industry: petrochemical refining
author: **dennis long** chief system designer

WATLOW®
Powered by Possibility

Electric Process Heaters Help Decarbonize Petrochemical Refining

The Electric Option:

Petrochemical processes have traditionally been heated with fossil fuels for a number of reasons, but the pressure is building to mitigate carbon dioxide emissions and advance long-term decarbonization goals. Engineers are exploring the potential of electric process heaters to enable all-electric processes, but they often approach the idea with many questions… and maybe a misconception or two.

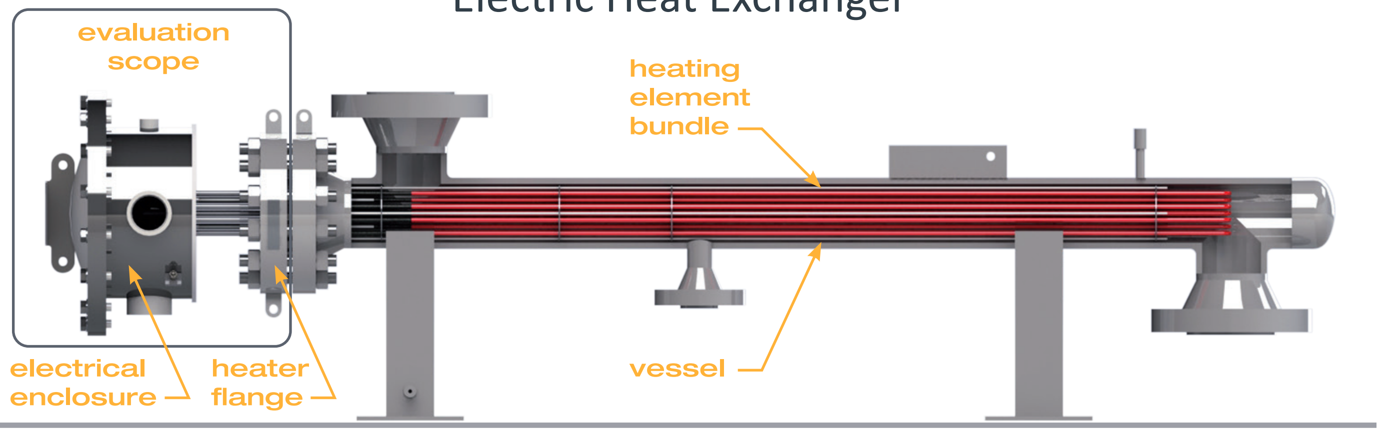
That's to be expected. Fossil fuel heated processes leave big shoes to fill when it comes to thermal processes, so electric process heaters often raise two big questions:

How big can an electric heater be?

What is required to maintain proper control of a large electric heater?

The technology behind process heaters has changed dramatically in the last 10 years, and so the answers to these questions have changed in that time. This is good news for the industry, as electric heaters must be able to provide the same—or improved—performance that petrochemical engineers have come to expect from fossil fuel powered heaters, if we are to make progress towards true decarbonization.

Electric Heat Exchanger



Can Electric Process Heaters Keep Pace With Fossil Fuel-Burning Heaters? The Size Question

To even consider replacing fossil fuel-burning heaters, we need to have a clear understanding of the current capabilities of electric process heaters. For example, replacement does not make sense to begin with if electric heaters do not come with the needed size and power required to heat processes that currently depend on fossil fuels. Many of those processes would require larger electric heaters well above the well-known one megawatt (MW) variety; for example:

- Feed/Product Exchanger, 2 MW (or larger)
- Dehydration Inlet Preheater, 3 MW (or larger)
- Heater Treater, 4 MW (or larger)
- Molecular Sieve Regen, 6 MW (or larger)
- Waste Gas Heater, 6 MW (or larger)
- Once-Thru Steam Generator, 20 MW (or larger)
- Crude Heater, 28 to 200 MW (or larger)
- Hot Oil Heater, 32 MW (or larger)
- LNG Vaporizer, 34 MW (or larger)
- Thermal Oxidizer, 54 MW (or larger)
- Hot Water Heater, 56 MW (or larger)
- FCC Heaters, 150 to 200 MW (or larger)

Fortunately, heaters do exist that can handle these power requirements. In terms of physical size, 60-inch NPS tubesheets are highly attainable. Nothing prevents even greater size; the technology exists to produce electric heat exchangers of physical size comparable to a shell and tube heat exchanger. An electric heat exchanger of the same physical size (as a shell and tube) will have a larger available heating duty, due to the constant heat flux technology.

With equipment of this size, a single vessel can have two heat exchanger bundles. Such a setup can produce a single process vessel with a 15-MW duty rating or more. The few suppliers providing electric heaters at this scale can raise or lower the duty rating as technical requirements dictate. This kind of size and power presents a viable alternative for operations currently fired by fossil fuels.

Besides reducing the use of fossil fuels, electric heaters and heat exchangers have other well-documented advantages as well:

- Less thermal lag: Temperature is controlled through direct application of electricity.
- Safer operation: No fossil fuels to burn or combust.
- Smaller overall footprint: Constant heat flux capability results in a smaller footprint as compared to the non-constant heat flux in shell and tube heat exchangers.

What Is Required to Maintain Proper Control of a Large Electric Heater? The Control Question

Simply put, most engineers have never seen electric process heaters and heat exchangers of these sizes or capabilities. So, naturally, some of the most common questions about larger process heaters have to do with control. What additional elements are needed to ramp up the heater? How does that affect the existing electrical system? How is temperature monitored and controlled? What additional safety precautions are needed?

Just because larger electric heaters have not traditionally been used to heat all processes in the petrochemical industry does not mean that the technology is theoretical or untested. Far from it: Field-proven power switching devices have been in use for low voltage electric process heaters and electric medium voltage motors in a number of industries for years, and the ability to control voltage is well established.

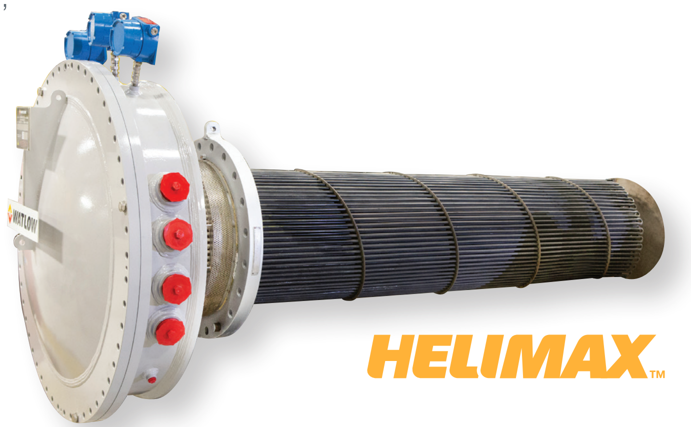
PLCs and similar power management systems bring heaters online in ways that do not cause problems for other devices connected to the same power source. The heater and controller are part of one closed-loop system, which streamlines integration and yields more control over the entire system. This technology's tried and true nature in other applications reduces the risk for petrochemical process heating.

New Technologies Driving the Energy Transition in Thermal

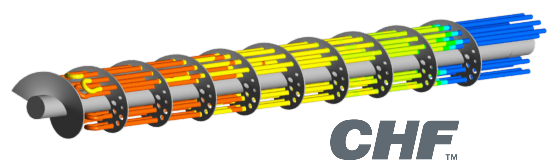
With these two common questions now answered, it is worth taking a closer look at some of the technologies that make electric process heaters and heat exchangers promising candidates for replacing more traditional heaters.

HELIMAX™

HELIMAX™, with its ***Continuous Helical Flow (CHF) Technology™***, is playing a critical role in making large electric process heaters more robust and economical. With CHF, the baffles with the heater do not exist as discrete elements, but rather as a single continuous spiral winding around the interior of the shell side of the heater. This further forces the flow to be rotational and helical, resulting in an even better heat transfer coefficient per unit pressure drop compared with more traditional segmental baffles.

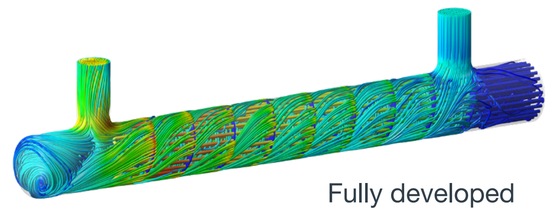


Heaters with Continuous Helical Flow Technology, including Watlow's ***HELIMAX***, do not have dead zones, or areas with insufficient flow. Because there are no disruptions to flow, there is dramatically less likelihood that hot spots can develop. Without hot spots or dead zones where material can collect and adhere, the potential for greatly reduced fouling rates can be realized. The improved heat transfer compared to legacy technologies also means that these heaters can have a much smaller footprint, thus allowing the process machinery to make a much more efficient use of space.



CHF™
Continuous Helical Flow Technology

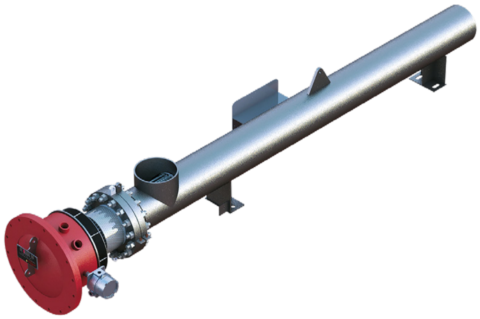
A single removable ***HELIMAX*** bundle can supply up to five megawatts of power duty range, even with a smaller footprint, than fuel-based heat exchangers. Combine this efficiency with the reduced need for maintenance to address coking, and you have a product that increases productivity even as it contributes to decarbonization efforts. This ultra-efficient heat exchanger also has a reputation for lasting longer and avoiding system failure because it is not as susceptible to fouling.



Fully developed flow pattern

Increasing Watt Densities

Watt density is the heat flux emanating from the effective heater surface. A heater's watt density rating is used in thermal calculations to determine approximate heater skin temperatures in the application; the maximum watt density rating is normally associated with the highest allowable skin or film temperature in thermodynamic calculations. Higher watt density ratings allow equipment to be designed smaller, thus lowering capital equipment costs, keeping costs down and reducing the overall footprint while meeting temperature requirements.



OPTIMAX®

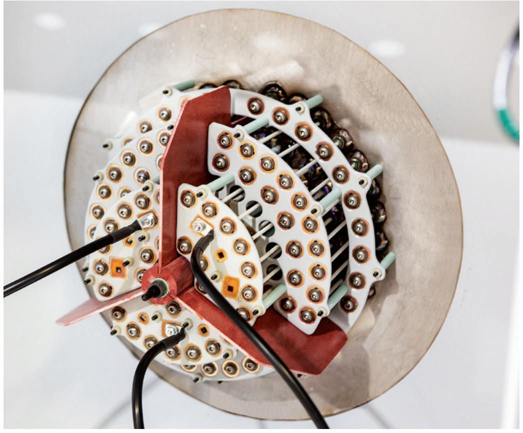
Watlow® has done extensive testing over many years, on both traditional heater designs and on designs with enhanced heat transfer performance features (such as our own ***OPTIMAX®*** and ***HELIMAX***), showing that smaller heater package designs using higher watt densities will always meet critical specifications for sheath temperature, shell temperature and other customer constraints.

Integrated Control Systems

Large, modern electric heaters also require modern control systems. Selecting the appropriate thermal control system is paramount to safety, as well as to the longevity of the heater. It is crucial to have fast, reliable control systems for all heat exchangers, especially in a field such as petroleum processing, where errors can be extremely costly.

POWERSAFE™

POWERSAFE™ is a medium voltage heating and control solution. It combines both the electric heat exchanger and control system. Better still, the system has been proven to operate safely and reliably even at 4160V and higher. It also offers a flexible combination of a silcone controlled rectifier (SCR) and contactor circuits up to 25 megawatts within a single control package, delivering high-efficiency power greater than 99%, which reduces the overall size and weight of the power controller solution. Medium voltage connections result in much lower amperage as compared to low voltage, so the end user realizes much lower connection cabling costs. The significant installation cost savings are not the only benefits of ***POWERSAFE***, either.



POWERSAFE™

POWERSAFE meets strict requirements for safety and reliability. The system offers a high-speed protective relay, rapid shutdown breaker, optimal fluid dynamics and safety interlocks to maintain control over a wide variety of thermal processes. These qualities make ***POWERSAFE*** a clean, safe and long-lasting asset for engineers tasked with decarbonizing thermal systems. Efficiency and longevity make this clean electric solution a strong choice for replacing fossil fuel solutions.

But Is the Cost of Electrification Justified?

Given that electric process heaters are a proven alternative to fossil-fueled heaters for a number of petrochemical processes, their role in energy transition becomes a question of cost. There are three primary types of expenses to consider when transitioning to electric power: **1)** Capital expenditure, **2)** operating expenditures and **3)** human learning expenditures.

1) Capital Expenditures to Change Equipment

The equipment itself is the first significant cost associated with electrification. Beyond the cost of new equipment, there is also the cost of integrating electric process heaters into the existing electrical grid and ensuring their smooth operation, including technology to store electricity that comes from renewable sources as well as control technology to ensure that the local grid is not stressed or overloaded.

If a business needs a new process heater immediately, sticking with fossil fuels might save money in the short term. However, there are a number of drivers forcing the industry's hand when it comes to electrification, and so more needs to be considered than just short term costs. That said, the capital cost of electric process heating equipment systems is typically very competitive with the cost of fossil fuel heated system technologies.

2) Operating Expenditures: Clean Energy Storage and Grid Integration

The operating expense of electrical process heating equipment is almost completely tied to the cost of electricity. Currently, the cost of electricity is typically higher than fossil fuels such as natural gas. That said, the routine maintenance cost of electric heating systems is typically lower than a natural gas or similar fired system. Electrical systems have no burner to maintain, and the heat exchanger bundle cleaning schedule is typically the same as a non-electric shell and tube technology.

3) Human Capital and the Learning Curve

Finally, there is the question of human capital and the availability of relevant engineering expertise. Manufacturing processes with fossil fuels are ubiquitous, as is the equipment that runs said processes. Additionally, while most companies will have electrical engineers on staff familiar with large electrical equipment such as motors, not all will have extensive field experience with electric process heaters. This means something of a learning curve—though that learning curve is much easier when an organization can team up with a knowledgeable partner.

Cost Incentives Are Not the Only Incentives

The low cost of fossil fuels has traditionally meant that there was little incentive to consider electric heating alternatives for anything other than small applications. Today, the legal and social ramifications of not decarbonizing are heavy enough that there are growing incentives to make the transition to renewable electricity, as far as possible. For example, many countries and states have already adopted government mandates and incentives around carbon footprint reduction. Calls for decarbonization are coming not just from governments and regulatory bodies, but also from the general public and even the financial sector.

The pressure to reduce emissions leaves little doubt that electrification of process heating will continue to become more prevalent. Of course, every organization will have to factor in their own local regulations and incentives. The math might look different in each instance. But transitioning thermal processes to electric heaters and heat exchangers is a huge step in the right direction. Many organizations are investing in electric process heating systems even as fossil fuels still provide a more cost-effective option.

Takeaways:

An informal survey of Watlow customers and prospects has revealed that a full 90% of oil and gas leaders are already actively engaged in decarbonization efforts. Oil and gas companies are no longer focused on if they should decarbonize, but how they will decarbonize.

Now is a good time for engineers who are not already familiar with electric process heating systems and heat exchangers to introduce themselves to new technologies. Gaining familiarity with electric process heating systems now will reduce the burden of energy transition later.

Specifically, engineers are realizing two things. First, there are far more opportunities to use electric process heating systems—and with far fewer size constraints—than energy and environmental engineers previously imagined. Second, control of these megawatt size heating systems is demonstrated in field applications, with precise control of process and skin temperatures.

Industry leaders like Watlow are solving the world's most challenging and essential thermal problems. The work includes breaking down the barriers to energy transition to provide clean, efficient and reliable ways to electrify processes traditionally heated with fossil fuels. Working with a reliable partner to electrify process heating systems is one of the surest ways to progress toward climate action goals without interrupting productivity or profitability.