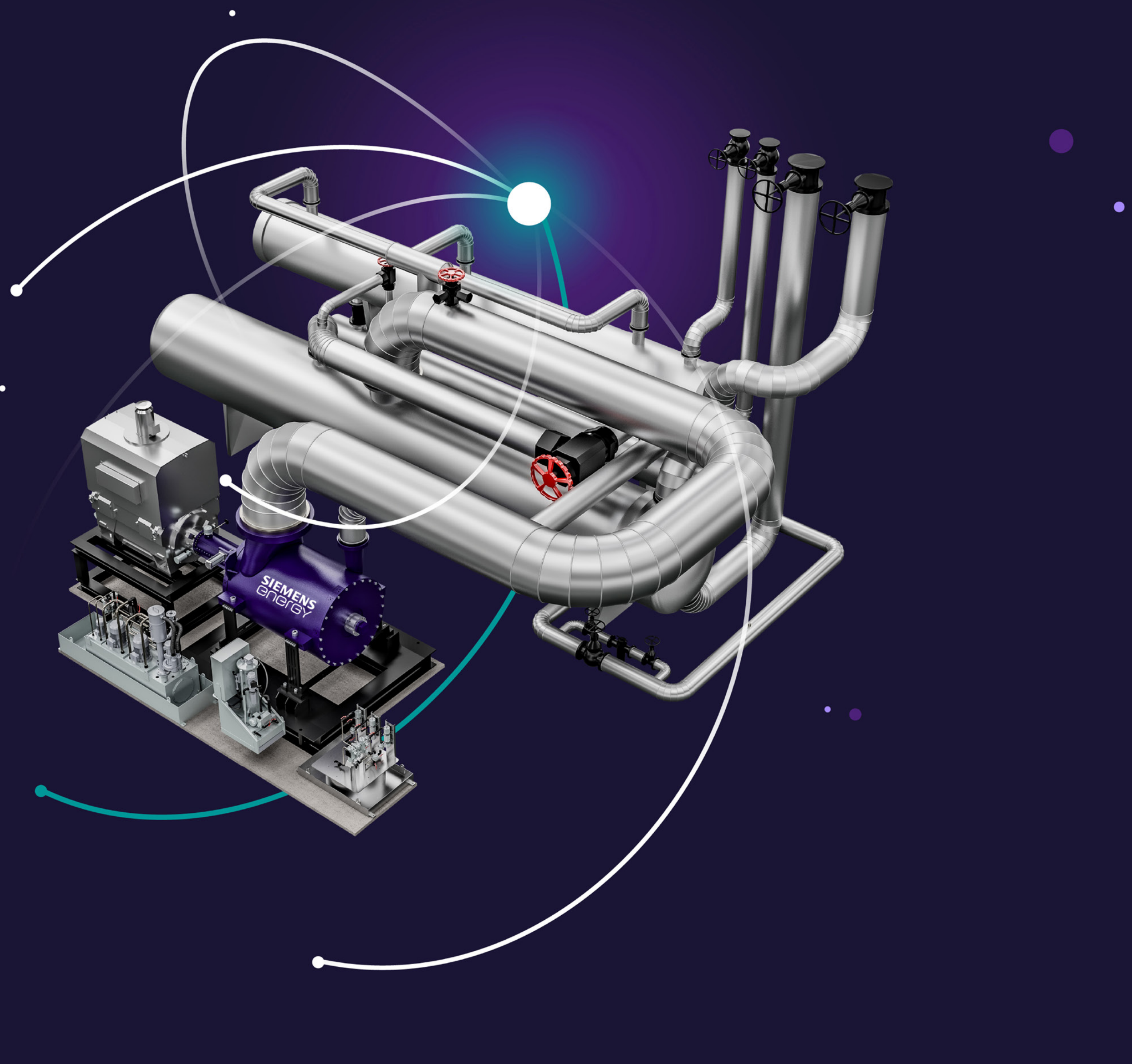
Decarbonization of district heating and industrial heat production

Reduce CO_2 emissions from networks with CHP (Combined Heat and Power) and P2H (Power-to-Heat)



Transforming heat production

We meet you at your starting point

Heat production accounts for half of the world's final energy consumption and contributes 40% of global carbon dioxide (CO_2) emissions.

The decarbonization of heat generation has emerged as a critical imperative in the pursuit of sustainable and climate-friendly industrial processes and district heating networks. Heat generation for industrial purposes and district heating networks often relies on fossil fuel combustion, contributing significantly to greenhouse gas emissions and ex-acerbating the global climate crisis. Recognizing the urgent need to transition to cleaner and more sustainable alter-natives, the focus has shifted towards decarbonizing heat generation.

Decarbonizing heat generation for district heating networks is crucial for creating resilient and efficient heating systems. Traditionally, these systems have relied on fossil fuel-based boilers or CHP plants. Transitioning to low-carbon heat sources, such as environmental heat, waste heat recovery, or the combustion of biofuels or hydrogen, has the poten-tial to not only reduce greenhouse gas emissions but also to improve air quality. Decarbonization of dis-trict heating networks also supports the integration of intermittent renewable energy sources, enabling better utilization of excess electricity during periods of high generation.

Similarly, decarbonizing heat generation in indus-trial processes holds immense importance. Many industrial sectors, such as manufacturing, chemicals, and refining, rely on high-temperature heat for their operations. These processes often involve the com-bustion of fossil fuels, leading to substantial green-house gas emissions. By shifting towards low-carbon or carbon-neutral heat sources, such as renewable energy-based technologies, industrial processes can substantially reduce their carbon footprint, mitigat-ing climate change impacts and enhancing environ-mental sustainability.

In conclusion, transitioning heat generation for in-dustrial purposes and district heating networks into net zero CO_2 heating systems is of paramount im-portance to combat climate change, reduce carbon emissions, and create sustainable energy systems.

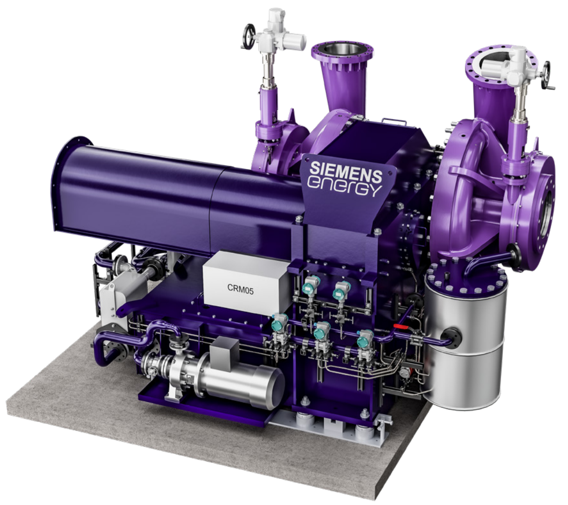


Figure 1: Compressor of a low-temperature heat pump

Siemens Energy's heat decar-bonization solutions provide several benefits

Affordability

Efficiency improvements and the use of waste heat can play a major role in decarbonizing heat production at rea-sonable cost. The technologies to decar-bonize industrial- and district-heating already exist and are ready to be scaled.

Sustainability

A rapid reduction in carbon emissions can be achieved by transitioning from coal- or oil-based steam plants to gas turbine powered CHP systems. Deep decarbonization can be reached by switch-ing from nat-ural gas to biofuels or hydrogen. Even negative CO_2 emis-sions can be attained by combining CCS (Carbon Capture Storage) with biofuels (BECCS).

Due to their high CoP (Coefficient of Performance) heat pumps provide low carbon heat. They are completely carbon neutral, if they are powered with renew-able electricity.

Flexibility

Heat can be stored significantly more cost effective than electricity. The com-bination of P2H with CHP stabilizes the power market. Heat pumps are prefer-ably operated at times of low power prices due to surplus renewable energy. When power prices are high CHP plants can profitably sell power and produce heat at the same time. At peak heat demand it is possible to operate the heat pump together with the CHP plant.

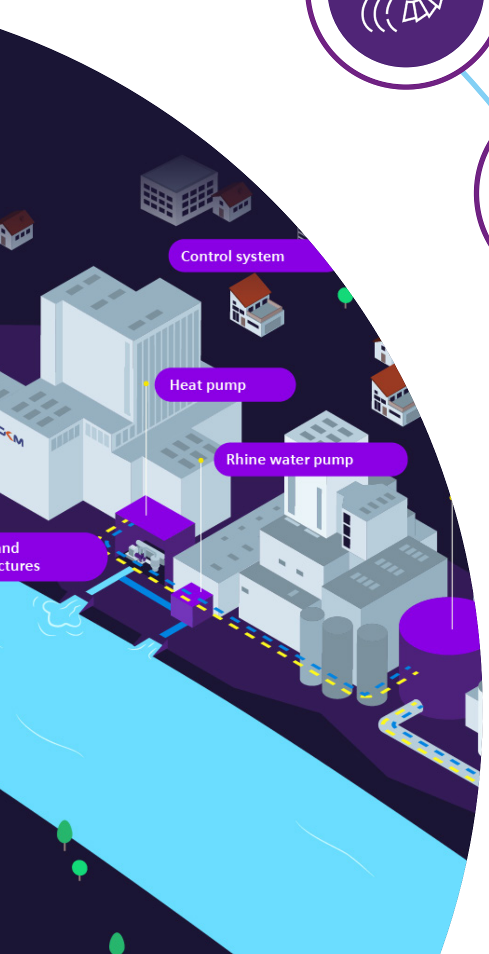
What is heat decarbonization?

Carbon footprint reduction in heat generation

Prepare your plant for a carbon-free future

Heat decarbonization, also known as heat transition, is a process for reducing CO_2 emissions from heat production. This can be achieved in different ways. One possibility is to switch to a low-carbon fuel and to make the fuel usage more efficient. This low-carbon fuel can also be replaced with a carbon-free fuel. Alternatively, heat production can also be electrified by using power from renewable energy. Existing heat infrastructure can be transformed fast and at large scale into affordable and flexible low-carbon energy systems.

Technologies to decarbonize heating



01 Increasing fuel efficiency with gas Turbine based CHP solutions

02 Hydrogen and biofuels

03 Biomass

04 Electrification of heat with power-to-heat technologies

01

Increasing fuel efficiency with gas turbine based CHP solutions

CHP generates electricity and heat from a single fuel source. Depending on the fuel used, the CO_2 emissions per kWh of thermal energy from traditional heating plants, differ widely and range between ~200 gr/kWh for natural gas to ~380 gr/kWh for lignite. Therefore, even a simple fuel switch may reduce CO_2 emissions by nearly 50%. In addition, the efficiency of the plant can be significantly increased by converting it into GT-powered CHP or into a CCPP (Combined Cycle Power Plant) with heat extraction.

The most modern combined cycle power plants achieve electric efficiencies of up to 64%. A total energy efficiency of up to 90% can be achieved by using combined heat and power or combined cold and power solutions. Siemens Energy has a proven track record of providing best-in-class products, solutions, and services for CHP. This is demonstrated by hundreds of cogeneration plants worldwide. From single gas and steam turbines or heat recovery steam generators to full turnkey installations, from waste treatment in Scotland to textile manufacturing in Mexico.

The same commitment is iterated in all of our projects around the globe, bringing out the best in CHP.

→ Find out which gas turbine fits best for your application

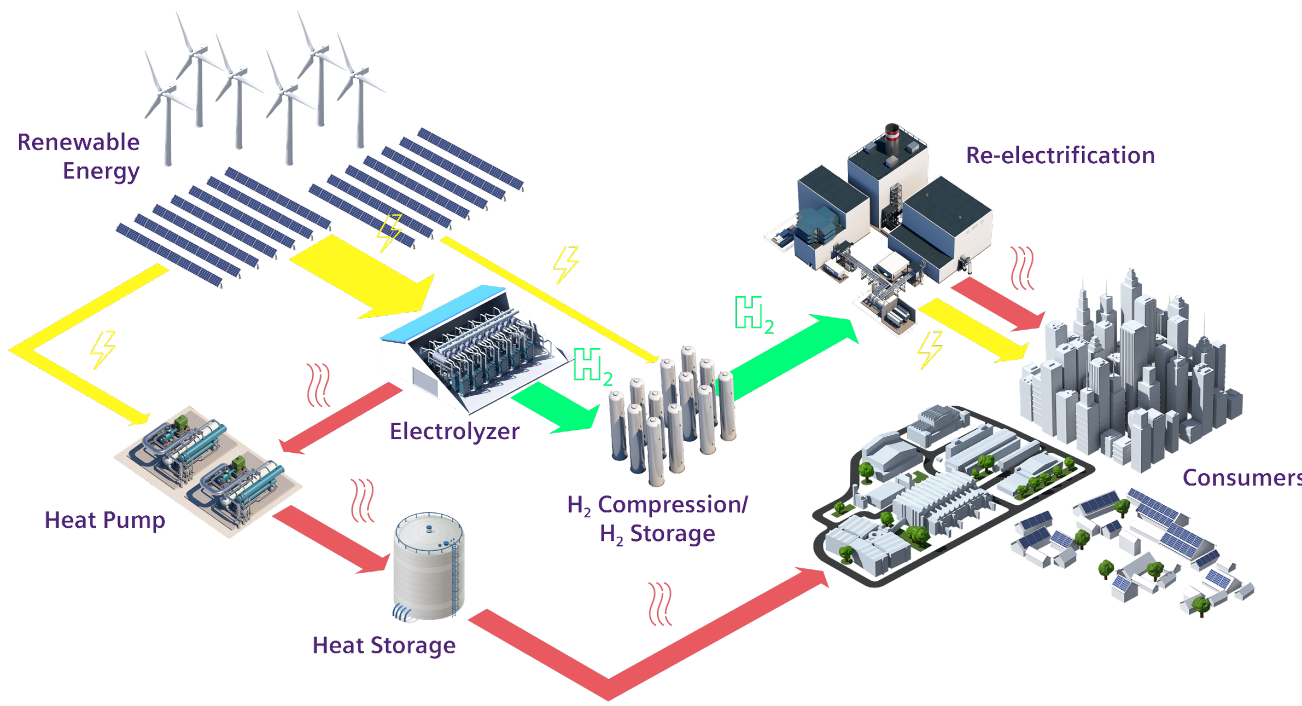


Figure 2: Sector coupling scenario including decarbonized heat

02 Hydrogen and biofuels

Clean fuels, like green hydrogen or biofuels, can significantly lower CO_2 emissions and eliminate fossil fuel dependency in gas turbines. This approach is an effective way to future-proof CHP plants and maximize their lifespan.

Hydrogen

Our hydrogen power plants include use cases for newly built as well as existing installations. Our goal is clear: we support our customers with their hydrogen ambitions, whether for existing or new units, and we can help with creating a roadmap to a full hydrogen power plant.

The hydrogen power plant can be customized to your project-specific needs. Find out how much carbon footprint you can reduce by burning green hydrogen in your gas turbine. Calculate your CO_2 reduction and cost-savings potential on carbon certificates.

→ Hydrogen decarbonization calculator

Figure 3: Siemens Energy hydrogen power plant

H_2 fired CHP may play an important role in future energy systems.

Competitivity of the technology will depend on:

- Availability and cost of H_2
- Cost of natural gas
- CO_2 certificate prices or taxes

Biofuels

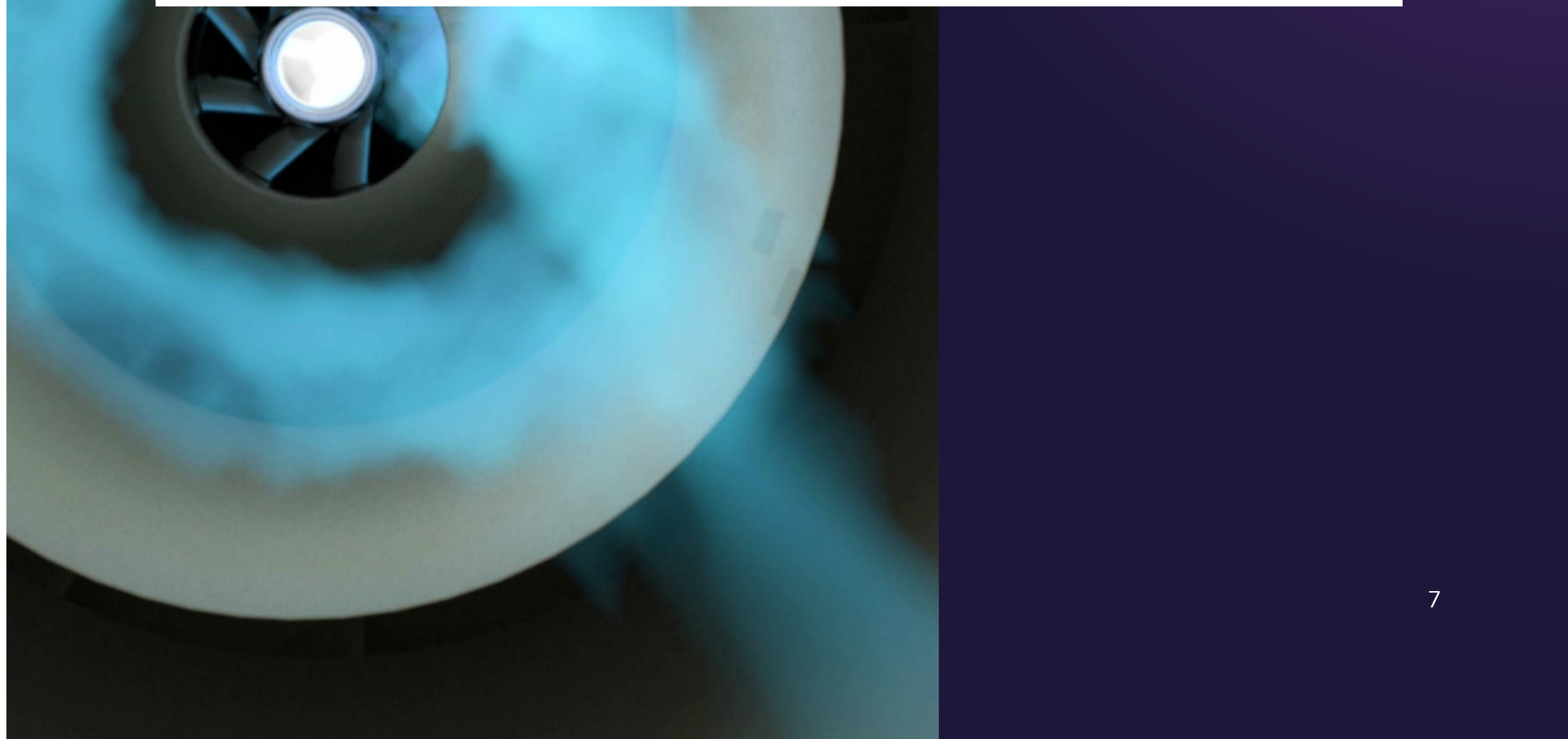
Biofuels like biogas, biodiesel, biomethanol and bioethanol are other important decarbonized fuels and part of our gas turbine R&D roadmap at Siemens Energy. Shift to operation with new greener fuels can be done in new and already existing gas turbines.

Biogas

Biogas is suitable where existing gas infrastructure is in place and can be blended with natural gas in a transitional phase. Flexible mixing of hydrogen with biogas also strengthens the gas turbine competitiveness as it allows the installed gas turbines to operate also when hydrogen is expensive.

Liquid biofuels

Liquid biofuels are suitable for back-up or peaking applications, especially where no gas infrastructure is in place, like in remote applications and island grids. Liquid biofuels can also be a backup fuel to natural gas, hydrogen or biogas. That way, the storage capacity for the gas can be dimensioned for the normal operational profile, while liquid biofuel can be available for more unusual events and provide an alternative in cases of interruption of gas supply.



03 Biomass

Another decarbonization path is to transform fossil fired heat generation by switching to sustainably produced biomass in CHP plants.

We are looking forward to support you on this journey with our broad portfolio offerings, from steam turbine technology to instrumentation and controls and cyber security solutions.

When adding CCS, biomass- or biofuel-based CHP plants can be further transformed into BECCS (BioEnergy with Carbon Capture and Storage), thus allowing for negative emissions and energy production at the same time.

→ Biomass power plant solutions

04

Electrification of heat with power-to-heat technologies

P2H systems signal a paradigm shift in the capabilities of low-carbon energy systems. Since these technologies can be exclusively powered by green electricity, it allows the integration of renewable energy sources in heat energy production – an integration that is both crucial and long overdue.

There are several technologies used in power-to-heat systems, each with its unique working principles and advantages. The choice of the right P2H technology depends, besides other factors, on the required temperature level. In this document we would like to focus on four different technologies:

Heat pumps

Heat pumps use waste or environmental heat from various sources and raise their temperature level with the help of electricity. Therefore, it is possible to achieve CoP that are much higher than the efficiency of electrical heaters. As a result of their low electricity consumption, their operational cost (OPEX) is significantly lower. Hence, they serve as an excellent option for providing a long-term heat supply.

Heat pumps are suitable for temperature levels of up to 150°C. Temperatures of up to 270°C can be achieved in combination with a steam compressor. Siemens Energy can look back on numerous large heat pumps installed in the 1980s and 1990s, mainly in Scandinavian countries. We have been offering solutions with thermal outputs of up to 70 MW from one unit. Also, the contribution goes beyond mere hardware delivery, we offer tailor-made comprehensive turnkey solutions from conceptual design to installation, commissioning and maintaining large heat pumps by using our own compressor portfolio.

→ Learn more about our heat pumps

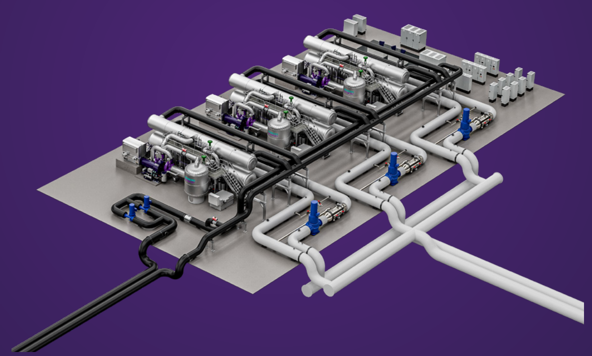


Figure 4: Low-temperature heat pump installation with building

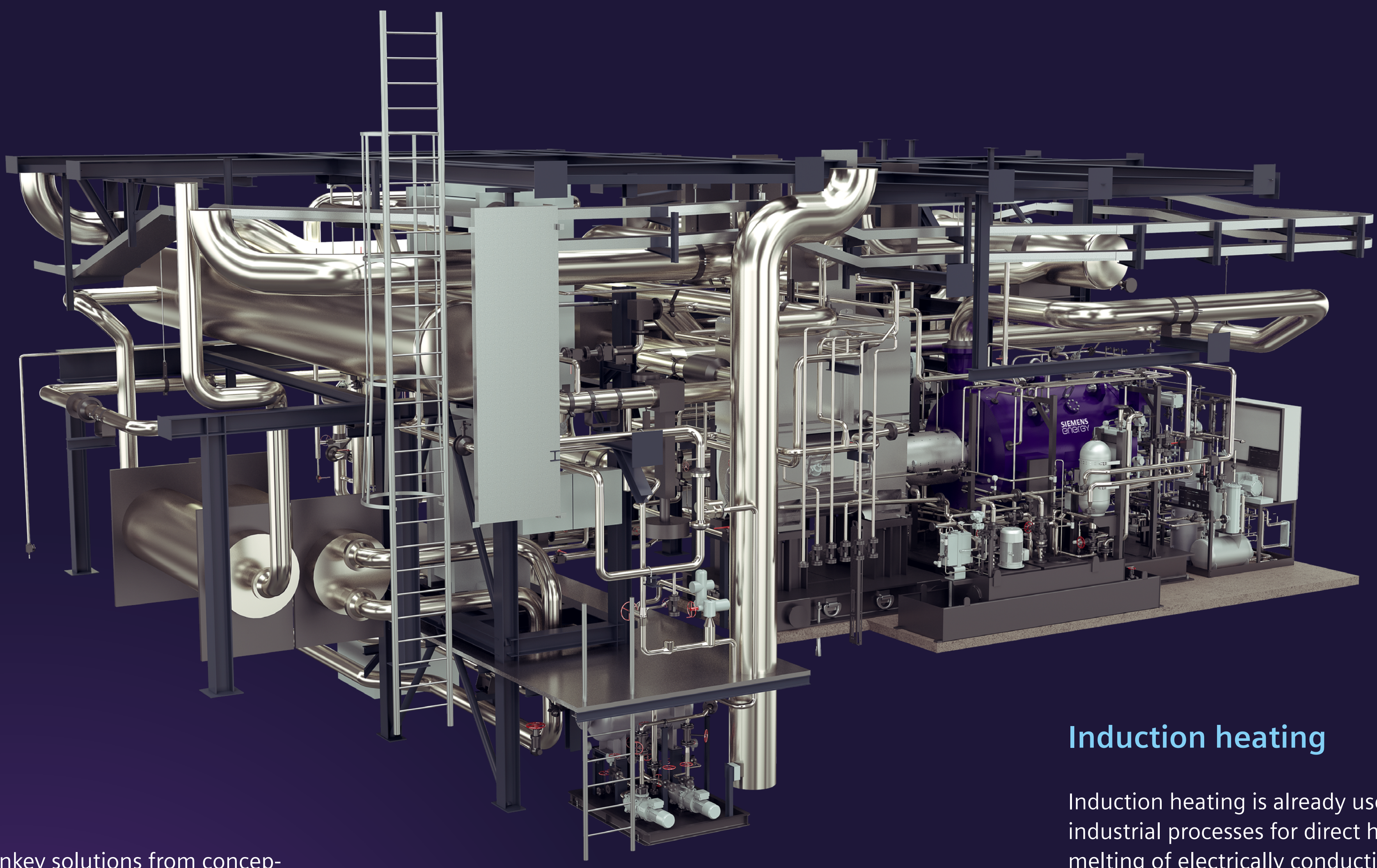


Figure 5: Industrial heat pump configuration for up to 150°C forwarding temperature and 70 MWth

Electrical boilers

Electrical boilers work with heating rods or electrodes. They are a well-established technology, simple, fast to install, and require relatively low capital expenditures (CAPEX). However, despite the fact that their efficiency is close to 100% they consume significantly more power than heat pumps. Electrical boilers can achieve temperature levels of up to 370°C.

Induction heating

Induction heating is already used in many industrial processes for direct heating and melting of electrically conductive materials. With growing pressure for decarbonization of industrial applications solutions for indirect heating of non-conductive fluids or gases emerge. The advantage of this innovative technology are temperature levels of up to 1000°C, compact space requirements, fast heat gradients and limited losses, as it can be directly integrated into the industrial processes.

Turbo heaters

Turbo heaters are another innovative technology for heating up process gases to temperature levels of up to 1000°C. A compressor accelerates the gas to a supersonic level. The resulting shock wave then converts the mechanical energy quite effectively into heat.

What is the best decarbonization option for your heating infrastructure?

For maximum efficacy, it often makes sense to combine different technologies. To make the best choice, there are several factors to consider. One of them is the required temperature level. Others are the need for dispatchable power, green electricity cost, availability of waste heat and annual heat curve. For instance, if you have a lot of renewable energy, it makes sense to consider P2H.

Contact us today to find the best solution for decarbonizing your heat network!

Contact Us

As most of the factors influencing the technology choice depend on the location of the heating network, there is no one-fits-all solution. However, a pre-selection of suitable technologies can be done. The matrix below shows the temperature level that can be achieved with different technologies.

Required heat temperature level	50°C-100°C	100°C-150°C	150°C-270°C	270°C-370°C	370°C-1000°C
Typical use case	District heating 3rd-5th generation Sterilization, bleaching etc. Food & beverages	District heating 1st-2nd generation Industrial distrillation, concentrating Seawater desalination	Chemical- or other high temperature processes Pulp and paper	Chemical- or other high temperature processes	Direct steelmaking manufacture Petrochemical processes (ethylene, styrene) Glas and cement manufacture
CHP	Yes	Yes	Yes	Yes	
Heat pump	Yes	Yes	Yes, with steam compression		
Electrical heater with heating rods or electrodes	Yes	Yes	Yes	Yes	
Induction heating			Yes	Yes	Yes
Turbo heaters or turbocrackers				Yes	Yes

Figure 6: Comparison of technologies for heat decarbonization

Repowering of existing heat production facilities for a decarbonized energy economy

Transforming existing heat infrastructure is an important lever for heat decarbonization. This can either be done by repowering heating plants or pure power plants into cogeneration plants. Alternatively, you can convert an existing heating or CHP plant into a P2H (Power to Heat) application.

For such undertakings we have developed our brownfield transformation approach. It is a holistic approach to decarbonize legacy plants within a short time frame and with reduced permitting efforts while saving costs by re-using as much of the existing infrastructure as possible.

We start where you are!

We know that power- and heat producers and industries have different starting points and move at different speeds on their energy transition journey. That's why, no matter where you are, we help you pick up speed on your road to decarbonization be it during the concept state, technically or exploring different financing models.

Our experienced service team is ready to assist you in deciding which solution is the right one for you. Please do not hesitate to contact your local Siemens Energy representative for further information.

Visit our Customer Energy Portal cep.siemens-energy.com or our webpage siemens-energy.com.

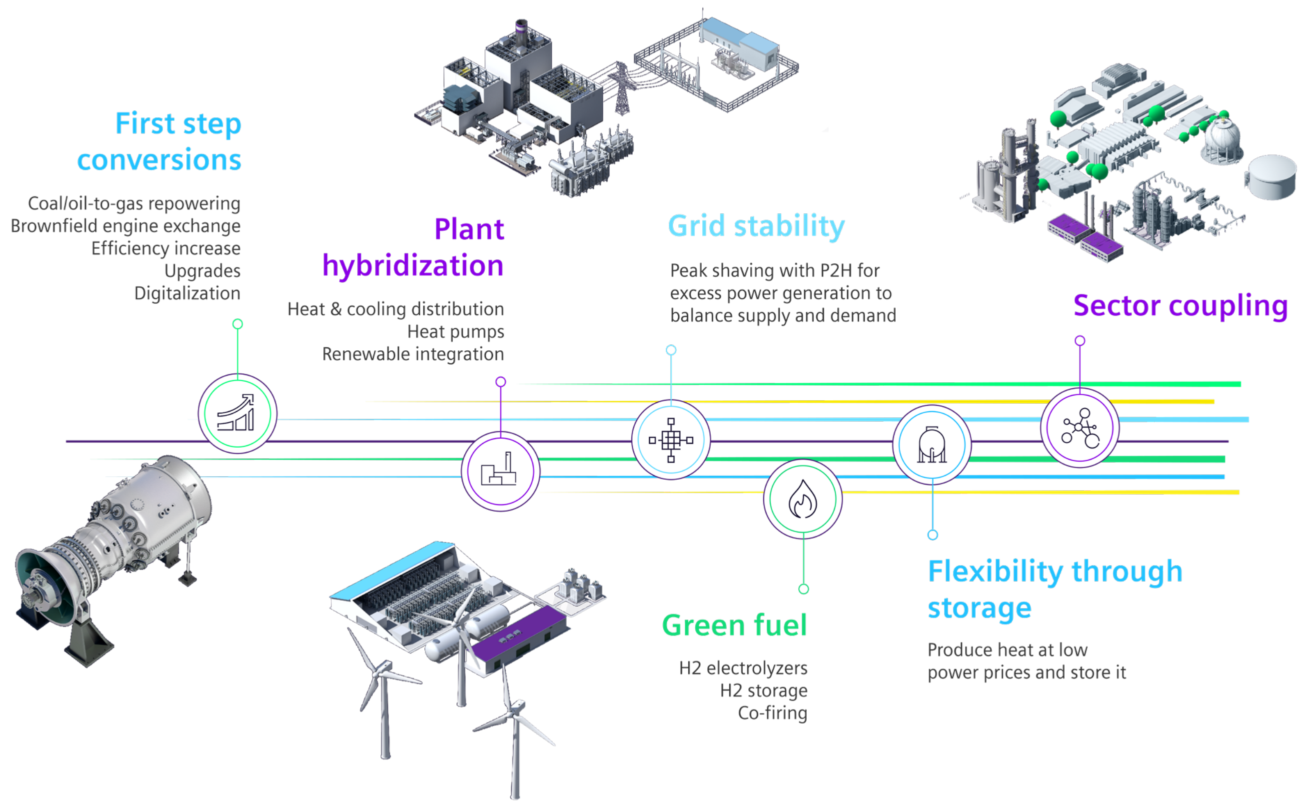
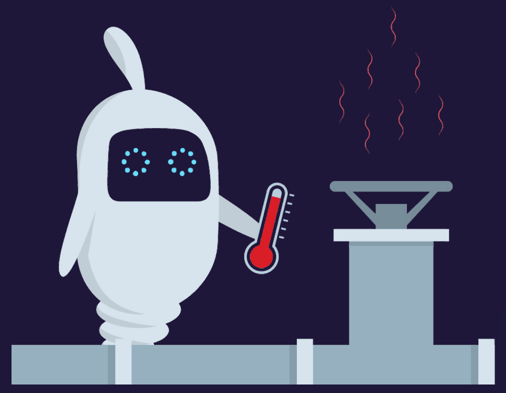


Figure 7: Decarbonization pathways for heat systems



Low carbon heat examples

The numerous advantages of P2H and CHP make it an ideal solution for an even greater number of possible applications.

See how businesses across the globe benefit from Siemens Energy products, from district heating in China to textile manufacturing in Mexico:

01 I Mexico

CHP in Mexico's textile industry

SGT-750 for Grupo Kaltex in Mexico | Siemens Energy Global (siemens-energy.com)

02 I Germany

Heat pump application for district heating in Mannheim

MVV Mannheim heat pump | Siemens Energy Global (siemens-energy.com)

District heating from waste heat in Berlin

Making the Most of Waste Heat | Siemens Energy Global (siemens-energy.com)

03 I Sweden

Biofuels in CHP plants in Stockholm and Gothenburg

Green fuels | Distributed Power Generation | Siemens Energy Global (siemens-energy.com)

04 I China

Replacing coal-fired CHP with highly efficient and low-carbon CCPPs in the Guangdong-Hong Kong-Macao greater bay area.

Siemens Energy to supply F-class gas turbines to power China's Greater Bay Area development | Press | Siemens Energy (siemens-energy.com)

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