Experience a lower total cost of ownership with an electric steam generator

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Figure 1. Modern gas fired boilers carry significant hidden costs including forced production down time, extensive maintenance requirements and emission permitting fees. Source: hxdyl/Adobe Stock

Chromalox's low and medium voltage electric steam generators are an economical and versatile alternative to gas and oil fired boilers.

When looking at fuel costs alone, a common misconception is that gas fired boilers provide the greatest cost savings. But comparison studies often fail to recognize the total cost of ownership. While a highly efficient fossil fuel fired boiler may be rated as high as 85% efficiency, observed thermal efficiency is much lower. Associated emission sensors, pollution compliance requirements, air purges, economizers and blowers expand installation and operational costs. Maintenance requirements and production downtime are also exacerbated by the complexity of fossil fuel fired units.

Electric steam generators eliminate many of the pitfalls of fossil fuel fired units and offer the further benefit of utilizing a sustainable, clean energy source. Resistance style boilers incorporate flanged immersion heating elements to deliver direct heat to fluid medium, achieving nearly 100% thermal conversion efficiency. They require minimal maintenance and reduce production downtime. Electric steam generators are also designed to capitalize on the benefits of renewable and distributed energy sources to provide pollution free steam or hot water generation. An in depth comparison study of electric versus fossil fuel fired boilers illustrates how electric steam generators not only support a zero carbon initiative, but also provide the lowest total cost of ownership.

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Thermal conversion efficiency

Fossil fuel fired boilers

Fossil fuel fired boilers rarely operate at published efficiencies, and actual thermal conversion efficiencies must be considered when evaluating operational costs. Published thermal conversion efficiencies of a fossil fuel fired boiler are provided under the assumption that the boiler is operated at full load, with minimal demand cycling, no seasonal variations, no soot buildup is present on nozzles or boiler tubes and oxygen and fuel mixtures are tightly controlled. Ideal conditions are rarely met and consequently the operating costs are greatly underestimated.

Fossil fuel fired boilers are sized to meet peak demands, but during typical operation are tasked with accommodating changing loads and can only operate within a finite turndown ratio. These step adjustments provide for partial load operation while incrementally lowering thermal efficiency by anywhere from 10% to 50%. In addition, observed burner efficiency of fossil fuel fired boilers is typically 5% to 10% lower than advertised during real time operation. Due to load variations thermal efficiencies are significantly reduced, increasing both fuel and operating costs.

Electric steam generators

Electric steam generators operate more efficiently than fossil fuel fired boilers by providing direct heat to boiler water. This simple design eliminates the need to operate and maintain blowers, pollution control devices, heat recovery equipment and ancillary devices, which all contribute to parasitic energy losses in a fossil fuel fired unit. The thermal conversion efficiency of an electric steam generator is only a function of boiler insulation and heater controllers, which can be designed to optimize thermal conversion efficiency. For every kW delivered, resistive heating elements effectively transfer 100% of the supplied thermal heat into the system.

Operational efficiency

Fossil fuel fired boilers require an electric blower to circulate air to the combustion system. These blowers are quite loud and can change over air two to four times before burners are fired, producing excess waste heat. Start up, cycling, turndown and shutdowns all contribute to efficiency losses. Sizing requirements are also at odds with peak efficiency levels as fossil fuel fired boilers rarely operate at anything more than a 75% duty cycle. While turndown ratios as high as 10:1 provide finite capacity adjustments, each step under full load lowers burner efficiency. In addition, skilled technicians are required to constantly balance boiler operating parameters with varying load demand.

Based on the process demands and calculated thermal loads, electric steam generators can be equipped with either contactors, SCR power control modules or hybrid controllers. These systems are devised to eliminate any amount of hysteresis, increase the response rate to load variations and optimize power consumption in a manner that is practical and economical. This ensures that all power provided is 100% converted to thermal energy, and, since electric steam generators are “unfired” vessels, they can be operated without a technician standing by.

Figure 2. Routine maintenance procedures for a fossil fuel fired boiler include vacuuming and cleaning of radiant tubes. Source: markim/Adobe Stock

Maintenance costs

Maintenance of fuel fired boilers is increasingly complex. Burner nozzles, boiler tubes, exhaust stacks, emission sensors, pollution control devices and heat recovery equipment are all susceptible to failure. Soot and scale build up must be removed regularly to maintain operational efficiency, and, as all devices are integral to operation, a fuel fired boiler is increasingly susceptible to unplanned shutdowns.

For instance, operators require extensive training as there are numerous devices to maintain and failure to operate fossil fuel fired boilers within predefined limits accelerates equipment degradation rates. Routine maintenance procedures are also more involved as cleaning and vacuuming of fire tubes and burner nozzles is paramount to operational efficiency and reliability. In addition, a specialized labor crew may need to be brought in to perform yearly service work due to the hazardous environment and training required. In review, the culmination of advanced safety measures, specialized tools, advanced skill sets, labor costs and training requirements contribute to significant expenditures.

Conversely, electric steam generators are simpler and require less maintenance. Daily blowdown can be completed automatically with the proper components. Simple monthly inspections are performed to monitor electrical contact. Annual overhauls can also be completed in a single day including removal, inspection, cleaning and, if needed, replacement of heater elements. All of the work can be performed by an in-house maintenance staff. When it comes to cleaning and restoration of critical components to maintain system efficiency and extend life

Figure 3. Packaged electric steam generator and hot water boilers are versatile heat sources. Source: Chromalox

expectancy, electric steam generators are clearly the most economical choice.

Production downtime

Scheduled and unscheduled maintenance both contribute to boiler downtime. According to analyst firms, the average cost of unplanned downtime can be hundreds of thousands of dollar per hour. Although both electric steam generators and fuel fired boilers endure a modest amount of downtime for routine blowdown vessel maintenance, electric steam generators provide a distinct advantage.

Complications with fossil fuel fired boilers arise from environmental regulations, system complexity, ancillary equipment failure and mandatory safety precautions for maintaining a “fired unit.” The need for and lack of highly skilled laborers can also further extend production downtime. The time and cost to bring a specialized service crew to a remote site can further extend the downtimes, especially in unplanned outages. Observed downtime of a fossil fuel fired unit is measured on the order of weeks per year.

Electric steam generators are less susceptible to unplanned boiler shutdowns. There are no emission sensors or environmental regulatory bodies to contend with. Corrosive flue gases and soot build up are also eliminated from the system. There are fewer ancillary devices to maintain and required maintenance procedures have a shorter turnaround time. Benefits of an electric steam generator are realized within their first year of operation as they provide for additional weeks of uptime every year.

In short, electric steam generators operate efficiently over a wide variety of loading conditions and for an extended period with little downtime. The streamlined design is easily adaptable to automated operation, which further reduces the risk for shutdowns and provides shorter turnaround times for maintenance.

Total cost of ownership

Annual operating costs of an electric steam generator are significantly lower than fossil fuel fired systems. The thermal conversion efficiency of direct immersion heating elements is greater than 99%. There is no waste heat escaping through the exhaust leg of boiler tubes, maintenance time is significantly lower, and downtime is minimized.

Electric steam generators also provide additional benefits of a zero emission technology. There are no expenses related to pollution control equipment. Emissions permitting fees inclusive of Authority to Construct (ATC) and after construction and demonstration of compliance, Permit to Operate (PTO) are also eliminated, further reducing the total cost of ownership. Furthermore, this does not account for the lengthy permitting process that can cause multi-billion dollar projects to be delayed due to the permitting of a single fuel fired boiler.

In a comparison study of a 10 MBtu/hr (2,931 kW) boiler, fuel costs alone suggest natural gas boilers provide the lowest cost of ownership. However, when operational efficiencies, maintenance requirements, production downtime and pollution compliance costs are factored in, electric steam generators are found to be most economical, providing an estimated annual cost reduction of $2,380,772.

Chromalox electric steam generators

Chromalox packaged electric steam generators and hot water boilers are economical and versatile heat sources that produce low or high-pressure steam or hot water for industrial, commercial and institutional applications. They operate on low (120 to 600 V) or medium voltage (2,000 to 6,900 V) and utilize flange-mounted resistance heating elements. By design, the Chromalox electric steam generator has zero moving parts and allows for efficient steam and hot water generation.

Boiler - Cost of Ownership			
Annual Costs	**Electric**	**Gas**	**Oil**
Fuel based on actual usage	$1,069,414	$442,830	$1,668,459
Maintenance cost	$18,444	$70,860	$71,160
Pollution compliance cost	-	$73,500	$85,500
Production downtime cost	$780,120	$3,640,560	$4,420,680
Installation cost (Average over 20 years)	$50,600	$71,600	$88,950
Total cost of ownership	**$1,918,578**	**$4,299,350**	**$6,334,749**
Lifecycle Cost	**Electric**	**Gas**	**Oil**
20-year life span	**$38,371,557**	**$85,987,007**	**$126,694,975**

Table 1: Electric steam generators not only support a zero carbon initiative, but also provide the lowest total cost of ownership.

DirectConnect™ medium voltage technology

DirectConnect is a proprietary technology developed by Chromalox that addresses installation and lifecycle costs of multi megawatt electric heating systems. The medium voltage, low amperage system delivers unprecedented efficiencies while reducing installation costs, maintenance costs and power losses. It eliminates the need for costly step down transformers, reduces the number of conduit runs required and operates over fewer circuits. A medium voltage system is an ideal solution for applications greater than 879 kW (3 MMBtu/hr).

Enterprise wide electric thermal solutions

Chromalox designs and manufactures a broad line of electric heating, heat trace and control products for a diverse set of end segment applications. Their range of electric steam generators and hot water boilers are complemented by a complete portfolio of component heating solutions. This uniquely positions Chromalox to deliver enterprise wide electric thermal solutions for commercial and industrial processes.

Worldwide distribution channels

Headquartered in Pittsburgh, Pennsylvania, Chromalox maintains six state of the art manufacturing plants uniquely positioned across the Americas, Europe and Asia. With more than 634,000 ft2 of manufacturing space, over 2,000 authorized distributors and approximately 1,250 active employees, Chromalox is well equipped to provide design and engineering expertise, project management, sales and service globally.

Conclusion

Chromalox's low and medium voltage electric steam generators are an economical and versatile alternative to gas and oil fired boilers. They address the need for zero emission steam and hot water boiler solutions, provide the lowest total cost of ownership and are designed and manufactured for easy installation and operational efficiency. Contact Chromalox today for more information on electric steam generators and additional electric process heating and temperature maintenance solutions.

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ABOUT CHROMALOX

At Chromalox, we develop advanced thermal technologies for the world's toughest industrial heating applications. We do it better, and we've been doing it longer than anyone else. We invented electric heating technology. Chromalox started with an innovative solution 100 years ago when a self-taught engineer invented the first metal-sheathed resistance heating element. It was this then-advanced-thermal-technology that launched an entire industry. That pioneering, innovative spirit continues today. Built on opportunity and innovation, Chromalox has grown to serve an increasing number of global markets and industries. We excel in industries that have high expectations. And we are acknowledged as experts at delivering solutions that exceed specifications, limit risk, and reduce operating costs.