy mappings and energy efficiency projects development. Therefore, it is essential that the results of onsite audit should be carried out carefully to ensure the conformity of collected results and all the needed data should be collect properly.

The energy mappings will then be developed based on the actual results of onsite measurements and realtime data collection. The results of energy mappings will include the analysis for: Yearly data for energy consumption and production capacity, Mass flow balance, process mapping, ultility mapping and overall result to integrate all the analysis. Sometimes, when there have any point without measurement, then the mathematic calculations will take into account with reasonable explanations.

Along with the work of energy mappings, the energy audit team also have to identify energy efficiency projects. Our approach at first is based on walkthrough audit to identify a screening list of energy efficiency projects, then all the onsite measurement will be done to secure the actual data and evidence to investigate the screening list. The energy mappings results is used a tool for EAC to develop the projects as well. The company also involved in the step of developing the screening list that they can choose the projects they are interested in or they can reject the projects that are not under their concerned. After all the onsite work and discussions, we shall work with Viegand Maagøe experts to verify these projects as a result of a shortened list of projects which is called projects Level B.

The level B projects shall be then investigated to determine their energy savings, investment budget, payback period and CO_2 reduction. All the data onsite will be prepared for evaluation and calculation.

The result of level B projects will then be reviewed by Viegand Maagøe experts before handling to the company. Another discussion between EAC and the company will took place to present the results of level B projects. After that, the company will choose upto 05 projects that they can see the possibility of implementation for further development, these projects are called Level A Projects. Their prioritisation is based on the short payback period with low to medium investment projects, for high investment projects they prioritised to choose the high CO_2 savings (sometimes it can be the projects to change the used of energy types with lower CO_2 emissions).

1.

3. Projects identified

The Gross list of projects (Level B) is established from walkthrough audit at the first time the EAC is approached the Company. This list is finallized after the onsite energy audit has been completed and all the discussions with the company has been taken. The results of investigations and analysis have shown as belows:

Table 3.1 Energy saving solutions and estimated investment cost

No.	System	Energy saving solutions		Estimated savings		Cost saving amount (VND/year)	Investment cost (VND)	Payback period (year)	Eva-luate
		Eliminate losses (Maintain working condition)	Improve (Enhance performance)	Amount	Unit				
I. Energy saving solutions with free of investment cost									
1	Compressed air system and circulating cooling water system	Regularly check for leaks in compressed air systems, cooling towers and cooling water supply systems and repair leaks to save compressed air energy and save water		N/A	kWh	N/A	N/A	Instant payback	Fea-sible
2	LPG filter and burner	Regularly check and clean the dust and gas filters of the Kiln LPG burner system to ensure efficient combustion and save LPG		4,064.09	Kg LPG	58,209,163	-	Instant payback	Fea-sible
3		Regularly check the gas pressure levels before and after the gas pressure		N/A	Kg LPG	N/A	-	Instant payback	Fea-sible

		regulators to ensure that the gas pressure supplied to the burner is well maintained							
4	Air conditioning systems	Periodically check and clean filters, heat exchangers, and pipe insulation quality of air conditioning systems to save electricity for air conditioning		18,396	kWh	34,216,560	-	Instant payback	Fea-sible
5	Production line equipment	Establish regulations and implementation of turning off unnecessary equipment or temporarily turning off electricity, reducing capacity when the production line has to stop under different specific conditions such as: Kiln shutdown according to the plan, shutdown due to line problems (electrical flashing, equipment failure, etc.)		24,091	kWh	44,809,632	-	Instant payback	Fea-sible

6	Production line equipment	Perform calibration of signals from temperature, pressure, differential pressure, and flow sensors to PLC and display on SCADA to ensure accurate signals for reliable operation and energy savings		40,640.91	Kg LPG	582,091,626	N/A	N/A	Fea-sible
7	Air conditioning systems	Increase inspection and raise awareness when using air conditioners such as closing doors when entering and exiting, checking door seals, etc. to limit heat loss in office areas, cafeterias, UPS rooms, etc		N/A		N/A	N/A	N/A	Fea-sible
II. Energy saving solutions with low investment costs									
1	Lighting and ventilating systems		Install a sensor control system to turn lights and fans on and off based on time, temperature, and human presence in areas such as the cafeteria, parking lot, restrooms, etc.	3,624	kWh	6,739,896	10,000,000	1.48	Fea-sible

2	UPS air conditioners		Install a control and monitoring system for the UPS room temperature by logically switching the UPS room air conditioners on and off according to base load and cooling load shedding modes.	8,112	kWh	15,088,000	20,000,000	1.33	Fea-sible
3	Cooling Towers		Optimize cooling tower operation by the return water temperature to control the cooling fan speed through PID inverter .	6,742	kWh	12,539,763	20,000,000	1.59	Fea-sible
4	Heating insulation	Reduce heat losses due to surface leakage by enhancing inspection and applying suitable thermal insulation to surfaces capable of insulation.		2,207	Kg LPG	34,204,457	50,000,000	1.46	Fea-sible
III. Energy saving solutions with medium investment costs									
1	Bearings maintenance		Increase the service life of the Support Roll, reduce downtime caused by bearing issues and Kiln rotation, using advanced surface restoration	11,327	kWh	21,068,183	55,000,000	2.61	Consi-dered

			solutions.						
2	Preventive maintenance		Enhance preventive maintenance through thermal imaging and analysis for equipment such as in the electrical control panels, heat-emitting surfaces of Drum Dryers, and Kilns.	33,064	kWh	61,498,296	75,000,000	1.22	Feasible
3	Dust collecting system		Recovering dust from Cristobalite line to use as input material for Bio Quartz line (new production line)	562.9	Tons of dust	281,448,000	80,000,000	0.28	Feasible
4	Ball mill power supply cabinet		Install a Bypass system for the large power inverter controlling the Ball Mill motor to reduce losses from the inverter, as well as heat generation and harmonic distortion caused by the inverter.	55,740	kWh	103,676,367	85,000,000	0.82	Feasible
5	Rotary Kiln		Install an online monitoring sensor system for the concentricity and displacement of the Kiln to ensure safe operation of the furnace	N/A	kWh	N/A	95,000,000	N/A	Recommended

6	Raw material conveying system		Installing a conveying system to transport raw materials from Washing line to Cristobalite line to reduce the consumption of DO used for transportation by forklift, and to reduce the greenhouse gas emissions	19,262	kWh	35,828,076	105,000,000	2.93	Consi-dered
7	Rooftop solar panel system	Maintain regular maintenance, repairing and cleaning of solar panels to warrant the panel's energy efficiency	Recommend	67,744	kWh	126,033,840	149,364,000	1.19	Fea-sible
8	Automated power monitoring system		Install an automated energy monitoring system integrated with a warning module and ISO 50001 to optimize system management.	50,418	kWh	93,757,000	155,000,000	1.65	Fea-sible
9	Greenhouse gas management		Develop and implement continuous improvements to the ISO 14064-1 and 14067 systems for determining baseline	N/A		250,000,000	200,000,000	0.80	Fea-sible

			greenhouse gas emissions and carbon footprints, to enhance energy efficiency and savings, and reduce CO2e emissions.						
10	Energy management system		Develop and implement continuous improvements to the energy management system according to the ISO 50001:2018 standard.	75,626	kWh	140,665,104	250,000,000	1.78	Fea-sible
11	LPG evaporating system		Renovate the current evaporation system to prioritize the use of solar energy in parallel with grid electricity for optimal evaporation	236,376	kWh	439,659,360	250,000,000	0.57	Fea-sible
12	Harmonic filter system		Install an Active Harmonic Filter (AHF) system for electrical panels with high harmonic levels in the Cristobalite and Grinding production lines	180,989	kWh	161,586,613	250,000,000	1.55	Fea-sible
IV. Energy saving solutions with high investment costs									
1	Compressed air system		Solution of	264,271	kWh	412,272,905	520,000,000	1.26	Fea-sible

			"Comprehensive solution for an energy-efficient and optimized compressed air system, minimizing air losses for the factory".						
2	LNG Burner		Renovate the LPG burner system and the supply system to switch to LNG (renovated and adjusted on the current burner instead of replacing the new one)			2,745,397,940	350,000,000	0.13	Fea-sible
3	Rooftop solar system		Install a rooftop solar power system to supply a portion of energy for production.	1,224,000	kWh	2,276,640,000	12,300,000,000	Detailed information in Appendix 1	
Total				**2,279,360**	**kWh/year**	**8,063,464,621**	**14,868,728,000**		
				46,912	**Kg LPG/year**				
				5,629	**Ton dust/year**				

In conslusion: The energy saving potential in the Table 3.1 above that the audit team has proposed will actively reduce energy costs and some solutions to reduce or limit risks that may occur during production operations. The investment costs for the solutions are provisionally estimated and will be calculated in detail when implementing the solutions. According to the audit team's assessment, the above solutions are highly feasible in terms of technology and economy:

- The company shall consider the projects with free of investment would be immediately implemented, they could only need to arrange their own resources to carry out these projects.
- For the low investment projects, they could be considered to be implemented in 1 or 2 years period, all the company needed is the suitable time for implementation.
- With the medium and high investment projects, The company should choose and prioritise which projects need to implement because these type of projects need budget arrangement and need to be further investigation before they are decided to be implemented.

4. Selected projects

The energy efficiency projects Level B is referred to Table 3.1 above, they were the final results of investigation and analysis work, and the cooperation with Viegand Maagøe experts. These project was presented to customer for further discussion their opinions of implementing these projects. After the meeting with customer, the Company has pointed out some of these project they are interested in (03 projects) that will be implemented soon. The energy audit team took these 03 projects for further analysis on risk assessment, non-energy profits which are called level A projects.

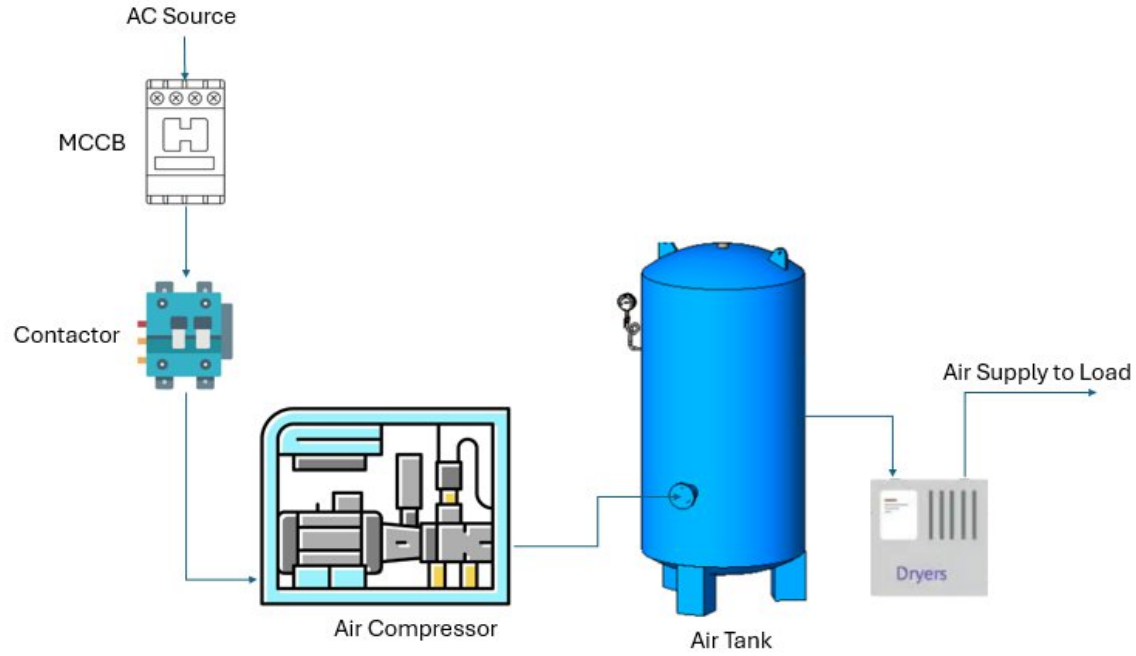
The detailed investigation of 03 Level A projects are shown as belows:

a) Comprehensive solution for an energy efficienct and optimized compressed air system, minimizing air losses for the factory

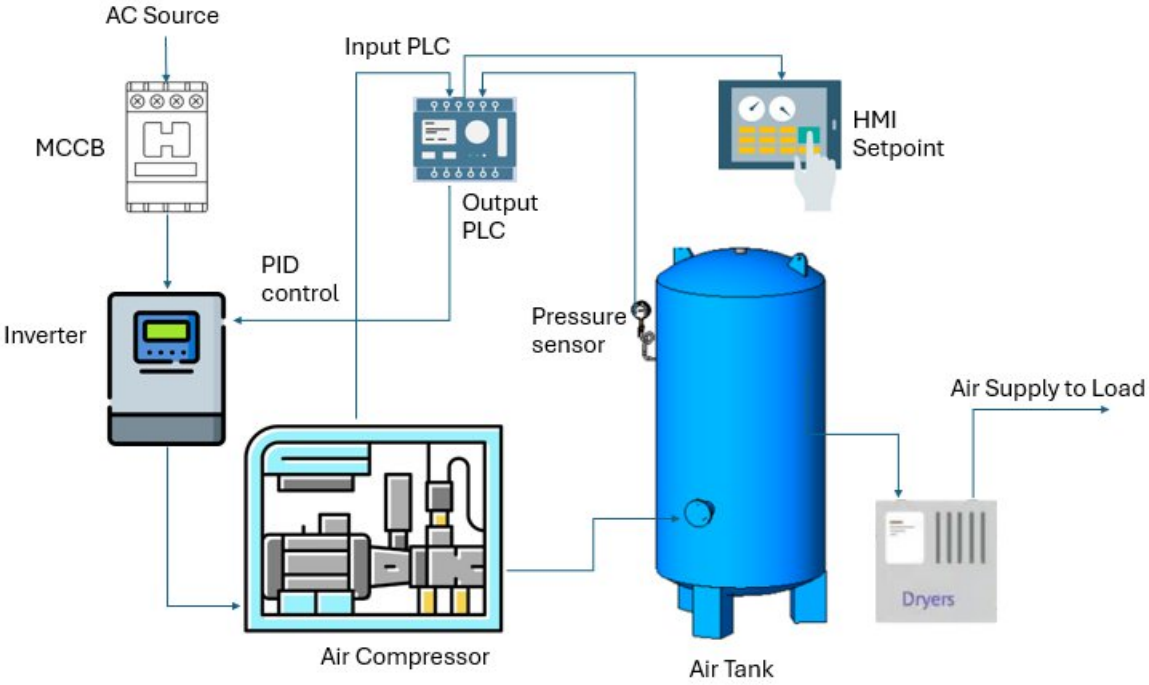
This project is an comprehensive upgrade for compressed air system of the Company and that they showed their interest. The idea is to build up a centralized control for the compressed air system along with annual maintenance to keep the compressed air machines at their best efficiency and reduce losses on the compressed air pipeline system. By implementing this project, the Company can save up to 15% of compressed air system consumption.

<table>
<tr><th colspan="3">PROJECT INFORMATION</th></tr>
<tr><td>PROJECT: Comprehensive solution for an energy-efficient and optimized compressed air system, minimizing air losses for the factory</td><td>PROJECT NO.: XXX-DE3-01</td><td>DATE:</td></tr>
<tr><td>ENTERPRISE:</td><td>AUDITING COMPANY:
TUV NORD VIET NAM</td><td>AUDITOR:</td></tr>
<tr><th colspan="3">PROJECT DESCRIPTION</th></tr>
<tr><td colspan="3">CURRENT SITUATION:
The company’s compressed-air system comprises three separate compressor sets, each serving a different load area:
• Quartz-grinding line: one 55 kW air compressor, an air dryer, and supporting compressed-air equipment
• Powder-grinding line: two 45 kW air compressors, an air dryer, and supporting equipment
• Firing line: two 45 kW air compressors, an air dryer, and supporting equipment
All compressors currently run in load/unload mode with a high no-load (unloaded) time fraction (> 50 %), which wastes energy and indicates significant savings potential if a more optimal control method is introduced.</td></tr>
<tr><td colspan="3">PROPOSED PROJECT: comprehensive solution for an energy-efficient and optimized compressed air system, minimizing air losses for the factory by install inverters and control system for aircompressor of kiln line, grinding line and quartz line.</td></tr>
<tr><th colspan="3">PROJECT ILLUSTRATION (PFD)</th></tr>
</table>

Before implementation:



After implementation:



PROJECT BUDGET

Element	Units	Unit costs (VND)	Costs (VND)
Inverter 55kW and accessories	**Pcs**	**90,000,000**	**90,000,000**
Inverter 45kW and accessories	**Pcs**	**80,000,000**	**80,000,000**
Inverter 45kW + PLC + HMI and accessories	**Pcs**	**100,000,000**	**100,000,000**
Labour for programming + installation system	**Lot**	**Included**	**Included**

Management Cost and After Service			**Lot**			**Included**			**Included**			
Total			**270,000,000 VNĐ**									
TIME SCHEDULE												
Activity (Working day)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Collecting other need information												
Design Electrical Diagram												
Programming of PLC and HMI for Control system												
Make list detail of all materials												
Request quotation												
Offer quotation for The company												
Making Agrrement of Quatation and Signcontract												
Staging materials, handing them over at the factory, and carrying out installation												
Power-up, configuration, and commissioning (trial run)												
Acceptance testing and handover to the client/operations												
SAVING												
Energy (annual): 142,002.82 kWh									**Financial (annual): 264,125,614 VNĐ**			
Co2 (annual): 93.61 tons									**Simple Payback (years): 1.02**			

RISK ANALYSIS
- A parallel PLC control system must be designed alongside the existing Atlas Copco compressor controller to retain critical protection signals for the motor and compressor—such as discharge-air temperature and pressure, oil temperature, etc.—making the solution more complex than the original stand-alone concept. - Risk: the VFD requires an optimised PID parameter set to regulate pressure to the desired set-point with fast, stable response, so multiple rounds of manual tuning and auto-tuning will be needed. - Risk: operating the oil-injected compressor at low frequency can impede oil circulation through the compression and recirculation loop; oil may overheat in some zones while other areas are starved of lubrication. - Risk: the VFD introduces harmonics and still generates heat, causing some energy losses. - Cooling: the VFD's cooling fan must be cleaned and inspected, or the VFD should be installed in an air-conditioned room, to ensure reliable operation and long service life. - Risk: even after new training, operators may still be unfamiliar with the updated procedures and make operational errors.
NON ENERGY BENIFITS
- Add motor protection function through the VFD's built-in protection features. - Optimize the control system with a function to alert the number of operational hours for periodic and preventive maintenance, ensuring more effective maintenance practices. - Output alerts via a siren and light when it is time for scheduled maintenance or when a fault occurs, enabling operators to easily detect and address issues. - The PID control pressure will be optimized to follow the set pressure, which will be lower than the previous Unload pressure threshold, thus reducing compressed air leakage at points that have not yet been addressed and minimizing the risk of high-pressure leaks. - Reduce greenhouse gas emissions by decreasing the overall electricity consumption.

b) Install a bypass system for the large power inverter controlling the ball mill motor to reduce losses from the inverter, waste heat generation and harmonic distortion caused by the inverter

This projects is also one of the Company's interested projects. When the inverter of grinding machine is only used for start-up and shutdown process then the running VDS during operation will consume more unnecessary energy, it also cause harmonic distortion that harmful for the power supply line and equipment efficiency. So this project needed to be implement for not only saving energy consumption but also to reduce the harmful effect of the VDS.

PROJECT INFORMATION		
PROJECT: Install a Bypass system for the large power inverter controlling the Ball Mill motor to reduce losses from the inverter, as well as heat generation and harmonic distortion caused by the inverter.	**PROJECT NO.: XXX-DE3-02**	**DATE:**
ENTERPRISE:	**AUDITING COMPANY: TUV NORD VIET NAM**	**AUDITOR:**
PROJECT DESCRIPTION		

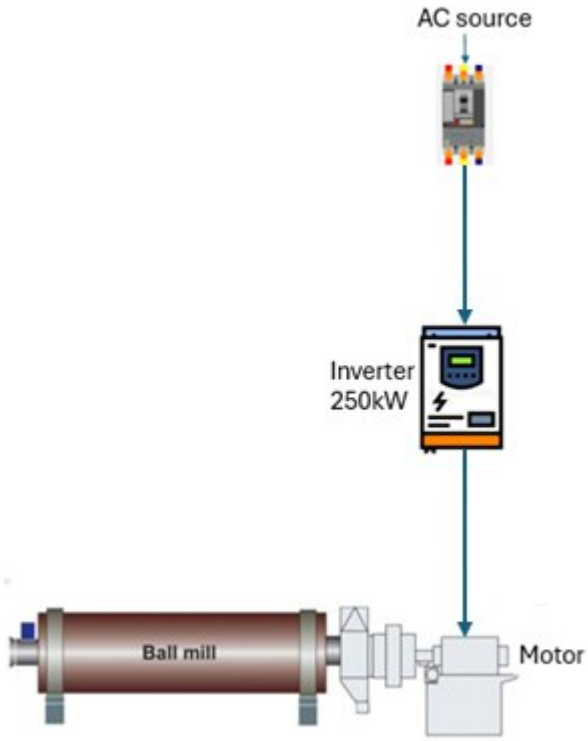
CURRENT SITUATION:

Through field surveys, it was found that the frequency inverter for the ball mill during grinding typically runs at a fixed frequency of 50Hz, and the operator rarely adjusts the frequency. Measurements revealed that the inverter produces a high harmonic distortion, and the use of the inverter only affects the load during the startup process and shutdown according to the acceleration time (ACC) and deceleration time (DEC) set on the inverter. Therefore, the auditor proposes the solution to reduce the losses on the inverter and the harmonic distortion.

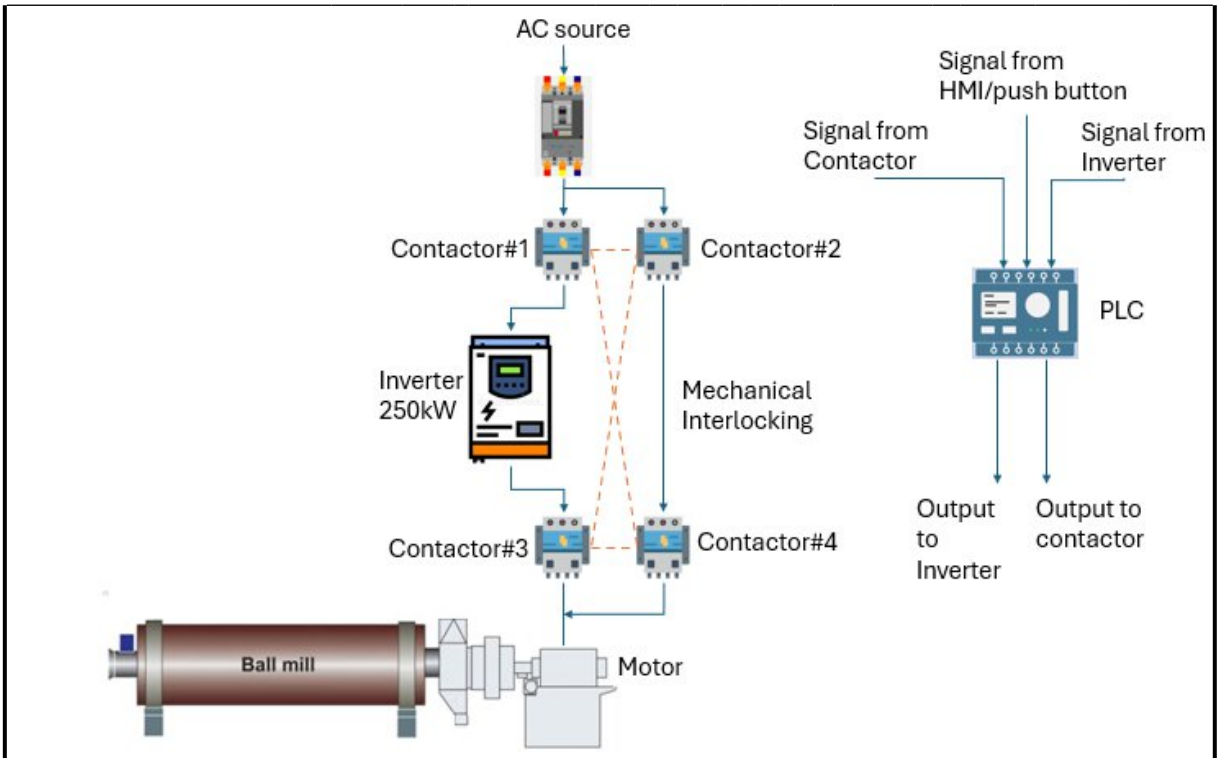
PROPOSED PROJECT: Install a Bypass system for the large power inverter controlling the Ball Mill motor to reduce losses from the inverter, as well as heat generation and harmonic distortion caused by the inverter.

PROJECT ILLUSTRATION (PFD)

Before implementation:



After implementation:



PROJECT BUDGET

Element	Units	Unit costs (VND)	Costs (VND)
PLC and Modules	**Pcs**	**15,000,000**	**15,000,000**
Program for Controlling	**Pcs**	**15,000,000**	**15,000,000**
Power Contactor and Interlock and Auxiliary Contacts	**Lot**	**30,000,000**	**30,000,000**
Cable, Connectors, Auxiliary Materials	**Lot**	**15,000,000**	**15,000,000**
Management Cost and After Service	**Lot**	**10,000,000**	**10,000,000**
Total	**85,000,000 VNĐ**		

TIME SCHEDULE

Activity (Working day)	1	2	3	4	5	6	7	8	9	10	11	12
Collecting other need information												
Design Electrical Diagram												
Programming of PLC for Control system												
Make list detail of all materials												
Request quotation												
Offer quotation for The company												
Making Agrrement of												

Quatation and Signcontract												
Staging materials, handing them over at the factory, and carrying out installation												
Power-up, configuration, and commissioning (trial run)												
Acceptance testing and handover to the client/operations												

SAVING	
Energy(annual): 55,739.98 kWh	**Financial (annual): 103,676,367VNĐ**
Co2 (annual): 36.74 tons	**Simple Payback (years): 0.82**

RISK ANALYSIS

- A parallel PLC control system must be designed alongside the existing one because several interlock signals from the variable-frequency drive (VFD) to the current PLC and HMI that control the crusher must be preserved to ensure an effective bypass capability.
- Risk: handling these interlock signals will require tracing and rerouting the existing wiring so the current interlocks can be connected to the inputs of the new PLC. This extra cabling work will consume additional time.
- Risk: during installation of the new control system, control wires might be connected incorrectly due to human error.
- Risk: if the control and interlock signals are not thoroughly tested and verified after wiring, it could lead to control malfunctions or even short circuits.
- Risk: operators may make mistakes while running the equipment if they do not fully understand and master the new operating procedures introduced during training.

NON ENERGY BENIFITS

- The bypass VFD has been isolated and kept de-energised, so its components can retain a longer service life.
- This 250 kW VFD can serve as a standby replacement for the high-power kiln-motor drive VFD should that primary unit fail or malfunction.
- It reduces high-order harmonic currents generated by the VFD, mitigating adverse impacts on other electrical systems.
- Reduce greenhouse gas emissions by decreasing the overall electricity consumption.

c) Optimize the operation of the cooling tower by measuring the inlet water temperature and controlling the fan speed through a PID inverter

The idea of this project is to optimize the central operation system of the Kiln, reduce the dependence on the operators. Therefore, the company need further risk assessment to see if it possible to carry out this project without any harmful to their center control system.

PROJECT INFORMATION		
PROJECT: Optimize the operation of the cooling tower by measuring the inlet water temperature and controlling the	**PROJECT NO.: XXX-DE3-03**	**DATE:**

fan speed through a pid inverter.		
ENTERPRISE:	**AUDITING COMPANY: TUV NORD VIET NAM**	**AUDITOR:**

PROJECT DESCRIPTION

CURRENT SITUATION:

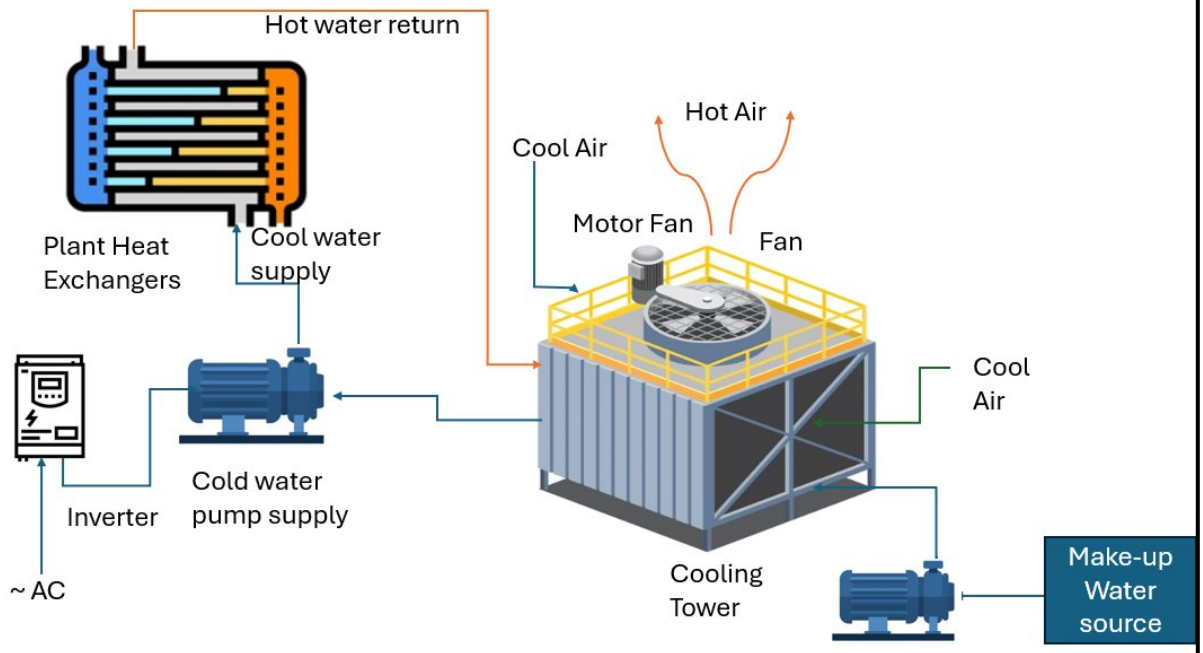
Based on the current situation observed during the audit, although the cooling towers have variable frequency drives for the fans and pumps, the control is entirely dependent on the operator. As a result, when the ambient temperature drops during the rainy season or at night compared to the daytime, the operator often keeps the settings the same as during the higher daytime temperatures, leading to energy wastage. This happens because the product only needs to be cooled to the appropriate temperature to ensure quality and does not need to be cooled beyond the technology range allowed.

The following table shows that the required temperature range for the output of the Fluid Bed Cooler area is about 100°C, which is quite wide and causes energy waste when not well-controlled. On the other hand, the output temperature range for the product in the Moving Bed area is 10°C, which can be controlled in a way that saves energy, keeping the product temperature at an optimal level around 55°C with a tolerance of +/- 2°C.

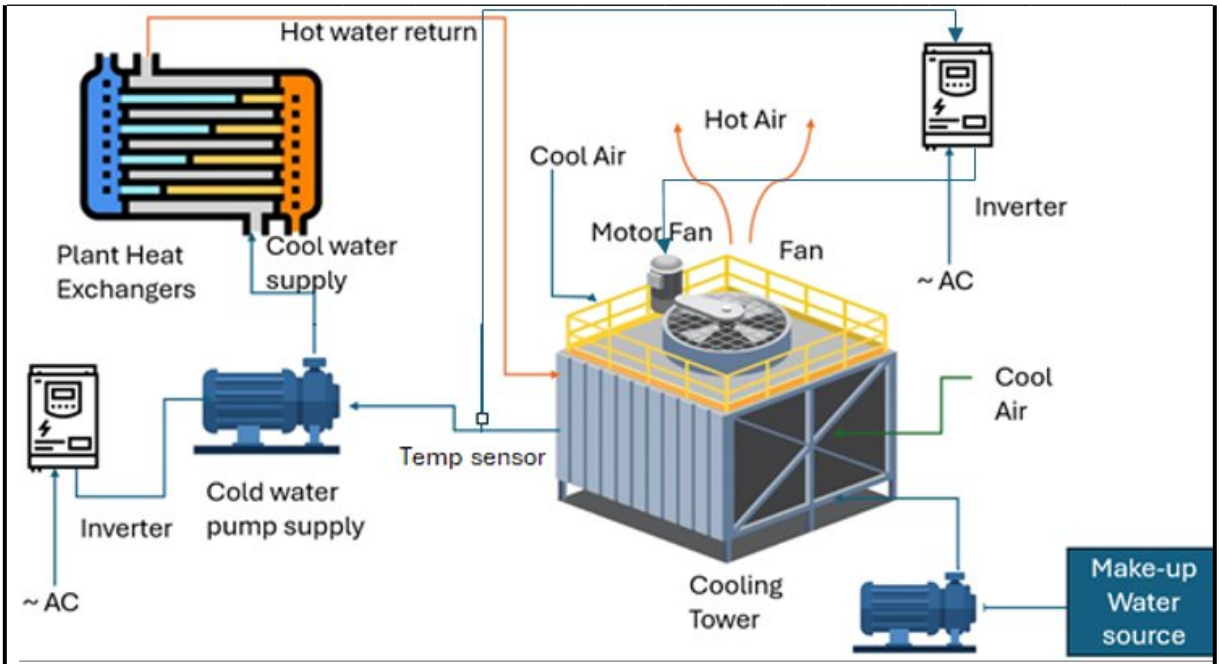
PROPOSED PROJECT: Optimize the operation of the cooling tower by measuring the inlet water temperature and controlling the fan speed through a pid inverter.

PROJECT ILLUSTRATION (PFD)

Before implementation:



After implementation:



PROJECT BUDGET

Element	Units	Unit costs (VND)	Costs (VND)
Temperture sensor 0 -100 0C	**Pcs**	**2,000,000**	**2,000,000**
Labour for setup PID in Inverter + installation system	**Pcs**	**10,000,000**	**10,000,000**
Management Cost and After Service	**Pcs**	**8,000,000**	**8,000,000**
Total	**20,000,000 VNĐ**		

TIME SCHEDULE

Activity	1	2	3	4	5	6	7	8	9	10	11	12
Collecting other need information												
Design Electrical Diagram												
Prepare List of Parameters for Setup PID functioning in Inverter for Cooling Tower's Fan												
Make list detail of all materials												
Request quotation												
Offer quotation for The company												
Making Agrrement of Quatation and Signcontract												
Staging materials, handing them over at the factory, and carrying out installation												

Power-up, configuration, and commissioning (trial run)												
Acceptance testing and handover to the client/operations												

SAVING	
Energy(annual): 6,741.81 kWh	**Financial (annual): 12,539,763 VNĐ**
Co2 (annual): 4.44 tons	**Simple Payback (years): 1.59**

RISK ANALYSIS

- Drilling holes and installing sensor mounts on the water supply pipeline to measure temperature requires flushing the pipeline to remove metal shavings from the drill.
- The sensor installation location is far from the VFD, requiring shielded signal cables, which poses a risk when removing cable trays and pulling wires.
- Sensors may accumulate scale due to the presence of certain levels of ions in hard water, leading to temperature measurement errors over time; periodic calibration is required to ensure accuracy and reliability.
- The VFD needs to be reconfigured with PID settings based on the desired temperature setpoint, and tuning is necessary to find suitable PID parameters for the pump, fan, and cooling tower load.
- Fans may experience issues such as rusted blades, imbalance, or slackened belts, affecting fan performance. This would require higher operational frequencies, reducing potential energy savings.
- New operator training is required to ensure the safe and efficient operation of the system.

NON ENERGY BENIFITS

- The fan operating at low frequency under light load will reduce vibrations. When running at slower speeds, the friction between the drive belt is improved compared to high-speed operation, leading to better power transmission efficiency.
- Reduce greenhouse gas emissions by decreasing the overall electricity consumption.