Cost Efficiency Optimization Project

Enabling Heat Pump for Production Line

(proposed by TRESOT and GenAI)

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Abstract

The document outlines a cost efficiency optimization project for a brewery, focusing on the integration of a large industrial heat pump to streamline energy use across several key production stages: drying, boiling, and cooling. By implementing the heat pump, the brewery aims to recover and reuse thermal energy, which significantly reduces energy costs.

The heat pump harnesses residual heat from various processes, allowing it to preheat liquids before boiling and cool them efficiently after the boiling stage, lowering overall power consumption. This optimized energy transfer system not only cuts down on fuel usage but

also decreases CO2 emissions, supporting sustainability goals. The improved thermal regulation during drying, boiling, and cooling ensures that product quality remains unaffected while reducing operational expenses. This integration is expected to result in notable long-term savings and enhance the energy consumption without compromising on output standards.

Summary

Financial Impact	pessimistically, around €1.543.000 or 32% of all energy consumption annual bill
Costs of Implementation	around €907.000
Expected period of return of investment	14 months (7 months for implementation, 7 months of exploitation)
Environmental Impact	Scope 1: -33300 kg CO2 Scope 2: -1924 kg CO2

Scope Definition

The project focuses on optimizing the brewery's production line by integrating a large industrial heat pump to enhance energy efficiency. The heat pump reclaims residual thermal energy from various processes and reuses it to preheat liquids before boiling and efficiently cool them afterward. This process reduces fuel consumption and lowers energy costs, while maintaining product quality. By improving energy transfer during key stages such as drying, boiling, and cooling, the brewery also reduces CO2 emissions, aligning with sustainability goals, and secures long-term savings without affecting output standards.

In the scope:
- Integration of a large industrial heat pump into the brewery's production line;
- Optimization of energy consumption during various production stages;
- Implement the most efficient recovery and reuse of thermal energy practices;
- Reduction in fuel usage and overall energy costs;
- Long-term cost savings without impacting production output;
- Decrease in CO2 emissions to support sustainability objectives.

NOT in scope:
- Modifications to brewing recipes, ingredients;
- Changes of production capacity, output volume, or production speed;
- Upgrading or replacing existing brewing equipment (other than the heat pump and support components);
- Implementation of renewable energy sources (e.g., solar, wind);
- Adjustments to packaging, distribution, or logistics processes;
- Redesign of the brewery's operational layout.

Financial Impact

The installation of an industrial heat pump in the factory is expected to deliver significant financial benefits by optimizing energy consumption. This project reduces the overall energy cost, especially in processes like drying, boiling, and cooling. This shift minimizes reliance on gas/oil, which are often more expensive and less efficient than electricity in this context. As a result, the factory can capitalize on lower electricity costs, reducing operating expenses, stabilizing energy budgets, and achieving a faster return on investment.

The main sources of costs optimization:

- Significant reduce of electrical energy consumption (€1894300 saved annually, statistical average);
- Reduce of gas/oil energy consumption (€2960 saved annually, statistical average).

Nevertheless, the project has extra costs of ownership and amortization:

- Components amortization, including main and support components (€50400 annually, €75400 including inflation);
- Components maintenance: pipes maintenance (€2500 annually);
- Components maintenance: refrigerant refill (€3200 annually);

The Total Costs of Ownership (TCO) is €81500 annually.

The Total Financial Impact (TFI) is:

- Statistical minimal is €1543000 saved annually;
- Statistical average is €1816000 saved annually;

The project doesn't impact production value, production performance, labor, or other materials (excluding maintenance materials which are included in price), thus doesn't change revenue.

The Value of Investment is €907625 single time average (from €822650 to €992600 for 90% accuracy).

Estimated period for return of investment is 14 months, what consists of project timeline (7 months) and exploitation period (7 months).

Non-Financial Impact

This project poses no legal risks, as it fully complies with current regulations (Germany). The installation of the heat pump and the associated energy optimization measures do not violate any environmental or industrial laws. There are no legal obstacles or partial involvement with restricted practices, ensuring a smooth and compliant implementation.

However, the implementation of this project allows reducing amount of greenhouse gas emission:

- Environmental Scope 1: (reduce) -33300 kg CO2
- Environmental Scope 2: (reduce) -1924 kg CO2

Production Process

Beer production involves several energy-intensive processes where thermal energy plays a key role, including but not limited to malting, boiling, and cooling. Malting requires production of dry air (drying of malt), while boiling sterilizes the wort. Both rely heavily on heat. After boiling, rapid cooling is necessary for fermentation and purifying.

Some stages may have specific equipment, details about this equipment aren't provided. This calculation will rely upon well-known approaches and overall production parameters such as production performance and amount of product.

The packaging facility is located in the other building, thus excluded from this project due to heat/cool losses for long-distance refrigerant transportation (pipes).

Production Line

The production line is fully automated and usually works 100% of all time (including working hours or employees, night shifts, etc).

Stage	Details	% of electricity	% of gas
Malting	Barley or other grains are soaked in water, allowed to germinate, and then dried in a kiln. This process converts the starches in the grain into fermentable sugars.	10%	10%
Milling	The malt is crushed to break down the grain's outer husks and expose the starches inside, which will later be converted into sugars during mashing.	small	-
Mashing	The milled malt is mixed with hot water in a mash tun. This allows enzymes in the malt to break down the starches into sugars, creating a sugary liquid called wort.	small	-
Lautering	The wort is separated from the spent grain in a lauter tun. The spent grains are removed, and the wort is collected.	small	-

Boiling	The wort is boiled to sterilize it and to add hops. Hops provide bitterness and aroma to balance the sweetness of the malt and act as a preservative.	40%	75%
Whirlpooling	After boiling, the wort is rapidly spun to separate hop particles and other solids from the liquid.	small	-
Cooling	The hot wort is cooled down to a low temperature for filtering from unnecessary protein sediment and then heating to temperature suitable for fermentation, through heat exchangers.	15%	-
Fermentation	The cooled wort is transferred to a fermentation vessel, where yeast is added. The yeast converts the sugars in the wort into alcohol and carbon dioxide, producing beer.	small	-
Maturation	After primary fermentation, the beer is conditioned or aged to develop its flavors and allow any remaining yeast or particles to settle.	small	-
Filtration	The beer may be filtered to remove yeast, proteins, and other particles, resulting in a clearer final product.	small	-
Packaging	The finished beer is bottled, canned, or kegged, ready for distribution and consumption.	10%	-

Heat Exchange

The project only allows optimizing the processes which strongly rely upon heat exchange (heating and cooling). The criterion of selected processes for optimization:

- The production stage requires a significant amount of heat.

The list of selected processes:

Stage	Details	Thermal operation mode	% of electricity	% of gas
Malting	Drying process requires generation of dry air: cooling, condensing, and then heating back the air. Heating and cooling are equal during performance.	-5-40°C	10%	10%
Boiling	Boiling process requires the significant amount of energy. The current production line has a pre-heating	70-80°C	40%	75%

	stage using heat from gas combustion. Only heating capacity is consumed. This process requires accurate thermal regulation, thus must be additionally controlled by the exact production equipment (usually embedded).			
Cooling	Cooling from 70-80°C to -1°C and then heating to 21°C. The balance between heating and cooling is 20/80.	-5-30°C	15%	0%

The best possible configuration with balanced heating/cooling budget:

- **INCLUDES** all electricity energy;
- **INCLUDES** gas energy for Malting and Cooling stage(s);
- **DOES NOT INCLUDE** gas energy for Boiling stage(s).

To identify the best-fit equipment, it's necessary to determine the fragment's of the project. Analysis of possible reasons for fragmentation of the heating/cooling pipe circuits reveals:

- The production processes of the selected stages are distributed by the building, but the building is less than 1000 m3 and less than 10m height (no fragmentation by location);
- The production processes of the selected stages maintain the similar or pretty similar temperature modes, thus are in the same heat pump category: 0-85°C (no fragmentation by equipment category);
- The production processes of the selected stages aren't related to health or life-critical function, thus aren't regulated and don't require additional measures for providing redundancy (no fragmentation by redundancy).

Power Consumption

The total percentage of electrical energy converted to thermal energy:

$$a_1 + a_2 + \dots + a_n = 10\% + 40\% + 15\% = 65\% = a_{el}$$

The total percentage of gas/oil energy converted to thermal energy:

$$b_1 + b_2 + \dots + b_n = 10\% + 0\% = 10\% = b_{gas}$$

The average energy consumption is equal or close to forecast of energy consumption in the available bills. The forecast of electrical energy consumption in 2024 is about 11000 MWh. The forecast of gas/oil consumption in 2024 is about 300.000 m^3. The forecast of gas/oil energy consumption in 2024 is about 3000 MWh.

The total energy converted to thermal energy (heating and/or cooling):

$$E_{th.avg} = A_{el} * a_{el} + B_{gas} * b_{gas} = 11000 * 65\% + 3000 * 10\% = 7450 \text{ MWh}$$

The electric energy optimization baseline is around 7150 MWh (by forecasts for 2024). The gas/oil energy optimization baseline is around 300 MWh (by forecasts for 2024). The total energy optimization baseline is around 7450 MWh (by forecasts for 2024).

The heating/cooling energy consumption by stages is:

$$A_{el} * a_{el} + B_{gas} * b_{gas} = 11000 * 10\% + 3000 * 10\% = 1400 \text{ MWh (Malting, 19\%)}$$

$$A_{el} * a_{el} + B_{gas} * b_{gas} = 11000 * 40\% + 3000 * 0\% = 4400 \text{ MWh (Boiling, 59\%)}$$

$$A_{el} * a_{el} + B_{gas} * b_{gas} = 11000 * 15\% + 3000 * 0\% = 1650 \text{ MWh (Cooling, 22\%)}$$

If the production process is not interruptible (100% of daytime), practically, the typical float of energy consumption for production lines is 0.8-1.2 from maximal consumption. Thus, the mean minimal and maximal consumption:

$$E_{th.min} = E_{th.avg} * 0.8 = 5960 \text{ MWh}$$
$$E_{th.max} = E_{th.avg} * 1.2 = 8940 \text{ MWh}$$

Heating/cooling capacity

The heating/cooling balance is equal to the product of percentage of heating and percentage of the stage, divided by the same product of cooling:

$$B_{hr} = \Sigma(heat\ ratio * stage\ ratio)/all\ heating\ budget =$$
$$= (0.5 * 1400 + 1 * 4400 + 0.2 * 1650)/9700 =$$
$$= 5430/9700 = 55\% \text{ of heating}$$

$$B_{cr} = 1 - B_{hr} =$$
$$= 1 - 0.55 = 45\% \text{ of cooling}$$

The heating source usually can compensate 30% of balance shift to heating and 15% balance shift to cooling. Extra balance shift could be compensated with extra electricity costs.

The typical float of energy consumption for production lines is 0.8-1.2 from maximal consumption. For heating and cooling, they are:

$$E_{th.min.h} = E_{th.min} * B_{hr} = 5960 * 55\% = 3278 \text{ MWh min for heating}$$
$$E_{th.max.h} = E_{th.max} * B_{hr} = 8940 * 55\% = 4917 \text{ MWh max for heating}$$
$$E_{th.min.c} = E_{th.min} * B_{cr} = 5960 * 45\% = 2682 \text{ MWh min for cooling}$$
$$E_{th.max.c} = E_{th.max} * B_{cr} = 8940 * 45\% = 4023 \text{ MWh max for cooling}$$

The actual heating/cooling balance shift is 10% to heating. This doesn’t decrease the efficiency of heat pump, or negligible.

Proposed Changes

Requirements to Equipment

The current production line has the following thermal parameters:

- The working temperature is between -5 and 80°C;
- The production line relies upon both heating and cooling processes, thus require at least one cooling and at least one heating pipe circuits;
- The level of reliance is similar of heating and cooling.

Due to these requirements, the determined type (category) is a simple industrial heat pump.

The thermal operation mode allows the use of water as a heat carrier (in heat transporting system).

Current Equipment

The current information doesn't reveal the signs of use of any kind of heat pumps. The production equipment has integrated controllers of temperature.

There is no identified equipment for decommission after the optimization.

Equipment List

As defined before, there is no reason for fragmentation of heating/cooling system. Thus, the equipment list consists of the heat pump, or array of them in a single location, and supporting equipment (pipes, thermal insulation, heat exchangers, etc).

The identified necessary equipment, the minimal list:

- Common industrial heat pump;
- Pipes for heat transporting;
- Thermal insulation for pipes;
- Secondary circuit refrigerant pump and tank;
- Heat exchanger.

Positioning

The input data doesn't allow identifying the ideal location of every part of the new system, but it's possible to identify the preferable (most effective) location. The special requirements and conditions:

- "Malting" stage operates in -5-40°C, consumes about 19% of energy in heat circuits, and requires both heating and cooling circuits;
- "Boiling" stage operates 70-80°C, consumes about 59% or energy in heat circuits, and requires only heating circuit;
- "Cooling" stage operates -5-30°C, consumes about 22% or energy in heat circuits, and requires both heating and cooling circuits.

The most effective location of the equipment is between working area of all selected for optimization processes, closer to “Boiling” stage area.

Heat Losses

Heat losses in a pipe circuit occur as thermal energy transfers from the hot/cold fluid inside the pipe to the surrounding environment. To prevent unnecessary heat losses, need to follow the specific measures:

- The length of all pipe circuits must be as short as possible;
- The pipes can be insulated to reduce the amount of heat loss (if necessary);
- The pipes must be located in the places with constant temperature (in building, or in thermal box in ground, not outside);
- The heat sinks of the first pipe circuit (within the heat pump) must be attached to heat sinks outside (usually in ground).

The heat loss of the fluid in the pipe circuit is equal to the difference between fluid and surrounding, multiplied by length of pipes, multiplied by specific heat loss coefficient. The specific heat loss coefficient depends on different parameters such as pipe diameter, material parameters, insulation parameters, etc. Statistically, it’s enough to define 5-15% heat budget to heat losses for long-distanced (100+ meters) heat transition.

The heat exchangers also might provide some heat loss, statistically 5%.

For current calculation, we use the statistically worst parameter. The identified heat losses:

$$HL = 1 - ((1 - HL_{pipes}) * (1 - HL_{exch})) = 1 - ((1 - 0.15) * (1 - 0.05)) \approx 19.3\%$$

Coefficient of Performance Degradation

The vendors provide only the maximal coefficient of performance for the best possible situation like the most effective difference of temperature between source and sink, amount of utilized heat and cool, etc. To make it more precise, it’s necessary to determine the practical CoP based on type of heat source (air/water/ground) and thermal delta.

For the longitude of the object is 48N, and the longitude is 11E, the average climate parameters for last 10 years:

Average air temperature (2m), Jan/Jul	1°C/19°C
Average soil temperature (-0.1m), Jan/Jul	3°C/18°C
Average soil temperature (-1.5m), Jan/Jul	5°C/15°C

To identify the statistical loss of CoP by environment condition, use the formula:

$$CoPLe_{air} = (0.0941 * \Delta T - 0.000464\Delta T^2) \div 6.02 =$$

$$= (0.0941 * |19 - 1| - 0.000464|^2) \div 6.02 \approx 25.5\%$$

$$CoPLe_{ground} = (0.2084 * \Delta T - 0.001322\Delta T^2) \div 10.29 =$$
$$= (0.2084 * |18 - 3| - 0.001322|18 - 3|^2) \div 10.29 \approx 27.4\%$$

$$CoPLe_{deep} = (0.2084 * \Delta T - 0.001322\Delta T^2) \div 10.29 =$$
$$= (0.2084 * |15 - 5| - 0.001322|15 - 5|^2) \div 10.29 \approx 18.9\%$$

To identify the statistical loss of CoP by consumed thermal energy, determine the percentage of consumed thermal energy and use the formula:

$$CoPLc = 1 - (0.6 + 0.8C - 0.4C^2)$$

Heat Pump(s)

To find the best option, use the previously calculated effective parameters for all available industrial heat pumps and provide the result for the best fit.

The exact model of heat pump is: **OCHSNER IWWHC 800 P2D TW**

The proposed industrial heat pump has the following technical parameters:

Heating capacity	300-800 kW_{th}
Cooling capacity	250-700 kW_{th}
Max. Coefficient of Performance	5
Power input	150-300 kW_e
Min and max temperature	-10°C and 85°C
Lifespan (90%)	18 years
Type of Source	Ground
Necessary maintenance	(1) pipes maintenance, annually; (2) refrigerant refill, semi-annually.

The percentage of consumed thermal energy is equal to actual thermal output divided by maximal thermal output:

$$C = ActualConsumption * (1 + HL) \div (MaxConsumption * 24 * 365)$$
$$C_{min\,h} = 3278 * (1 + 0.193) \div (0.8 * 24 * 365) \approx 56\%$$
$$C_{max\,h} = 4917 * (1 + 0.193) \div (0.8 * 24 * 365) \approx 84\%$$
$$C_{min\,c} = 2682 * (1 + 0.193) \div (0.7 * 24 * 365) \approx 52\%$$
$$C_{max\,c} = 4023 * (1 + 0.193) \div (0.7 * 24 * 365) \approx 78\%$$
$$C_{min} = (C_{min\,h} + C_{min\,c})/2 = (0.56 + 0.52)/2 = 54\%$$

$$C_{max} = (C_{max\,h} + C_{max\,c})/2 = (0.84 + 0.78)/2 = 81\%$$

$$CoPLc_{min} = 1 - (0.6 + 0.8 * 0.56 - 0.4 * 0.56^2) \approx 7.7\%$$

$$CoPLc_{max} = 1 - (0.6 + 0.8 * 0.81 - 0.4 * 0.81^2) \approx 1.4\%$$

The effective Coefficient of Performance is equal to maximal coefficient of performance for the selected heat pump multiplied by both types of losses:

$$CoP_{e.min} = CoP_{min} * (1 - CoPLe) * (1 - CoPLc) = 5 * (1 - 0.189) * (1 - 0.077) \approx 3.74$$

$$CoP_{e.max} = CoP_{max} * (1 - CoPLe) * (1 - CoPLc) = 5 * (1 - 0.189) * (1 - 0.014) \approx 3.99$$

The expected electric energy consumption is equal to actual consumption with heat losses, divided by coefficient of performance:

$$E_{e.min} = E_{hp.min} + (Thermal.Consum_{min} * (1 + HL) \div CoP_{e.min} \div E_{hp.max})(E_{hp.min} - E_{hp.max}) = $$
$$= 1314 + (5960 * (1 + 0.193) \div 3.74 \div 2628)(2628 - 1314) \approx 2265 \text{ MWh}$$

$$E_{e.avg} = E_{hp.min} + (Thermal.Consum_{avg} * (1 + HL) \div CoP_{e.avg} \div E_{hp.max})(E_{hp.min} - E_{hp.max}) = $$
$$= 1314 + (7450 * (1 + 0.193) \div 3,86 \div 2628)(2628 - 1314) \approx 2465 \text{ MWh}$$

$$E_{e.max} = E_{hp.min} + (Thermal.Consum_{max} * (1 + HL) \div CoP_{e.max} \div E_{hp.max})(E_{hp.min} - E_{hp.max}) = $$
$$= 1314 + (8940 * (1 + 0.193) \div 3.99 \div 2628)(2628 - 1314) \approx 2650 \text{ MWh}$$

The expected electricity consumption is 2265-2650 MWh annually or 250-300 kW. The average electricity consumption is 2465 MWh or 280 kW.

Costs of Implementation

The Costs of Implementation consist of costs of heat pump(s), costs of supporting components (heat sinks, pipes, heat carrier tank, heat carrier pump, insulation, etc), and costs of installation. The breakdown of costs available in the table below:

	Price, €	Count	Sum, €
Heat pump OCHSNER IWWHC 800 P2D TW	700000-800000	1	700000-800000
Ground heat source		(included in heat pump price)	
Heat sink	2000-3000	5	10000-15000
Heat pipe	80-100	200-320	16000-32000

Pipes insulation	40-50	100-160	4000-8000
Pipe circuit pump	1500-2500	2	3000-5000
Pipes circuit tank		(included in circuit pump price)	
Consumables, other items		+5% heat pump and +5% support components	
Heat pump installation	50000-80000	1	50000-80000
Pipes circuit mounting	15-30	200-320	3000-9600
Deinstallation of old equipment		(not necessary)	
Utilization of old equipment		(not necessary)	

Costs of heat pump(s): 700000-800000, €
Costs of support components: 69650-103000, €
Costs of installation: 53000-89600, €

Summary of costs: 822650-992600, € single time. Average is €907625.

Project Timeline

For small and middle -sized factories, it’s usually a simple project. It rarely has unexpected issues during execution. The typical reserved time budget for such project is 15% of the all timespan. This budget doesn’t include delays due to specific conditions of vendors, shippers, and/or service providers (performers of the project).

The implementation of the project consists of the following stages:

Stage	Duration	Necessary for
Detailed Engineering Project	8 weeks	Ordering the components
Ordering the components	10 weeks	Mounting heat pump, mounting pipe circuits, mounting heat sinks
Preparing place for heat pump	1 week	Mounting heat pump
Preparing place for heat source (ground)	3 weeks	Mounting heat pump

Mounting heat pump	2 weeks	Pre-operational testing
Mounting pipe circuits	3 weeks	Mounting heat sinks
Mounting heat sinks	2 weeks	Pre-operational testing
Pre-operational testing	1 week	Commissioning
Commissioning	1 week	Pre-operational testing

The total average time of the implementation of the project is 28 weeks (~7 months).

Costs of Ownership

Amortization is equal to costs of full replacement of a component (including installation) divided by lifespan:

$A = Avg. Costs\ of\ Impl. \div Lifespan = 907625 \div 18 \approx$ €50400 annually, without inflation

For long-time amortization (more than 7 years), it's worth to determine amortization with inflation. For the last 10 year in the location of production (Germany), the annual inflation is Then, the amortization with included inflation is:

$$A = Avg. Costs\ of\ Impl. * (1 + Inflation)^{Lifespan} \div Lifespan =$$

$$= 907625 * (1 + 0.0226)^{18} \div 18 \approx \text{€}75400 \text{ annually, with inflation}$$

Maintenance costs consist of pipes maintenance (M_a) and refrigerant refill (M_b). Single-time maintenance of pipes maintenance (Mst_a) is average €2500 for the location. Single-time maintenance of refrigerant refill (Mst_b) is average €1800 for the location.

$$M = \Sigma(Mst * 1\ year \div period) = 2500 + 1800 * 2 = \text{€}6100 \text{ annually}$$

The full costs of ownership are the sum of amortization and maintenance costs, with inflation:

$$A + M = 75400 + 6100 = \text{€}81500 \text{ annually}$$

Summary: around €81500 annually.

Change Impact

The project reduces energy consumption, because of a more effective way to produce thermal energy. The new amount of energy consists of the current consumption minus optimization baseline plus the consumption of new equipment in the selected operating parameters:

$$old\ consumption - optimisation\ baseline + consumption\ of\ new\ equipment =$$
$$= 11000 - 7450 + 2465 = 6015 \text{ MWh}$$

The project reduces gas/oil consumption, because the function is replaced by the new equipment. The new amount of energy consists of the current consumption minus optimization baseline plus the consumption of new equipment in the selected operating parameters:

$$old\ consumption\ -\ optimisation\ baseline\ +\ consumption\ of\ new\ equipment\ =$$
$$=\ 3000\ -\ 300\ +\ 0\ =\ 2700\ \text{MWh}$$

And the new amount of gas consumption is equal to new amount of necessary energy divided by specific thermal impact of the gas/oil:

$$W_{th}\ \div\ 10.24\ \approx\ 263000\ \text{m}^3$$

No significant impact to production process identified. More details are available in the full version.

Financial Impact

The forecast of costs of electric energy for 2024 **BEFORE** the project is the product of price and the forecast of amount of consumed electric energy:

$$€0.38\ *\ 11000000\ =\ €4180000$$

The forecast of costs of gas/oil energy for 2024 **BEFORE** the project is the product of price and the forecast of amount of consumed gas/oil energy:

$$€0.08\ *\ 300000\ =\ €24000$$

The forecast of costs of electric energy for 2024 **AFTER** the project is the product of price and the forecast of amount of consumed electric energy:

$$€0.38\ *\ 6015000\ =\ €2285700$$

The forecast of costs of gas/oil energy for 2024 **AFTER** the project is the product of price and the forecast of amount of consumed gas/oil energy:

$$€0.08\ *\ 263000\ =\ €21040$$

The financial impact is equal to the sum of the current costs of electric energy, thermal energy, and costs of ownership, minus the new costs of electric energy, thermal energy, and costs of ownership:

$$F_i = (F_e + F_{th} + CoO)_c - (F_e + F_{th} + CoO)_n =$$
$$=\ (4180000\ +\ 24000\ +\ 0)\ -\ (2285700\ +\ 21040\ +\ 81500)\ =\ €1815760\ \text{annually}$$

The expected costs optimization impact is roughly €1816000 saved annually. The statistical error of this calculation is ±15%. Pessimistically, it may save average €1543000 annually, or 30% or all energy consumption annual bill. To get the more precise calculation, please request the full version of the document.

The payback period of the project is equal to costs of implementation divided by annual financial impact (saved finances):

$$CoI\ \div\ F_i = 907625\ \div\ 1543000\ \approx\ 0.58\ years\ \approx\ 7\ \text{months.}$$

After the full implementation of the project, the payback period is 7 months.

Environmental Impact

CO2 emission scope 1 covers emissions from sources that an organization owns or controls directly, including burning fuel, waste gas in chemical production, emission during recycling, etc.
The forecast of current gas consumption is 300.000 m3. The forecast of new gas consumption is 44.000 m3. The CO2 emission reduction of scope 1 is equal to difference of gas consumption in m3 multiplied by CO2 emission factor:

$$(GC_n - GC_c) * CO2_{ef} = (263000 - 300000) * 1.9 = - 33300 \text{ kg1 CO2}$$

CO2 emission scope 2 covers indirect emissions from energy sources (purchased electrical energy).
The forecast of current electrical energy consumption in 2024 is about 11000 MWh. The forecast of new electrical energy consumption in 2024 is about 5950 MWh. The source of energy is not determined by vendor, thus the average coefficient of emission for the country (Germany) is 0.381 kg CO2 per kWh. The CO2 emission reduction of scope 2 is equal to difference of electrical energy consumption multiplied by CO2 emission factor:

$$(GC_n - GC_c) * CO2_{ef} = (5950000 - 11000000) * 0.381 = - 1924 \text{ kg CO2}$$