Opportunities to get EU industry off natural gas quickly

Cost analysis of alternatives to natural gas in food, chemical and glass industries

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Climact Team

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Executive Summary – Chemical & food industries

- Due to the energy crisis caused by the war in Ukraine, EU industry needs to find ways to switch away from natural gas. Synergies with energy security, geopolitics and environment are also at stakes.
- Chemicals & food sectors have been identified as the main consumers of natural gas in EU industry, responsible for 52% of its use.
- The key alternatives to gas for chemical & food sectors are heat pumps and electric boilers.
- Electric boilers are similar to gas boilers in terms of investments but have higher operating costs for a common grid connection. Decentralized electricity generation (e.g. PV production) can potentially be a way to reduce the electricity bill compared to grid-based electricity.
- Heat pumps, especially high-T° ones, have high capital expenditures partially due to low market penetration and standardization. On average, a low-T° heat pump is 3 times more expensive (8 time for high-T°) than a gas boiler.
- Thanks to a higher energy performance, heat pumps consume about 4 times less primary energy than a boiler for the same useful output. It enables low and more resilient operational costs. Hence, for low-T° needs, replacing gas boilers by heat pumps is profitable after a few years, even if the gas boiler did not reach the end of its useful lifetime yet.
- There are various mechanisms and subsidies (EU and national levels) to support companies for such investments. These can help to make such investments profitable.
- The “worst-case” scenario of a consistently high energy price over the course of the decade renders heat pump comparatively more interesting than gas boiler due to their lesser primary energy consumption. Under such a scenario, high-T° heat pumps even become competitive with gas boilers.
- Numerous pilot projects on low-T° heat pumps have already demonstrated their economic viability. Investments in high-T° heat pumps projects need to be scaled, some large actors (e.g. BASF) are leading the way in this direction.

Executive Summary – Glass industry

- Due to the energy crisis caused by the war in Ukraine, EU industry needs to find ways to switch away from natural gas. Synergies with energy security, geopolitics and environment are also at stakes.
- Glass sector has been identified among large consumers of natural gas in EU industry, responsible for about 7% of its use.
- The key alternatives to gas for glass sector are full and hybrid electric furnaces.
- In glass making, electrodes can easily be incorporated in existing lines of productions, resulting in a hybrid furnace. This electric boosting makes a relatively implementable solution for gas reduction et short-term.
- Full electric furnaces can cause quality degradation (not a problem for container and fiber glass which makes up for most glass production) and are electricity intensive which requires a reliable power supply.
- There are various mechanisms and subsidies (EU and national levels) helping companies to invest and operate such assets.
- As there is no significant gain in energy efficiency, electric heating shows higher operating costs than gas heating. Nevertheless, to meet their climate targets, some actors (e.g. AGC) already begun to increase the share of electricity in their primary energy mix for production lines. They could benefit of substantial national subsidies for their capital investments.

Context of the study

Opportunities to get EU Industry off natural gas in the short-term, divided in 2 parts

1. Assessment of the **high-level potential** of natural gas reduction in the EU industry*

- Identification of the 4 main consumers of natural gas in the EU industry (chemicals, food, glass & ceramics sectors)
- Assessment of the main alternatives to natural gas in these sectors
- High-level outlook of natural gas reduction in the short-term (i2027) for each of these sectors
- **Main result** : a highly ambitious scenario would bring down by 20% gas use in the EU industry without increasing biomass use, only looking at these 4 sectors

2. Assessment of the **economics** of the most promising alternatives

- Focus on the most promising alternatives (excluding ceramics) **
- Benchmark the cost of switching away from natural gas (industry pilot projects and literature review)
- Objective : to gather real-world data to showcase the costs and benefits of switching to alternatives

► 1. Food & Chemicals (processing) industries show **heat pumps & electric boilers** as most promising alternatives to gas.

► 2. Glass industry shows partial **electric heating** in existing installation as short-term most promising alternative.

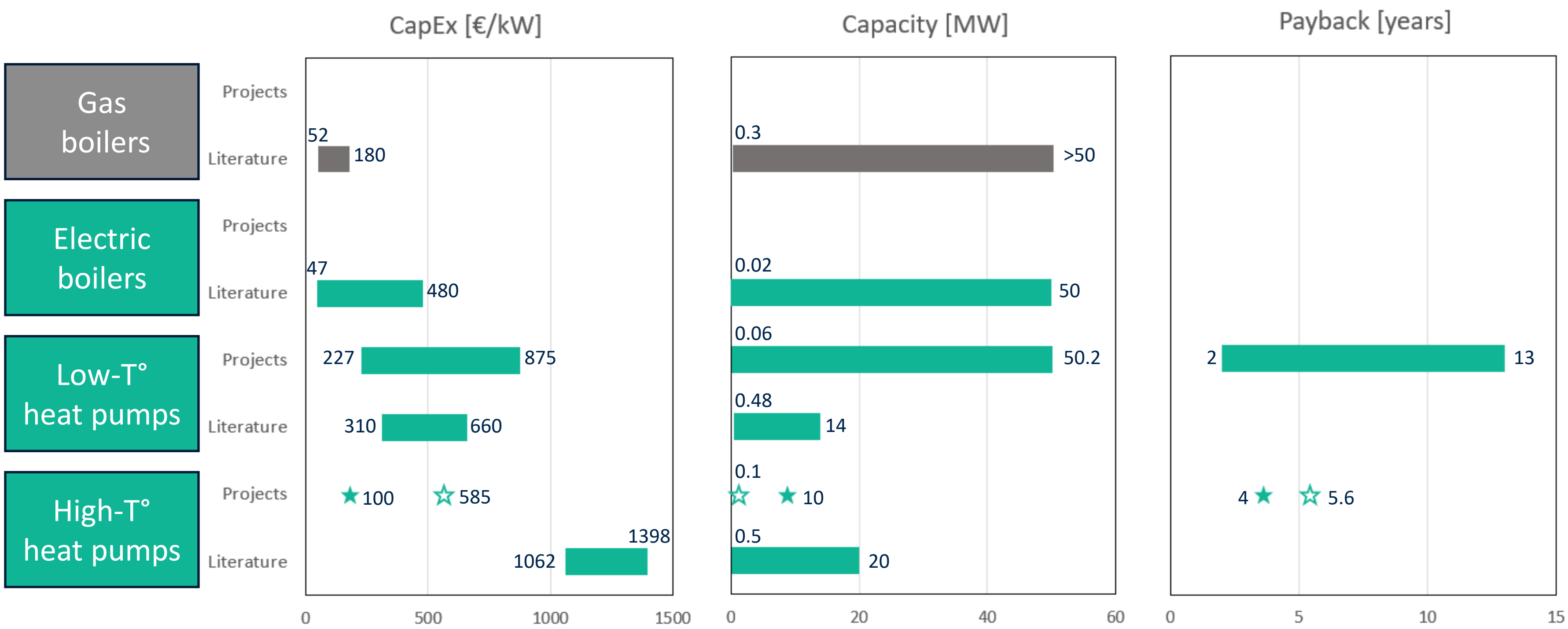
*The results of the first part are available on Climact website.
**The most promising alternative for ceramics, identified as microwave assistance heating, has been researched. No pilot project or concrete information were available, hence its exclusion from the second part of the study. A broader research for electric kiln in ceramics has not been conducted.

Sources

Number	Coordinator	Type	Technology	Source
1-3	FOODDRINK EUROPE	Literature[1]	Heat pumps Electric boilers	*Decarbonisation road map for the European food and drink manufacturing sector*
4-6	GOV.UK	Literature[2]	Electric boilers	*Industrial Fuel Switching Market Engagement Study*
7	DGC Danish Gas Technology Centre	Literature[3]	Heat pumps	*Future gas utilisation in the industry – heat pump, electrical and gas-based application feasibility studies*
8-9	PBL Netherlands Environmental Assessment Agency	Literature[4]	Heat pumps	*Decarbonisation options for the dutch potato processing industry*
10	European Commission	Literature[5]	Electric boilers	*Mapping and analyses of the current and future (2020 - 2030) heating/cooling fuel deployment*
11-13	European Commission	Literature[6]	Electric boilers Heat pumps Gas boilers	*Long-term (2050) projections of techno-economic performance of large-scale heating and cooling in the EU*
13-25	SINTEF	Projects[7]	(High temperature) heat pumps	*DryFiciency; SkaleUp; FUSE; BAMBOO; SuPrHeat; SteamHP;...*
26	QPINCH	Projects[8]	Chemical heat pumps	*Qpinch*
27-35	European Commission	Projects[9]	Waste heat recovery	*TASIO; SUSPIRE; VULKANO; Indus3Es; I-ThERM; LOWUP; ...*
36-66	iea International Energy Agency	Projects[10]	Heat pumps	Companies' projects over the world (*Nestlé, Unilever, VIVO GmbH, ...*)
67-91		Projects[11]	Heat pumps Waste heat recovery	Handbook *ReUseHeat*

Global overview of all data & results for electric boilers and heat pumps

All CAPEX, installations Capacity, and Payback periods are gathered in intervals, all sectors combined



*Stars show 2 projects of chemical heat pumps. Their technology differs from common HP, the costs are reduced, and COP increased, the process utilizes waste heat to drive its process and is hence limited by the Carnot efficiency of about 50%. Hence their special status among heat pumps.

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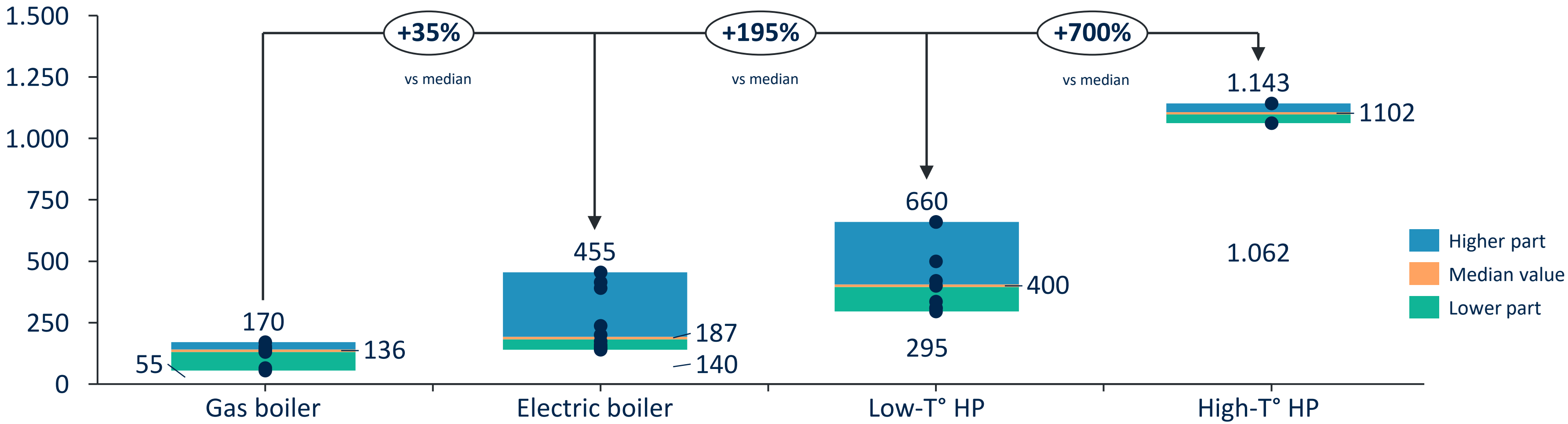
First focus : Capital expenditure (CAPEX)

CAPEX-wise, gas boilers are currently the cheapest option but alternatives are expected to become more competitive in time

CAPEX for considered technologies* [€/kWth]



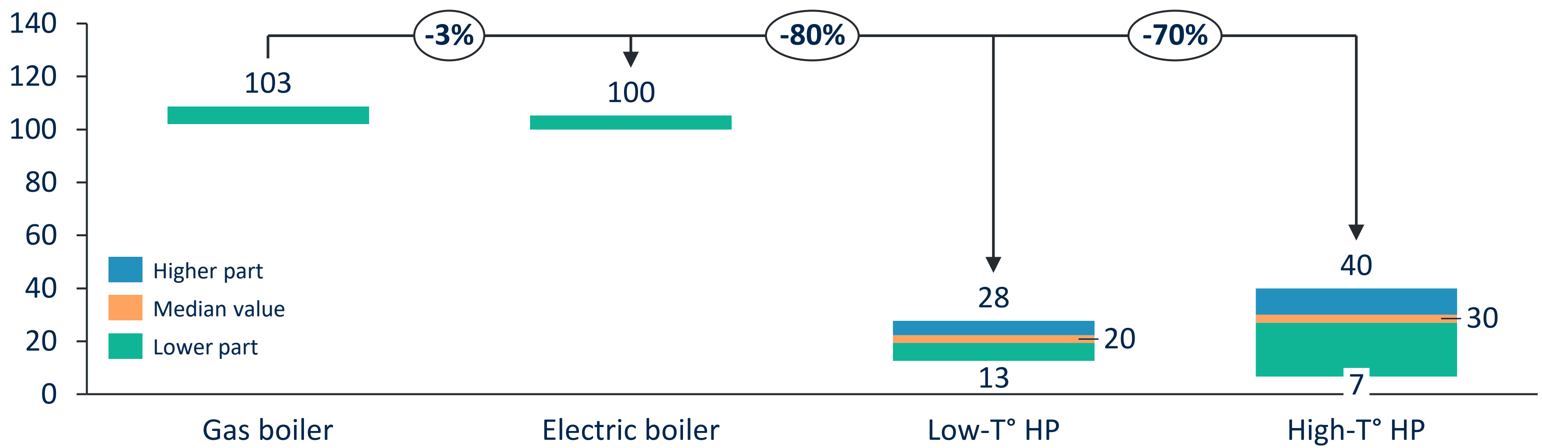
- Gas and electric boilers present a similar median CAPEX. Higher cost for electric boiler are explained by additional infrastructure costs (grid connection, etc).
- Heat pumps have a significant higher CAPEX than boilers. It is partially due to the fact that heat pumps are only emerging in industry. Their prices are expected to decrease with higher market penetration and standardization. This is especially true for high-temperature heat pumps that are an emerging technology.

*Installations of 0,5-6MW, all sectors combined, CAPEX are transcripted as a whole, they can include infrastructure addition costs

Second focus : Operating costs (OPEX)

Operating costs are key to compare alternatives to gas as heat pumps consume much less energy

Energy consumed for 100kWh of heat production for considered technologies* [kWh]



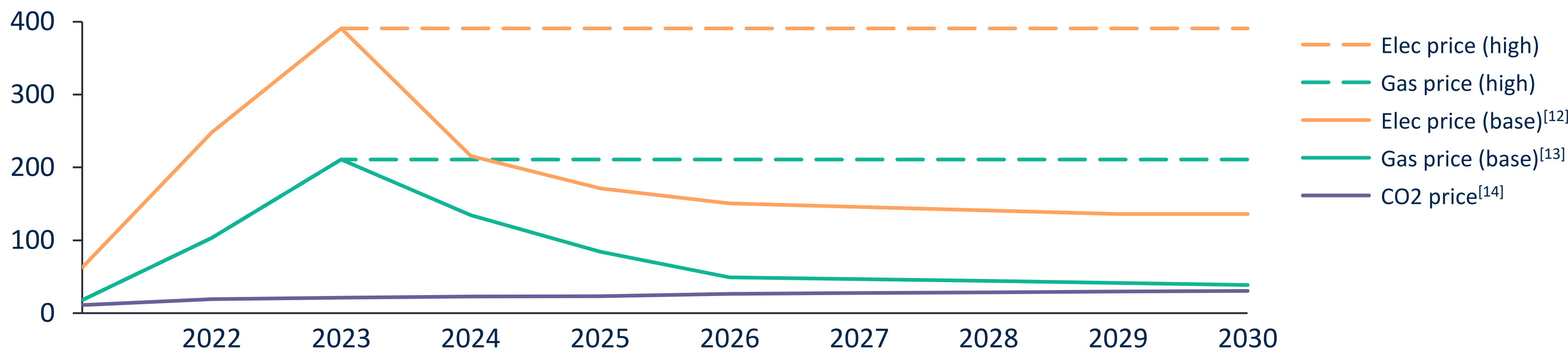
- Heat pumps consume around 4-5 times less energy to produce the same heat output than boiler.**
- Gas and electric boilers present a similar efficiency at 95-100%. They require 100-105 kWh to produce 100 kWh of heat.
- Heat pumps on the other hands are largely more performant as their operation only requires a fraction (e.g. 20%) of the useful heat output in the form of electricity. It means they only require around 20 kWh of electricity to produce 100 kWh of heat. The ratio between the useful output heat and the input electricity consumption is called the COP (Coefficient Of Performance) and often varies between 3 and 10.

*Installations of 0,5-6MW, all sectors combined. ** in the interval of temperature output of heat pumps (50 to 100°C for LT ; 100 to 200°C for HT), COP for High-T° HP is not very robust as there are only few sources that mention it.

Two energy prices scenarios are considered to compare gas and electricity

Electricity and gas prices are foreseen to be significantly high in the coming years

Energy prices and forecasts [€/MWh]

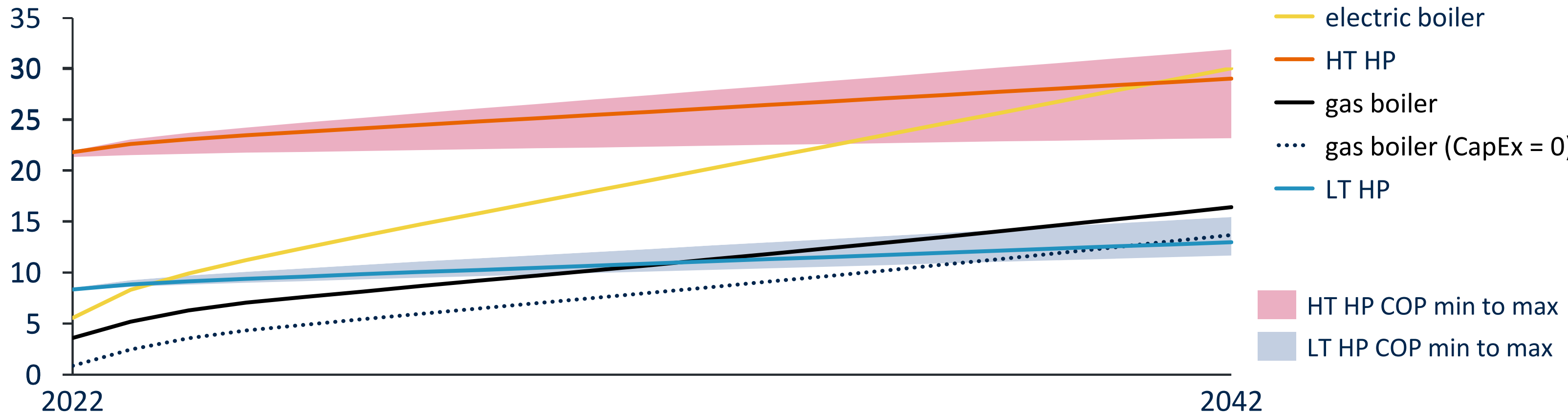


- Gas prices are currently very high due to the geopolitical context in Europe and Russia. This also affects the electricity prices. These figures are from September 6th, 2022 and only reflect the current situation.
- The price forecasts are based on the forward market prices (available up to 2025). Post 2025, gas prices are based on RePowerEU's forecast, and electricity prices are based on the cost of producing electricity with a gas plant subject to the same gas price forecast.
- These prices, especially post 2025, are highly uncertain. For example, RePowerEU foresaw a gas price for 2025 that was revealed (3 months later) to be twice less than the forward price for that year.
- Compared to electricity-based assets, gas-based assets are also subject to CO_2 price related to their GHG emissions
- Dashed lines correspond to worst case scenarios. They have been designed to assess the impact of consistently high energy prices.

Comparison of the total cost of various options in the base energy prices trajectory

Lower fuel costs make alternatives more and more competitive with gas boilers

Total cost (CAPEX on year 0* + yearly OPEX**) for 1MW installation [M€]



- In year 0 (2022), the total cost correspond to the initial investment cost***: High-T° heat pumps have a notably higher cost. Low-T° heat pumps and electric boilers also start above gas boilers as their CAPEX are higher.
- OPEX considered here are not cumulated throughout the years: the slope of the lines corresponds to the yearly OPEX , which is proportional to fuel prices. Even though the electricity price is higher, heat pump OPEX are lower due to their lesser energy consumption compared to gas boilers.
- Thanks to lower OPEX Low-T° HP become more profitable than gas boilers after a few years (even in the case of an existing gas installation). Electric boilers, however, cannot compete with gas boilers unless electricity becomes cheaper than gas, which is possible with decentralized renewable production. As for High-T° HP, the lower OPEX is not sufficient to balance its high CAPEX.

*Yearly CAPEX is cumulated on year 0 (2022) for a lifetime of 20 years, 6400 yearly running hours. It does not consider price actualization. **OPEX includes O&M and fuel costs. ***OPEX 2022 cost are also included, hence the different ratio between technologies than in slide presenting CAPEX.

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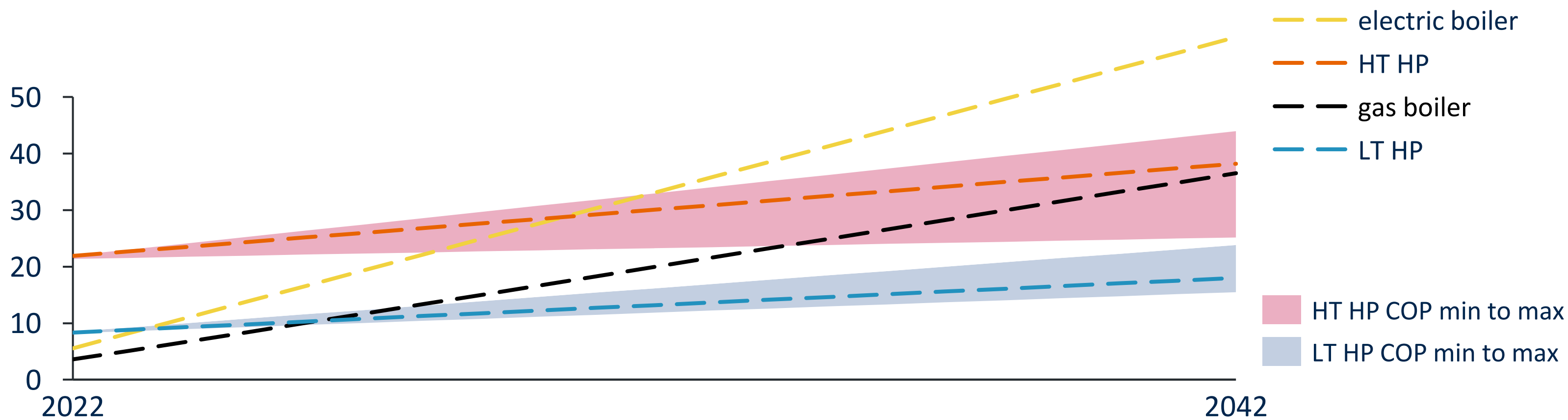
Comparison of the total cost of various options in the high energy prices trajectory

Higher fuel costs make alternatives more and more competitive with gas boilers

Total cost (CAPEX on year 0* + yearly OPEX**) for 1MW installation [M€]



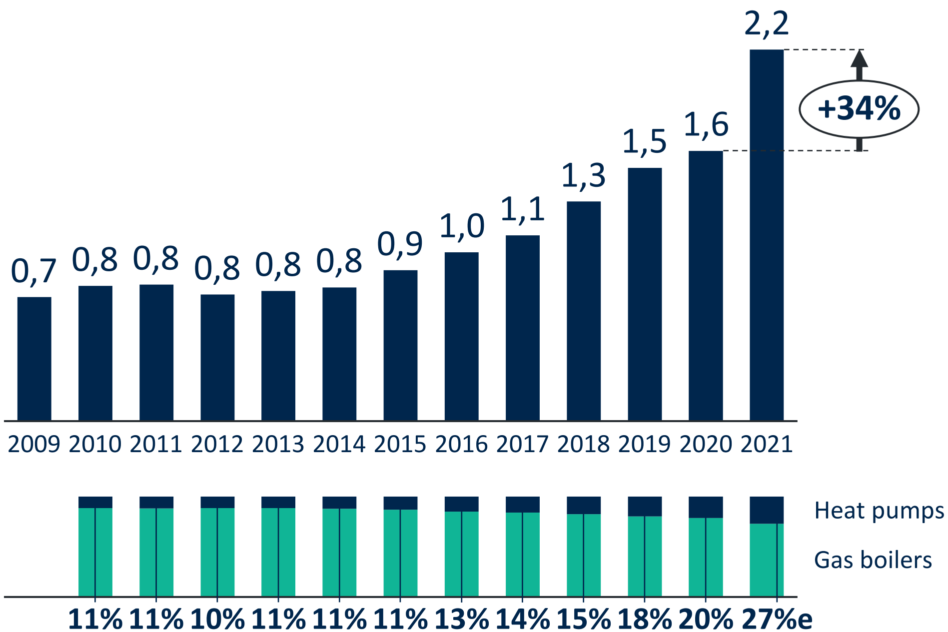
- In a consistently high price scenario, Low-T° heat pumps become largely more interesting than gas boilers and competitive with them within the decade.
- It shows how the lesser energy consumption of heat pumps becomes a strength in the context of high energy price volatility.
- Energy price forecast is always a delicate exercise and the forecasts shown here should be taken with caution. However, they highlight the greater resilience of heat pumps to energy price fluctuation. As uncertain energy prices are more than realistic, it makes sense to consider it as an argument in favour of heat pumps.

*Yearly CAPEX is cumulated on year 0 (2022 for a lifetime of 20 years, 6400 yearly running hours. It does not consider price actualization.
**OPEX includes O&M and fuel costs.

Industrial heat pumps market will take advantage of the flourishing market of heat pumps for buildings space heating

For 5 years, the heat pumps market has doubled and reaches 25% of new heater sales in buildings [26]

Heat pumps sales in EU [million units][26] – above
Market share in total heater sales in households [%][26] – below



- 2021 marked (all HP, mainly for building) an increase of 34% compared to 2020 for heat pumps installation.
- In 2021, it amounts to around one quarter in total heater sales.
- As for today, there are a stock of 17M heat pumps units. Residential heating is predominating, while industry is following the trend of space heating.
- In EU, there are over 170 sites of heat pumps manufacturing, at a SME-scale, with a turnover of 14,5B€ and 117k jobs.
- EHPA targets a 12m units sales in 2030.
- To meet the current heat demand <200°C by the EU industry, which amounts to 700 TWh (37% of process heat), EU should install 300MW per month to reach the necessary 105GW by 2050.

Glass industry [21, 22, 24]

Description of the perspectives of electrification in the glass sector

- Full electric furnaces:
  - **Full electric furnaces already exist for small production** typically up to 70 tons/day capacity. It only works for transparent glass without cullet (i.e. no recycled glass). The largest all-electric furnace in operation worldwide is located in Western Europe with a melting capacity of 400 tonnes/day for fibre glass.
  - They are currently **not demonstrated at larger scale for float and container glass** (typical industrial lines are around 500t/days). They need a stable and continuous power supply and an adequate grid connection to ensure secured power supply.
- Hybrid technology
  - Introduction of electrodes in the glass bath allows to supply **up to 20% of the necessary energy with electricity** (the rest, >80%, being supplied by gas), **without needing to change the installation.** However, the installation of electrodes requires temporarily shutting down the installation.
  - Increasing the electricity share above 20% requires to redesign the whole installation. With higher shares of electricity in the process, the hybrid technology brings additional reliability compared to the full electric one as it allows the use of natural gas in case of a power supply disruption. Furthermore, their vertical design ensures better thermal insulation for the furnace, hence greater efficiency

Limitations

  - Plants run **7 days a week, 24 hours a day for 15-20 years**. Difficulty to perform retrofit without significant economical and technical consequences
  - The **quality of the produced glass can be impacted** by electrification (it causes bubbles in the finished product). Float glass requires a higher quality than container glass.
- Possible support:
  - EU funds
  - National help

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Investment support schemes

There are various kind of support schemes[1]

- The EU has funds with **various budgets** [2,3;672,5] b€ and **TRLs** (1-9)
- Their help can come in different ways: equity finance, guarantees, debt financing and grant/subsidies
- Their main focuses are on
  - **Cross-cutting R&I** on technologies (e.g., energy efficiency, CCS, etc.)
  - **Reduce emerging disparities** caused by the transition
- **National support schemes** exist in various forms (e.g., subsidies, tax exemption, etc.)
- Carbon Contracts for Difference (**CCfDs**) guarantee investors a **fixed price** that rewards **CO_2 emission reductions** above the current price levels in the EU Emissions Trading System (ETS)[23]

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Investment support schemes

What are the potential investment support schemes to help industries make the switch?[1]

Name	Focus	Description	Instrument	Budget + TRL
The European Fund for Strategic Investments (EFSI)	Cross-cutting research to maximize the energy efficiency of cross-sector industrial components in a cost-efficient manner	EFSI's goal is to help overcome the current investment gap in the EU and ensure that money reaches the local economy.	Equity finance, guarantees and debt financing	- 26 billion € - TRL 6-8
Programme for Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME)	Electricity efficiency; Heat efficiency and recovery; Carbon capture and storage; Sustainable infrastructure; Renewable energy	Provides venture capital and mezzanine finance to expansion and growth stage SMEs.	Equity finance	- 2,3 billion € - TRL 1-9
		Facilitates access to debt finance for SMEs.	Guarantees	
Recovery and Resilience Facility		Supports reforms and investments undertaken by Member States.	Debt financing, Grant/Subsidies	672,5 billion €
Horizon 2020	Cross-cutting R&I: improving system integration, optimal design, intelligent and flexible operation, including industrial symbiosis to increase energy and resource efficiency	2021-2027 EU Research Framework Programme.	Grant/Subsidies	- 100 billion € - TRL 1-9
H2020: INEA Grants for energy and transport		Helps innovative projects in the field of transport and energy.		- 5,3 billion € - TRL 6-8
Connecting Europe Facility (CEF) Energy		Makes direct investment into European transport, energy and digital infrastructures to address identified missing links and bottlenecks.	Grant/Subsidies, Guarantees, Debt financing	- 5,3 billion € - TRL 9
Innovation Fund	Sector-specific R&I: increasing the cost effectiveness of not yet economically viable technologies	Supports low-carbon innovative demonstration projects in energy intensive industries, innovative renewables, energy storage, CCUS	Grant/Subsidies	- 10 billion € - TRL 7-9
Just Transition Fund	Reduce emerging regional disparities caused by the transition towards a climate neutral economy (investments in SMEs, R&I, Deployment of technology and infrastructure, etc.)	Reskilling people, providing cleaner transport and energy efficient homes in sectors requiring major transformation, such as the steel, cement, chemicals and car manufacturing sectors	Various	7,5 billion €

Perspectives

Heat pumps represent the best short-term option and higher market penetration is expected to further decrease their costs

- **Currently no large-scale industrial heat pump project in Europe**, especially regarding high-temperature heat pumps

  → The EU needs to put **more focus on showing support to encourage initiatives**

- Gas and electricity prices depend on several factors: geopolitical, economical, legislative, etc. These factors undergo quick and significant changes (see current discussions around a price cap on gas or a revenue cap on the day-ahead electricity market).
- However, the EU aims at shifting away from fossil gas and increasing the share of electricity in the mix. Hence, it seems reasonable to assume that electricity prices will be more stable than gas prices in the near future.
- Need to ensure that the **heat pump sector can keep up with an increasing rate of installation**

  → **Enough qualified manpower** for production and installation

  → **Enough resources** to produce the heat pumps (the needed materials* are similar to gas boilers)

  → **Efficiency gains** to be expected from **centralized installations** shared between several industry actors rather than individual ones.

*Mostly iron castings, stainless steel components and aluminum tubine.

Conclusion : key messages

Food and chemical industries can already invest on heat pumps which are competitive with gas boilers

- **High capital investment of industrial low-temperature heat pumps is compensated by lower operational costs**. The total cost of investment and operation becomes lower for heat pumps than for gas boilers after a few years.

- **High-temperature heat pumps CAPEX are expected to decrease as they enter the industrial market.** They currently lack demonstration projects.

- Heat pumps lower operational costs result from **a significantly lower energy consumption (3-7 times lower)**. It makes them far **more resilient to fuel cost changes**.

- **Fuel costs are variable and dependent on external factors** (e.g., the geopolitical situation). Current context of high volatility of gas energy price confirms that **energy security is key**. Local renewable electricity production is complementary to heat pumps/e-boiler installation as it ensures stable prices compared to fluctuating prices of grid-based electricity.

- **There are support schemes to switch from gas to alternatives** (EU funds (e.g., EFSI, COSME, Horizon 2020, etc.), country-specific National subsidies, CCfDs). These will help to introduce the costly technologies to the market which in turn should drive their costs down.

Pilot projects - Food

Heat pump in a brewery - Hanspeter Graßl KG – workshop in Germany[15]

Company

- Hanspeter Graßl KG is a **small-scale brewery** that markets its beer under the brand name **Schäffler Bräu** and is **located in Missen, Germany.**
- Schäffler Bräu was **founded in 1868** and produces beer for their inn but also for supermarkets, restaurants and private consumption.

Beer brewing process

1. Malt and water are heated in the mash pan while stretch and enzymes are dissolved in the water to form sugar.
2. The brew is heated up to 80°C before insolvable components are removed from the brew.
3. The brew is cooked at 90 to 120°C (**part of the water is evaporated**) before being filled into fermentation tanks where yeast converts the sugar into alcohol (**it generates heat → the tank needs to be cooled to keep it at 5 to 15 °C**).
4. The beer is filled into bottles.

Project

- The heat pump's installation was commissioned **in 2012 to recycle waste heat** generated by the **cooling plant and the bottle cleaning and filling plant.** The heat comes out **at 55°C** and the **heat pump's capacity** is of **77 kW.**
- The investment cost amounted to around **0,03 M€** with a **lifetime of 20 years, a COP of 4,3 and a payback period of 6 years.**

Contact: sg@schaeffler-braeu.de

Pilot projects - Food

Heat Pump in a dairy – Arla Foods – plant in Rødkærsbro, Denmark[16]

Company

- Arla Foods is **headquartered in Jutland-Central, Denmark.** It is an **international cooperative** which is the **largest producer of dairy products in Scandinavia.**
- Their main products are **mozzarella cheese, whey and cream.**

Project

- Both vapor compression heat pumps use ammonia as refrigerant and are responsible for the **heating (1.5 MW)** and the **cooling (1 MW).** They were installed in **2014** and, since then, run 7800 hours each year.
- The investment cost amounted to around **5,5 M€** with a **lifetime of 20 years** and an **O&M cost of 4 €/MWh.** They received **1,23 M€** in the form of **energy saving subsidies.**
- It results in a **payback period of 6,1 years** and saves, each year, **640 000 € in energy costs, 16 010 MWh in energy and reduces the CO_2 emissions by 2 980 tons**. It helped them reduce their natural gas consumption by **42%** but increased their electricity's consumption by **11%**.

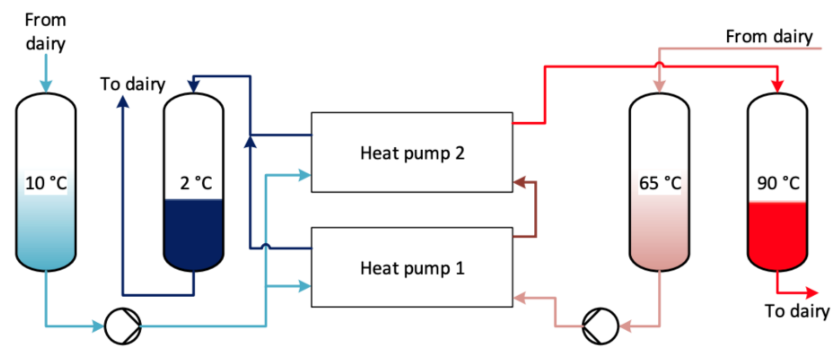


Figure 5-7: Two, two-stage heat pumps supplying both process cooling and process heating.

Contact: cje@viegandmaagoe.dk (report's coauthor)

Pilot projects - Food

Heat Pump in alcohol condensation process – CP Kelco – plant in Lille Skensved, Denmark[16]

Company

- CP Kelco is **headquartered in Atlanta, USA.** It is a **nature-based ingredient solutions provider** with over 85 years of experience working **with food, beverage and consumer product manufacturers worldwide.**

Project

- The vapor compression heat pump uses ammonia as refrigerant and is responsible for the **heating (3.5 MW)** and the **cooling (3 MW).** They were installed in **2017** and, since then, runs **8 600** hours each year.
- The heat is supplied to VEKS, a district heating company, at temperatures varying throughout the year between **75 and 85°C.**
- The investment cost amounted to around **3,92 M€** with a **lifetime of 20 years, a COP of 8,5** and an **annual O&M of 2 €/MWh and 7000 € for fixed maintenance.** Their investment was partly covered by receiving **2,4 M€** in the form of **energy saving subsidies.**
- It results in a **payback period of 2,1 years** and saves, each year, **48 860 MWh in energy and reduces the CO_2 emissions by 10 000 tons**.

Contact: cje@viegandmaagoe.dk (report's coauthor)

Pilot projects - Food

Heat Pump in production – Tivoli Malz – production site in Hamburg, Germany[17]

Company

- Tivoli Malz is **headquartered in Hamburg, Germany** and is part of the company **GlobalMalt.** In 2013, they produced about 400,000 tons of malt per year, with 105,000 tons coming from Hamburg.
- Malt is produced from cereals that germinate under humid conditions and is a major ingredient for beer brewing.

Project

- The heat pump is responsible for the **heating (3.25 MW)** and receives air at 22°C before heating it up at **35°C.** It was installed in **2010** and, since then, runs **6 000** hours each year.
- The heat pump is used to preheat inlet air by using ammonia as refrigerant.
- The investment cost amounted to around **1,68 M€** with a **lifetime of 20 years** and **a COP of 6.**
- It reduces, each year, **the CO_2 emissions by 6 300 tons**.

Contact: hello@crispmalt.com

Pilot projects - Food

20 MWh high temperature thermal storage from renewable power for an organic farm in Germany[25]

Company

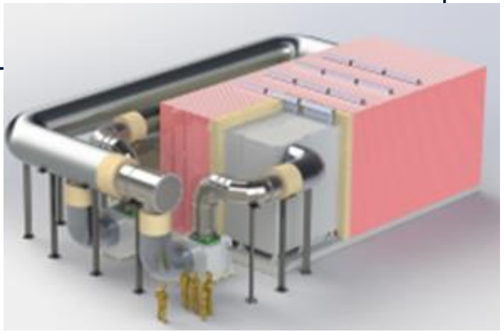
- **LUMENION GmbH** is a German company that has developed a technology of thermal storage for renewable heat. It received the Berlin Brandenburg Innovation Award in 2020.

Project

- **In Germany, Heide, the bio-farm BIO-Frost Westhof is building a 20 MWh LUMENION thermal energy storage** to produce 17 bar steam instead of a gas heated steam generator. The farm processes organic frozen vegetables with a production capacity of 10 tons per hour.
- The project is **under construction** and expected to be fully completed in Q4 2023.
- **The unit has a 7 MW_{peak} charging power from RES** (mix of wind, PV and biogas) and provide, through discharge (2 MW_{th} capacity), a **1.1MW_{th} steam generation.** The charging time is around 4 hours, about 4 times higher than simultaneous discharge during which **it provides 4,6t/h of 207°C steam.**
- With low Capex and Opex, the **LCOS** (levelized cost of storage) is around **220€/kWh_{th}.**

Technology

- The unit is constituted of **steel, 100% recyclable, with high energy density and longevity.**
- With a **thermal capacity of 5 to 500 MWh_{th} (0,2 to 20 MW_{th}),** it stores thermal energy as heat **up to 600°C** generated from renewable power. It can provide **reliable and continuous provision of process heat (150-400°C).**
- It shows an **efficiency of up to 95%.**



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Pilot projects - Chemicals

Chemical Heat Pump in Polyolefin producer – Borealis – site in Belgium[18]

Company

- Borealis Zwijndrecht is **located in Antwerpen, Belgium.** It produces around **100kt of polyolefin** each year, with main fields of application being wire & cable industry.
- It is part of the **Borealis group**, an Austrian company and world's eighth largest producer of polyethylene (PE) and polypropylene (PP).

Project

- The installation was commissioned **in April 2021**. The investment cost amounted to around **2,6 M€** with a **lifetime of 20 years.**
- The heat pump uses 2.6 MW of waste heat to heat **1.3 MW of steam from ~120° to 184°C**.
- To produce 1.3MW of thermal energy, it consumes about **50 kW of electricity** which represents **4%** of the output steam and a COP of 25.
- It results in an expected **payback period of 3 to 5 years** and saves, each year, **10.6 GWh of gas** and avoids 2.2kt of CO2 emissions.

Technology

- **Qpinch** is a start-up that uses a **chemical** heat pump to **capture waste heat and transform it into process heat** (up to 230°C) through phosphate oligomerization - deoligmerization cycle energy system. Their heat pump's **capacity can range between 1 and 100 MW.**

Contact: bruno.de.jonckheere@qpinch.com

Pilot projects - Chemicals

Heat Pump in coatings manufacturer – FreiLacke – logistic center in Bräunlingen[17]

Company

- Freilacke is **headquartered in Germany.** It develops and produces all **common coating systems** such as system coatings, powder coatings, industrial coatings / liquid coatings, electrodeposition coatings and composites.
- It exists since **1926** and has subsidiaries in multiple countries (e.g., Sweden, UK and China).

Project

- The heat pump's installation was commissioned **in 2010 as the heating system of their newly built logisitic center**. They decided to use the **process cooling network** from their powder coating production as **heat source.** The heat comes out **at 45°C** and the **heat pump's capacity** is of **240 kW.**
- The investment cost amounted to around **0,21 M€** with a **lifetime of 20 years and a COP of 5.**
- The heat pump covers most of the **heating demand of the production hall and the storage and shipping warehouse**. During summer, the heat pump is also used **for cooling the production halls.**
- It results in a **payback period of 5 years** and saves, each year, **23 000 €**.

Contact: anwendungstechnik@freilacke.de; anlagenplanung@freilacke.de; wirtschaftlichkeit@freilacke.de

Pilot projects - Chemicals

Future largest industrial Heat Pump in chemical production by BASF [19,20]

Company

- BASF is **headquartered in Ludwigshafen, Germany**, it is a multinational chemical company and the **largest chemical producer in the world**. Around the globe, it operates six integrated production sites and 390 other production sites in all kind of chemicals (plastics, agricultural products, coatings, solvents, etc).

Project

- In collaboration with MAN Energy Solutions, BASF develops the **installation of a 120MW high-temperature heat pump** in the Ludwigshafen site. This the world's largest integrated chemical complex.
- This project is **currently under a feasibility study** (for end of 2022).
- The planned large-scale heat pumps will have a **thermal output of 120MW** with 150t of steam per hour. This project should **reduce the emissions of the site by 390kt CO2e per year** (~1700 GWh of natural gas).

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Pilot projects - Glass

Measures taken by AGC Belgium to reduce their CO_2 emissions in one of their plant[21]

Company

- AGC Glass Europe produces, processes and distributes flat glass for the building industry, the automotive industry and various other sectors (transport, solar power and high-tech applications)
- It represents **more than 100 sites in Europe** and has more than **15 000 employees**

Project

- In 2019, AGC **boosted one of its production line in Belgium, Wallonia, with electrodes for a total of ~5MW.**
- The plant operates a 70m long, 10m wide line including 1m high of glass for a production of **700 tons$_{glass}$/day** with a **50 MW capacity.**
- The Electrodes (diameter: 80 cm) are pushed in the glass bath and work by the **Joule effect** to boost the melting and allow to save gas from the burners.
- **The share of gas and electricity on the line is respectively 90% and 10%.** They target to increase the ratio as much as possible in the coming years and to extend this electric boosting on their other production sites.

Help received

- The project received **national subsidies that covers 30% of the CapEx.**
- AGC notes that for their other planed projects, help from EU can cover CapEx and OpEx, and that other national help (ie in France) are more substantial than in Belgium.

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Pilot projects – other (ceramics)

High-temperature heat pump in brick factory in Austria [27]

Company

- **Wienerberger AG, the largest brick producer** in the world, operates around 200 brick dryers.

Project

- **In 2019, part of H2020 fund**, the DryFiciency heat pump was integrated in the **brick production process in Uttendorf, Austria**, supplying heat for the drying process.
- The heat pump is supplied by water at 90°C from waste heat to lift water from 96°C **to 121°C (COP of 5) with a heating capacity of 296kW**. It can go in higher temperature but loses efficiency, to lift 131°C input water to **160°C output water**, it results in a COP of 2,2.
- The DryFiciency heat pump was operated for more than 4000 h covering a large range of operation conditions.
- Operating at 120°C, it **reduces energy consumption by 2,2GWh/year**, CO2 emission by 590 t/year, resulting in **60500 €/year of energy cost savings**.

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