Improving the Efficiency of Process Heating Systems

How existing process heating systems can be modernized through heat recovery, electrification, and targeted retrofits - without the need for complete replacement.

AURA PROCESS HEAT

Introduction and Overview

Many industrial process heating systems were designed under operating conditions that no longer apply today. Rising energy prices, increasing CO_2 costs, stricter emissions requirements, waste heat utilization, and expanding documentation obligations have significantly changed the operating environment. At the same time, replacing an entire system is not always the most economical or technically appropriate solution.

This white paper explains how existing process heating systems can be modernized through targeted measures, without the need for complete replacement. It focuses on **heat recovery, electrification, targeted retrofits, as well as service, maintenance, and technical optimization.**

Its purpose is to provide operators with an **initial framework** for evaluating their options: Which modernization measures should generally be considered? When is a technical assessment worthwhile? What role do energy efficiency, emissions, regulatory requirements, and funding eligibility play? How can operators determine whether an existing system should be optimized, expanded, or gradually retrofitted?

Does any of these situations sound familiar?

Energy consumption

The system operates reliably but consumes too much energy.

Waste heat

Flue gas or exhaust air is discharged without being utilized.

Emissions

Emission limits must be complied with.

Cost-saving measures

Major capital investments are currently not feasible.

Regulatory requirements

Documentation requirements and new regulations require action.

Future readiness

It is uncertain wether the system will remain economically viable over the coming years.

Learn which modernization options are available for your existing process heating system and which key questions operators should answer before implementation.

Introduction

Many industrial process heating systems were designed under operating conditions that are very different from those of today. Energy prices were lower, CO_2 costs played a much smaller role, waste heat was often regarded as an unavoidable loss, and sustainability requirements were far less specific. These conditions have changed.

Today, operators of process heating systems face a much more complex challenge: the system must continue to operate reliably, investment costs should be kept to a minimum, energy consumption and emissions must be reduced, regulatory requirements must be met, and production should not be put at unnecessary risk.

Especially in times of economic uncertainty, replacing an entire system is not always the most obvious first step. In many cases, the existing system is still in good technical condition. However, it may no longer be optimally positioned from an energy, economic, or regulatory perspective.

For many operators, this raises a practical question:
How can the efficiency of an existing process heating system be improved without replacing the entire system?

WHY EXISTING PROCESS HEATING SYSTEMS SHOULD BE RE-EVALUATED

In 2021, industrial heat consumption in Germany amounted to approximately 460 TWh. Within this total, process heat accounted for 68%, making it the largest area of industrial heat demand.
Process heat is therefore a key economic lever. When energy is lost in this area, it has a direct impact on operating costs, emissions, and future competitiveness.
An existing system does not have to be inadequate in order to benefit from optimization. Many systems continue to operate reliably but were designed under previous energy price levels, emissions requirements, and production conditions.

Today, this may raise new questions:

- Can existing waste heat be recovered and utilized?
- Can fuel consumption be reduced?
- Are there other processes within the facility that require heat?
- Is an electric or hybrid solution feasible?
- Would targeted retrofits be more economical than a complete replacement?
- Are there regulatory requirements that will become relevant in the future?
- Are funding programs available?

Particularly when investment budgets are limited, it is worth evaluating these questions.
Modernization does not automatically mean a major capital project. In many cases, it begins with a technical assessment of the existing system and a realistic evaluation of which measures are feasible.

FUTURE-PROOFING YOUR SYSTEM

When modernizing existing process heating systems, the goal is not only to achieve short-term efficiency improvements. For many operators, it is equally important to ensure that their system can continue to operate **economically, safely, and in compliance with regulations in the years ahead.**

Future-proofing includes several aspects:

- lower energy consumption,
- reduced emissions,
- improved utilization of existing waste heat,
- compatibility with new energy sources or sustainability targets,
- improved maintainability and ease of inspection.

Regulatory requirements are also becoming increasingly important. Companies with an average annual total energy consumption of more than 7.5 GWh over the previous three completed calendar years in Germany are required to implement an energy or environmental management system.

In addition to technical feasibility, the availability of funding also plays an important role in modernization projects. If an existing system is to remain in operation, funding programs can provide additional leverage to make efficiency measures more economically viable.

For operators, this means that funding opportunities should be considered early in the process, but they should not be the starting point for decision-making. The first step should always be a technical assessment: Which waste heat sources are available? Which consumers could make use of this heat? Which modifications are technically feasible? Would electrification or a hybrid solution make sense?

WHICH MODERNIZATION APPROACH IS RIGHT FOR YOUR SYSTEM?

There is no single modernization solution that fits every process heating system. The most appropriate measure depends on the system, the process, the medium, the required temperature level, operating hours, available space, and the facility's heat demand.

In practice, four main approaches are typically considered:

- Heat recovery,
- Electrification,
- Targeted retrofits,
- Service, maintenance, and technical optimization.

These approaches are not mutually exclusive. In many cases, the most effective solution is achieved by combining several measures. For example, heat recovery can help make better use of existing energy, while optimizing the control system can stabilize operation, or adding electric heating can reduce local emissions.

The key is not to implement as many measures as possible at the same time. Rather, the objective is to identify the measures that best match the specific starting conditions. This first requires understanding where energy is currently being lost, which requirements have changed, and which modifications to the existing system are technically and economically viable. The following pages provide an overview of possible modernization pathways.

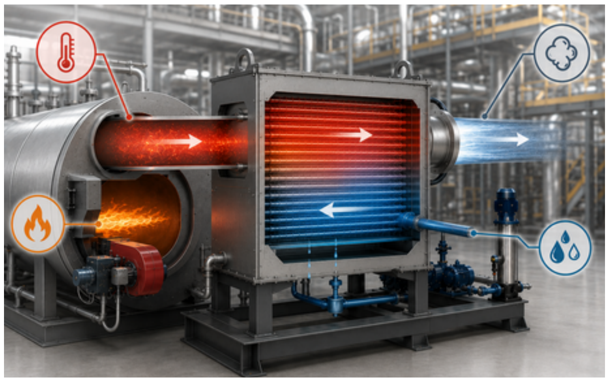
Heat Recovery

Heat recovery is a collective term for technical solutions that make use of heat that would otherwise be lost unused. This heat may originate from flue gas, exhaust gas, exhaust air, or other process streams. Depending on the application, the recovered heat can be used to preheat air, water, thermal oil, or other process media. It can also be integrated into existing process loops or supporting processes.

Heat recovery is particularly attractive when:

- high exhaust gas or flue gas temperatures are available,
- the system operates for many hours,
- suitable heat consumers are available,
- significant energy losses can be identified,
- the existing heat generation system is to be relieved,
- fuel consumption and the associated emissions are to be reduced.

Heat recovery can reduce energy consumption, operating costs, and - depending on the fuel used - CO_2 emissions and pollutant emissions, because existing waste heat is reused instead of being discharged unused. At the same time, the topic is becoming increasingly important from a regulatory perspective. Companies are required to avoid waste heat wherever technically feasible and to make unavoidable waste heat usable wherever possible. As a result, waste heat is becoming a measurable and verifiable resource for operators.



FLUE GAS EXCHANGE HEATER

A flue gas heat exchanger utilizes waste heat from flue gases with temperatures of up to 1,200°C and transfers it to a process medium such as water, thermal oil, steam, or air. This returns energy to the process that would otherwise be lost through the chimney. As a result, additional energy demand is reduced, relieving the load on existing heat generation equipment.

From a technical perspective, this application is particularly suitable when flue gas temperatures are consistently above approximately 200°C, continuous gas flow is available, and there is an appropriate heat consumer.

Flue gas heat exchangers can be used in a wide range of applications, including thermal oil and hot water systems, steam boilers, industrial furnaces, dryers, thermal afterburners, gas turbines, CHP units (combined heat and power), engine systems, and other processes with continuously hot exhaust gas streams. Typical applications include heating thermal oil, water, or process air, preheating boiler feedwater, or generating process steam.

AIR PREHEATER

An air preheater is a type of heat recovery system used in fired process heating equipment. An air preheater utilizes the residual heat of hot flue gases to preheat the combustion air before it enters the burner. As a result, the burner requires less energy to reach the required process temperature. Fuel consumption decreases, and the efficiency of the fired system increases.

Fired heaters equipped with an integrated air preheater can achieve efficiency improvements of up to 97%. The actual performance depends on factors such as the system design, flue gas temperature, fuel type, operating hours, load profile, and integration into the existing system.

Practical example: Increasing the efficiency of a fired thermal oil system by installing an air preheater

Food industry: Heating edible oil

Heating capacity: 1500kw
Operating temperature: 280°C

Efficiency without: 85%
Efficiency with: 93%

Energy savings: 650,000 kWh/year
Payback period: 22 months

An air preheater is particularly relevant when a fired system is expected to remain in operation for the foreseeable future, or when fuel consumption, CO_2 costs, or emissions are to be reduced.

FURTHER POSSIBILITIES

In addition to air preheaters and flue gas heat exchangers, waste heat can also be integrated into existing process heating systems in other ways. The key consideration is which energy carrier is actually required during operation: steam, thermal oil, hot water, process air, or another medium.

Possible approaches include:

- Generating process steam from flue gas or waste heat,
- Heating thermal oil to supply existing heat consumers,
- Preheating boiler feedwater, process water, or hot water,
- Heating combustion air for drying or combustion processes,
- Integrating waste heat into existing thermal oil, hot water, or steam networks,
- Reducing the load on existing fired steam generators or heaters,
- Utilizing waste heat from gas turbines, engines, industrial furnaces, or combustion systems.

Example: Flue gas-heated steam generator
Thermal energy from hot flue gases is transferred to boiler feedwater, generating usable process steam. The steam produced can supplement existing steam systems and thereby reduce the load on existing steam generators.

Example: Flue gas-heated thermal oil system
Waste heat from flue gases is transferred to circulating thermal oil. The heated thermal oil can then supply downstream consumers requiring high-temperature process heat.

Electrification

Electrification can be an effective option when existing fired systems are to be partially or completely replaced, supplemented, or relieved of load. In this approach, process heat is generated electrically rather than through combustion, for example, to heat thermal oil or hot water. Electric heaters are particularly suitable when local emissions are to be reduced, fossil fuels are to be replaced, or processes require more precise control. Since no combustion takes place, there are no direct flue gas emissions at the installation site. In addition, conventional flue gas handling systems required for fired equipment are no longer necessary.

Electrically heated thermal oil and hot water systems offer continuously variable control, a compact design, and can optionally be supplied with explosion protection. Electric thermal oil and hot water systems are available with capacities ranging from 100 kW to 6,000 kW. The operating temperature range extends up to 450°C for thermal oil and 210°C for steam.

When evaluating a potential electrification project, five key questions should be considered:

- Is the required electrical connection capacity available?
- Does the load profile suit electric heat generation?
- How do electricity costs compare with fossil fuel costs?
- Which local emissions can be avoided?
- Is an electric or hybrid solution eligible for funding?

Electrification can also be implemented step by step, particularly in existing systems. A fossil-fuel-fired system does not always need to be replaced entirely. In many cases, adding electric heating, implementing a hybrid concept, or electrifying individual process stages is more practical than a complete conversion.

Electrification is therefore not solely a sustainability measure. It is a technical and economic option that is particularly relevant wherever emissions regulations, CO_2 costs, internal decarbonization targets, regulatory compliance, or long-term future viability are important considerations.

OUTLOOK: ARE HYBRID SYSTEMS A PRACTICAL SOLUTION?

Hybrid systems combine fired and electric heat generation within a single overall system. An existing fired system can be supplemented with an electric heater, allowing process heat to be supplied by the burner, electrically, or through a combination of both, depending on operating conditions.

A hybrid system is particularly beneficial when full electrification is not yet feasible, for example, due to limited electrical connection capacity, high peak loads, or fluctuating energy prices. The existing burner continues to provide security of supply, while the electric heater reduces fossil fuel operating hours and avoids local emissions during specific operating phases.

Retrofits and Optimization

Particularly in existing process heating systems, it can be beneficial to selectively modify, upgrade, or technically re-evaluate individual components. The objective is to continue utilizing the existing system while unlocking additional efficiency potential.

TARGETED RETROFITS

Retrofits are appropriate when a process heating system can fundamentally remain in operation but no longer fully meets current requirements. Typical reasons include new temperature requirements, changes in the heat transfer medium, or a planned expansion of the system.
Possible modifications may involve burners, heat exchangers, piping, pumps, valves, control systems, safety equipment, or instrumentation.

The key advantage is that the existing infrastructure can largely be retained. Instead of replacing the entire system, modifications are made only where there is a technical or economic need. This can reduce investment costs and minimize downtime.

It is important to consider the system as a whole. A retrofit affects more than just a single component - it can also influence temperature control, pressure conditions, control strategies, safety engineering, and maintenance accessibility. For this reason, retrofits should always be planned within the context of the overall system.

TECHNICAL OPTIMIZATION

Efficiency begins during day-to-day operation. Regular service and targeted maintenance help identify wear at an early stage, maintain operational reliability, and prevent unplanned shutdowns.
Technical optimization goes beyond routine maintenance. It also includes evaluating whether the system is operating under the right conditions: Are the control parameters and load profile correctly configured? Are pumps, valves, and instrumentation operating efficiently? Are there unnecessary heat losses? Are spare parts readily available? Does the current documentation accurately reflect the systems condition? Are there indications of fouling, corrosion, or unfavorable operating conditions?

Particularly in older systems, a technical assessment may reveal that relatively small measures can already have a significant impact, for example, improved control strategies, replacing individual components, optimizing maintenance intervals, updating documentation, or adapting the system to changed operating conditions.

Service, maintenance, and technical optimization are therefore not merely supplementary activities, they are an essential part of any modernization strategy. They help operate systems more efficiently over the long term while also providing the basis for deciding whether further measures, such as retrofits, heat recovery, or electrification, are technically and economically justified.

PROCESS HEATING UNDER NEW REQUIREMENTS

Existing process heating systems are receiving increased attention as operational requirements continue to evolve. Rising energy prices, CO_2 reduction targets, investment constraints, and growing documentation obligations mean that systems must not only remain operational, but also become more efficient, better documented, and future-ready.

Particularly for fired systems, efficiency measures must always be considered together with flue gas handling, burner operation, emissions, measurement, and documentation.

Regulatory frameworks are becoming an increasingly important factor in modernization projects. Depending on the country and industry, operators may be subject to requirements relating to energy efficiency, emissions, environmental protection, monitoring, reporting, permitting, or energy management systems. These requirements can significantly influence the technical design, economic feasibility, and implementation of modernization measures.

While Germany, for example, has specific regulations such as the Energy Efficiency Act and the 44th Federal Immission Control Ordinance, other countries have their own legal frameworks and compliance requirements. For internationally operating companies, applicable legislation should therefore always be reviewed on a site-specific basis before planning or implementing a modernization project.

THE MOST IMPORTANT DECISION-MAKING QUESTIONS FOR OPERATORS

Before planning a modernization project, operators should clarify several key questions. These questions help structure the discussion and support informed decision-making.

- Which system or process generates the greatest heat demand?
- Where do visible or known heat losses occur?
- Are there flue gas, exhaust gas, or exhaust air streams with usable temperature levels?
- How many operating hours does the system run per year?
- Are there suitable heat consumers within the same process or elsewhere at the facility?
- Will the system continue to operate over the coming years?
- Are there internal energy, CO_2, or sustainability targets?
- Are there emission requirements, measurement obligations, or permitting issues that must be considered?
- Would a step-by-step modernization be more economically viable than a complete replacement?
- Is the project generally eligible for funding?
- What shutdown windows would be realistic for retrofit work?

Rethinking Process Heating

For more than 40 years, AURA has been developing and delivering industrial process heating systems for demanding applications. With more than 6,000 successfully completed projects, we have extensive expertise in system design, manufacturing, commissioning, and long-term support of customized heat transfer systems.

We also help operators of existing systems identify the most effective modernization opportunities. Our approach is not limited to AURA systems, we also evaluate third-party installations. The key question is always which solution best fits the specific system, the process, the required temperature level, the load profile, and the economic requirements.

Possible modernization approaches range from heat recovery and electrification to hybrid systems, targeted retrofits, as well as service, maintenance, and technical optimization. The objective is not to implement the largest possible number of measures, but to identify the solution that is technically and economically best suited to your system and your process.

We would be happy to assess with you which modernization measures are appropriate for your process heating system.

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