



SUSTAINABLE ENERGY



SUSTAINABLE ENERGY REQUIRES SUSTAINABLE SOLUTIONS

THE FOSSIL FUEL AGE

Advances in technology have led to developing countries consuming energy at an alarming rate, with every year the energy needs of our planet being greater than the year before. Fossil fuels continue to be the dominant source of fuel, leading us to the aptly named Fossil Fuel Age.

Reliance on fossil fuels for energy has its limits, however, and the attributed pollution that comes from them are starting to leave a scar on our planet that may be irreversible. This significant challenge to break away from fossil fuels has brought on great strides of ingenuity and technologies aimed at changing our reliance from the finite, to the sustainable.

At Chromalox, we specialize in zero emission thermal solutions, powered by our innovative technology, to generate heat from sustainable sources like the sun, wind, water, and earth for a complete carbon neutral solution.

THE CHROMALOX DIFFERENCE

Vertically integrated from our core component technologies up through our industrial heating packaged solutions and enhanced by our global on-site services, we provide a comprehensive and complete solution from concept to startup

Our commitment to Sustainability goes beyond just our products. It is the foundation for our core values and demonstrated in

- ▶ Health and Safety
- ▶ Our Workplace
- ▶ Our Supply Chain
- ▶ Our Environment
- ▶ Our Customers
- ▶ Our Communities

LEARN MORE AT WWW.CHROMALOX.COM/SUSTAINABILITY

WITH FIRST IN CLASS THERMAL TECHNOLOGIES, WE DON'T JUST HEAT TODAY, WE ENGINEER PREMIUM SUSTAINABLE SOLUTIONS FOR TOMORROW.



SOLAR

Solar power plants feature a variety of technologies used to harness the power of the sun into direct power for the grid or energy storage.

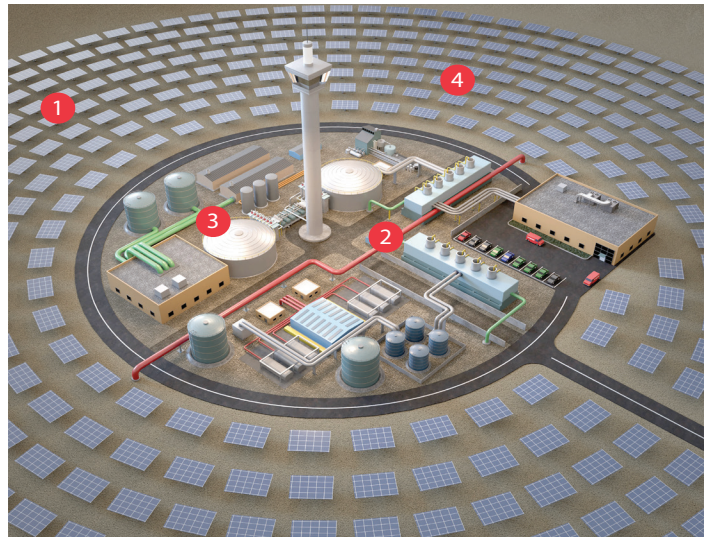
PHOTOVOLTAICS

Photovoltaic (PV) plants utilize large scale panel grids to convert solar energy into electricity, which is then fed to the power grid or to energy storage for later use. Manufacturing PV panels requires a high degree of precision and quality from deposition to curing, drying, and lamination.

CONCENTRATED SOLAR PLANT

Concentrated Solar Plants (CSP) use large mirrors or reflectors to direct sunlight to an absorber which carries a heat transfer fluid. The heated medium flows to a steam generator which drives a turbine to generate electricity or on to thermal energy storage tanks.

- 1 MaxiZone cartridge heaters** provide high precision temperature uniformity and heat distribution which is critical for deposition, drying and curing of solar panels during manufacturing.
- 2 Heat Tracing CSP plants** direct solar energy to absorber pipes which contain heat transfer fluids like thermal oil or molten salts. These fluids must be piped from the receiver panels to downstream processes. Chromalox Heat Tracing and controls ensure proper temperature management along pipelines to prevent losses.



Chromalox electric heaters serve a wide range of thermal processing needs to ensure efficient conversion from solar energy to power

- 3 In-line circulation heaters or storage tank heaters** are used to maintain critical melting point temperature of molten salt for use in thermal energy storage systems. Dropping below its melting point can cause molten salt to freeze up, which is catastrophic to tanks, piping and pumping systems.
- 4 Lamination of solar PV panels** is vital to ensuring they are capable of withstanding the harsh environments they are subjected to. Chromalox Component Heaters are a flexible solution that provides even heat distribution across the panel surface and ensuring a consistent finish.

WIND

Wind turbine plants harness wind to spin a turbine in order to generate electricity. Freezing temperatures and ice build-up are detrimental to the operation of the turbines through excess drag weight, wear on bearings due to shaft imbalance, and even lock-up. Chromalox thermal technologies provide the means to ensure wind turbines continue to operate at peak efficiency despite extreme conditions.

Application	Solution
Freeze protection of wind turbines	Silicone laminate heaters, heat trace, or comfort heaters can all be utilized inside turbine nacelles or blades to prevent ice buildup or freezing.
Application	Solution
Lube Oil Heating	Small immersion style heaters are ideal for preheating of gearbox lubrication oils that allow the wind turbines to operate efficiently, even in colder climates.



ENERGY STORAGE

THERMAL STORAGE

Application:

Maintaining molten salt above its melting point is critical to prevent solidification, which is catastrophic to holding tanks, pipeline and pumping systems.

Solution:

Direct immersion or inline circulation heaters utilizing high temperature heating elements prevents freeze up of molten salt tanks. High quality tubular element assemblies and MI cables capable of processing temperatures to 1100°F can also be used to trace piping, valves and vessels.

Application:

Heating dense solid objects like lava rocks, bricks, or concrete is a valuable way to store heat energy until it can be extracted for steam generation.

Solution:

High temperature Low Voltage or DirectConnect air heating systems are capable of providing the heat necessary for thermal storage systems



REDOX FLOW BATTERY

Application:

Electrolytes used in Vanadium Redox Flow Batteries have varying behaviors depending on operating temperatures. Both the positive and negative electrolytes behave differently, so specific heat requirements may differ between the two mediums.

Solution:

Using tank heaters, in-line circulation heaters and/or heat tracing products allows precise control of the electrolytes to prevent precipitation, increase stability, and improve conductivity which ultimately increases the charge and discharge efficiency of the battery.



LITHIUM ION BATTERY

Application:

Lithium battery storage modules must be maintained above freezing temperatures to ensure capability to recharge and allow the battery to hold a charge for longer durations.

Solution:

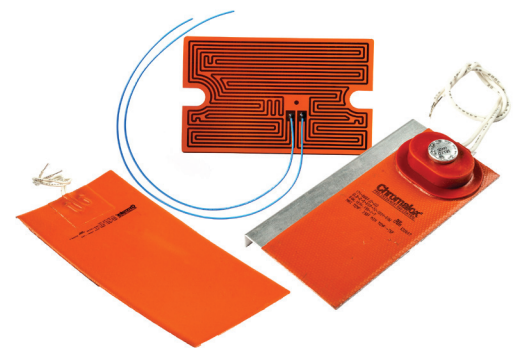
Flex heaters, heat tracing, and enclosure heaters are all possible solutions for maintaining lithium ion battery modules above critical temperatures for peak battery performance.

Application:

Production of the Anode and Cathode requires precise drying conditions dependent on temperature and rate to avoid cracking.

Solution:

Chromalox heat transfer systems can be used to provide stable and accurate temperature distribution to the anode and cathode materials. Using advanced cascade control schemes allow for further control of the drying rate and temperature.

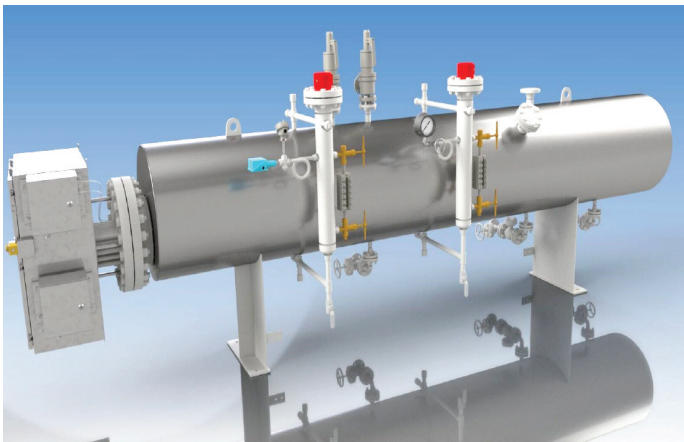


DECARBONIZATION & ELECTRIFICATION

Greenhouse gas emissions come from a number of sources from industrial process to transportation. Increased emission regulations globally are putting more emphasis on the need for clean electric power.

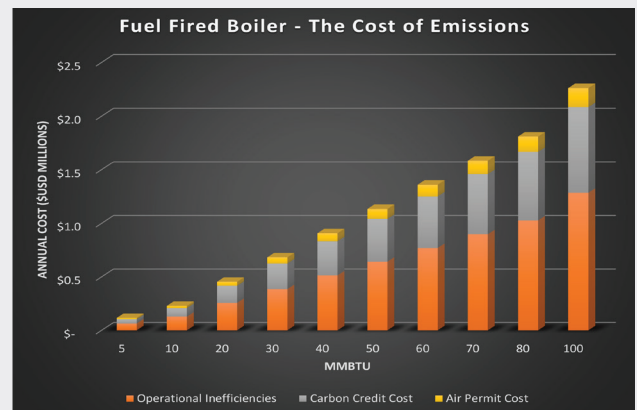
ZERO EMISSION STEAM GENERATION

The process of generating steam utilizing fossil fuel fired boilers is a large contributor to greenhouse gas emissions. By converting those boilers to DirectConnect™ Electric Steam Generators, you can eliminate carbon emissions and simplify your installation, maintenance, and operation.



THE COST OF CARBON

As state and federal legislation continues to put pressure on companies to decarbonize, the annual fees associated with carbon credits or taxes will be an additional cost to bear. With Chromalox zero emission steam generators you won't be faced with taxes, credits, or penalties every year.



RENEWABLE FUELS & BIOMASS


Renewable fuels provide sustainable energy by utilizing vegetable oils, animal fats, recycled cooking grease and other biological materials which are broken down into chemical molecules. Creation of these types of fuels can be done through a number of processes which rely on accurate temperature control.

Application	Solution
Thermal depolymerization reactors to use heat to aid in the breakdown of plastics or organic waste during feedstock creation and fractional distillation steps	Chromalox Heat Transfer Systems and tank heaters are ideal for tight temperature control and direct heating.
Pyrolysis ovens allow steady temperature increases in the absence of oxygen to slowly break materials down into their base molecules	High quality tubular elements or strip heaters are used to easily wrap around drums to preheat solutions prior to further processing
Drums holding oils, fats and chemicals require heating as initial step in biofuel process	Durable and flexible silicone drum heaters are used to easily wrap around drums to preheat solutions prior to further processing
Final biofuel product requires heating to maintain viscosity and keep above the fuel's cloudpoint	Chromalox LTFX immersions heaters allow for large storage tank heating with the ability to replace the heating removal elements
Renewable fuel feedstocks are required to be preheated for proper processing	Chromalox low watt density inline circulation heaters can preheat a wide variety of plant and animal based feedstock without scorching and degrading and allowing for high quality renewable fuel

HYDROGEN

The production of hydrogen takes many forms with varying degrees of complexity, cost, and carbon emissions. Chromalox process heaters are backed by over a century of engineering knowledge and experience, ensuring the right design for your application.

Types of Hydrogen Production Processes	
Brown/Black Hydrogen	Coal Gasification
Grey Hydrogen	Steam Reforming
Blue Hydrogen	Steam Reforming + Capture
Green Hydrogen	Water Electrolysis



Application	Solution
Coal Gasification for production of brown/black hydrogen	Immersion heaters used in fluidized bed systems heat sand or other solid media which then passes heat to a pressurized gas or liquid through the bed chamber
Methane/Steam reforming for production of grey/blue hydrogen	Electric heaters are used in methane reforming reactors as a way to provide uniform heat distribution to the catalyst bed which breaks methane down into pure hydrogen and carbon based emissions. To eliminate added emission from fuel fired systems, electric heaters are a clean alternative to limit pollution.
Water Electrolysis for green hydrogen production	While electric heat is not used in the electrolysis process itself, auxiliary processes such as water storage tanks, KOH/NaOH tanks, preheaters and process piping utilize electric tank heaters or heat tracing in order to maintain suitable temperature levels.
Hydrogen feed gas for turbines and storage	Electric circulation heaters are used to condition gas that is fed to next generation turbines that accept hydrogen/natural gas blends. These plants also utilize hydrogen storage where H2 gas is pumped underground and extracted when demand calls.

AMMONIA

One of the biggest challenges to Hydrogen becoming a dominant energy source, beyond the cost to produce, is its challenge in storing and transporting. For this reason, Ammonia is often used as the storage medium for Hydrogen as it's easier to compress and transport. In addition, Ammonia has numerous industrial and commercial uses from fertilizers to cleaners.

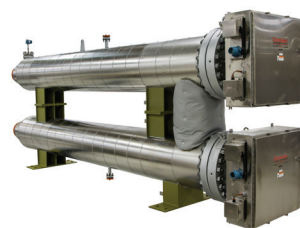
Production of Ammonia first starts with creating Hydrogen through steam-methane reforming or electrolysis process. Once pure hydrogen is created, it is blended with Nitrogen through the Haber-Bosch method to create Ammonia. In this process, Chromalox heaters can provide the heat necessary to improve yield quality.

Since Ammonia is stored at subzero temperatures, it must also be heated prior to its industrial uses. Dehydration of moisture formations is critical, but elevating the temperatures too high risks flashing the ammonia. Let Chromalox's team of skilled engineers work with you on identifying the right solution for your application.

THE FUTURE OF POWER TURBINES

Next generation power turbines are looking at Hydrogen-Natural Gas blends, as well as Ammonia for fuel supply.

Whether feeding process gas directly, or pulling from captured stores, Chromalox in-line circulation heaters are capable of conditioning a variety of feed gases to prepare them for injection into the turbine.



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