Energy Efficiency and Conservation Authority
Te Tari Tiaki Pūngao

Technical Information Document

Electrode and Electric Resistance Steam Generators and Hot Water Heaters for low carbon process heating

Technical Information Document 2019

New Zealand Government

Introduction

An electric steam boiler produces steam using electricity as fuel rather than fossil or biomass fuels. Electrically-generated steam or hot water suits many process applications including food manufacturing and materials manufacturing.

These boilers can also be found in commercial buildings like hospitals and aged-care facilities. The benefits of electric steam and water boilers include simple and easy operation and considerably lower capital and installation costs.

Electrode and electric steam generators are nearly 100% efficient and can closely follow variable loads. They can also have relatively-low upfront capital costs and low operations and maintenance (O&M) costs – especially compared to solid-fuelled boilers. This means that despite their 'fuel' costs being higher per unit than traditional fuels, in some situations their total operating costs can be comparable to, or lower than, other boiler options especially if operating hours are low. Simplicity, small size, and ease of use can also make electric boilers a practical choice for commercial facilities.

Another important feature and potential significant benefit of electric boilers is that they can be located much closer to where the steam is needed. This further lowers capital costs by minimising the amount of steam distribution piping. Reducing or eliminating piping heat-losses lowers operating costs. Hazards from flues, fuel tanks and fuel lines are also eliminated giving a significant safety and space-saving benefit.

Because New Zealand's electricity supply is primarily generated from renewable sources, electric electrode and resistance steam generators offer cost-effective, low-carbon steam for process-heat applications. While application of these technologies has been limited in New Zealand, international experience with electrode boilers demonstrates that they are economically viable in many situations.

Integrating electric boilers with thermal storage can support electricity-system flexibility and resilience, enabling the increased use of intermittent renewable electricity.

Strata ENERGY CONSULTING

Efficient Energy International
Markets • Policies • Results

EECA commissioned Strata Energy Consulting and Efficient Energy International to produce this document which is one of a series on electrical heating.

Technical features

Modern electrode steam generators

Electrode steam generators produce steam by passing an electrical current directly through the water between the boiler's high voltage electrodes. Water's conductivity allows a high current density to produce heat throughout the water and generate steam[1].

Capacities range from 30 kW up to 34 MW and produce steam at up to 40 bar(g) pressure.

Modern electrode steam generators operate at distribution voltages which avoids the need for transformers and use power electronics to enable highly-accurate output-control and minimise the use of heavy contactors. Their steam rate is controlled by variable frequency drive feed pumps which continuously modulate the steam output to match the process' steam demands. Step-free turndown of 100:1 is possible. Electrode steam generators and water heaters can be designed for both single-phase and three-phase operation.

Efficiency and responsiveness

Electrode boilers transfer energy directly to water which makes them very compact and consequently they contain only 20% of water compared to an equivalently-sized combustion boiler. Compared to combustion boilers that have high thermal inertia, electrode boilers have greater flexibility and very high ramp rates and full steam output can be achieved very quickly; typically in less than a minute.

Improved design

Electrode steam generator design improvements avoid the maintenance problems of older designs which lowers operating and maintenance costs.

- Modern electrode boilers do not need the dielectric barriers and special water treatment that earlier models required. Conductivity controllers automatically manage blowdown[2] to maintain water conductivity at ideal levels.
- The output of modern electrode boilers is varied by controlling water throughput using integrated feed water systems and variable speed feed pumps. These features remove the need for adjustable electrodes, packing glands and the electrode shield positioning systems that were used to control earlier model electrode boilers. In conditions of low or no water, the circulation pump has no water available for the steam generation electrodes, so current cannot flow and the boiler ceases to operate making it 'fail-safe' in low water conditions.

A schematic view of a modern electrode steam generator is shown in *Figure 1*. High voltage electrodes pass current through the water to directly heat it. Because of the low-mass vertical pressure vessel configuration, the electrode steam generator delivers dryer steam than most other boilers.

HVJ Electrode Boiler – Operation

A jet-type electrode boiler utilizes the conductive and resistive properties of water to carry electric current and generate steam:

The boiler circulation pump (1) delivers water to the nozzle header (2) where the water flows through the nozzles (3) to impact the energized electrodes (4) and counter-electrodes (5).

These water streams (6) serve as resistive conductors, allowing electric current to pass from the electrodes to the nozzle header. The electric resistance of the water generates heat directly in the water, vaporing a portion of the water to generate steam.

The steam output from the boiler is regulated by controlling the flow rate of water through the circulation pump to the nozzle header. A VFD adjusts the speed of the motor (7) that powers the circulation pump, so that a greater or smaller number of nozzles are supplied with water, and thus, a greater or smaller amount of water contacts energized electrodes. The higher the flow rate of water that hits the electrodes, the higher the rate that steam is generated inside the boiler.

The VFD control reacts according to the pressure inside the pressure vessel- modulating the circulation pump speed to maintain the boiler set-point pressure. If the boiler pressure falls below set-point, the VFD speeds up to Increase the steam production rate until it reaches the set-point pressure.

A secondary control loop prevents the boiler from drawing more than the desired kilowatts when the steam requirements exceed the kilowatt limiting set-point. A third control loop modulates a control valve (8) to regulate the release of steam from the boiler

Source: courtesy RCR Energy

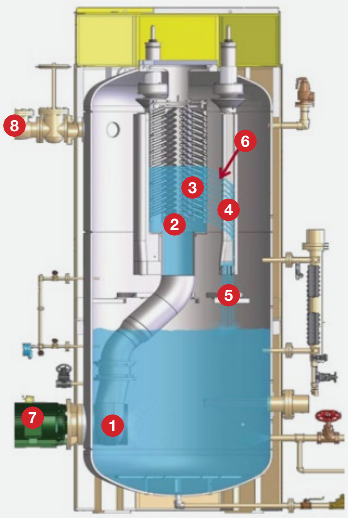

Figure 1. Provides an example of a modern electrode steam generator installation demonstrating its compactness and absence of flues.

1. The conductivity requirements of an electrode boiler's feed water are generally no different than for a fossil boiler. A small quantity of dissolved salt is needed to provide appropriate water conductivity.
2. In other boilers, a small amount of boiler water is deliberately blown out of the bottom of the boiler by steam pressure to reduce the concentration of impurities left in the boiler from continuous evaporation.

Electrode water heaters

Electrode boilers can also be configured to produce hot water rather than steam. The basic construction is similar but for hot water production; boiler feed water is circulated internally at a rate that avoids steam production temperatures being reached at the boiler operating pressure. As shown schematically in *Figure 3*.

Electric resistance steam generators

Electric resistance steam generators produce steam using insulated resistance elements (*Figure 4*) to heat water in a pressure vessel. Banks of immersion elements are automatically staged to maintain the steam pressure in a compact boiler chamber. Elements can be individually replaced making maintenance relatively easy, keeping costs down. The steam generators are compact, supplied with integrated controls, safety and water management systems. Operating voltages are typically between 240 and 600 volts, single or three-phase. As with the electrode steam generator, the low-mass vertical pressure vessel configuration delivers dryer steam than many other boilers.

Figure 2. A modern compact electrode steam generator
Source: Kelford Engineering Services Ltd.

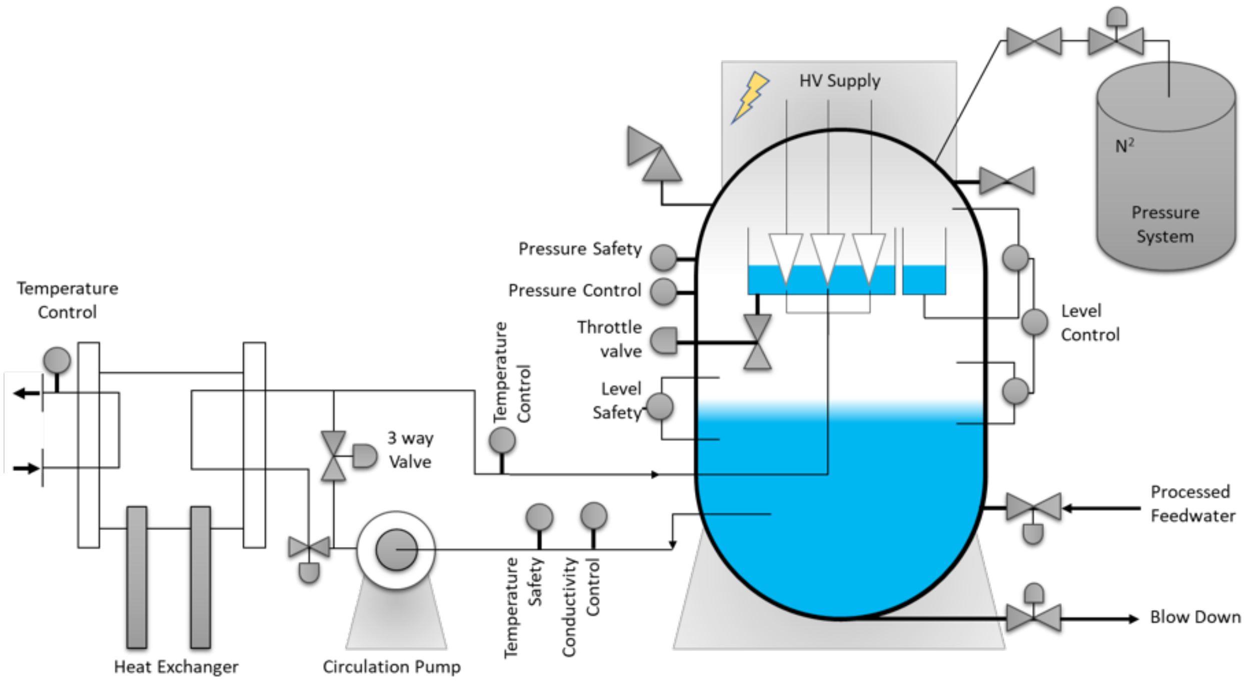

Figure 3. Modern electrode water heater
Source: Strata Energy Consulting Ltd.

Electric resistance hot water boilers

At the small scale (<150 kW), low or mains water pressure electric resistance water heaters are simply larger versions of domestic hot water heaters designed to operate at low pressure. These are often supplied as a basic water heater with the installers adding necessary temperature, pressure, safety and flow rate controls as required by specific installations. Higher pressures and temperature boilers are available and are packaged units with fully integrated controls.

Electric steam superheaters

The steam quality from electrode and electric steam is very dry, however some applications demand still higher temperature steam. An electric steam superheater can be included in the steam supply system to deliver superheated steam. This is similar to a non-storage steam calorifier having a resistance element bundle within the pressure vessel rather than a steam pipe bundle.

Figure 4. Typical electric resistance steam generator and electric resistance immersion elements

Source: Balkrishna Boilers Ltd www.indiamart.com/proddetail/electric-steam-boiler-9056661297.htmlx and Jiangsu Austin Heating Technology Co., Ltd www.hcheater.com

Manufacturers, suppliers and installers of electric steam and water heating systems

In New Zealand electric boilers tend only to have been used for small-scale applications such as sterilisers, humidifiers, and laboratory steam supplies, and have yet to expand widely into process heat applications although a 6 MW system was installed by diary company Synlait in 2019.

New Zealand Suppliers

Devham Services
www.devham.co.nz/html/contact_us.html

Kelford Engineering
www.kelford-engineering.co.nz
(03) 381 44099

RCR Energy
www.rcrtom.com.au

Energy Plant Solutions
www.energyplantsolutions.co.nz

International suppliers

Cleaver Brooks
Thomasville, GA 31792 USA.
www.cleaverbrooks.com/products-and-solutions/boilers/electric/electrode/index.html
info@cleaverbrooks.com

PARAT Halvorsen AS Norway
www.parat.no
www.parat.no/media/201154/Electrode-Boiler-web.pdf
+47 994 85500
office@parat.no

Benefits

Convenience and capital cost
Electrode boilers are compact and can be installed close to heat loads. Capital costs are about half that of coal boilers where 90% of the life cycle operating costs are energy costs.

Efficiency
With negligible heat loss, 99% of electricity is available as process heat. There are no combustion (stack) losses and radiated heat losses from a smaller boiler unit are negligible.

Responsiveness
High controllability, rapid load response and high turndown allow safe operation to as low as 1% of output, meeting peak duty with fast response.

Durability
With few components and with only the water at high temperature, there is little thermal stress and very little heat loss.

Safety
Loss of water self-regulates the electrode current. This offers safety benefits as a lack of water supply simply prevents element operation. Unlike combustion boilers, no part of the electrode or electric boiler is at a temperature higher than the steam.

Network integration
As power networks require more rapid demand response, electrode boilers can offer significant demand response capability when used for peaking, load balancing and reserve applications.

Reduced downtime
Fewer parts and quicker annual surveys (less than a week) mean lower O&M costs.

Dry steam
The vertical structure produces dryer steam – typically about 99.8 % dryness fraction.

Challenges

Energy costs
Despite much lower capital and O&M costs, electricity is relatively expensive compared to other fuels.

Legacy steam system costs
Older, inflexible steam systems have very high losses and O&M costs. Electric boiler options work best when the high operating costs of legacy systems can be advoided.

Electricity supply capacity
Electrode and electric steam boilers may require significant increases in a site’s electricity supply capacity. Although they operate at distribution supply voltages (4 to 35 kV) the additional switch gear, metering and cabling costs can be significant.

Electricity network capacity charges
Capacity, time-of-use and peak demand charges mean electrode and electric steam boilers can incur high peak period charges if steam demand is coincident with other demand peaks. Installing thermal storage can reduce costs and improve the resilience of steam supply to interruptions.

Regulatory requirements
As with any steam boiler, electrode and electric steam generators are subject to Boiler Regulations.

Still have steam-system O&M costs
Scaling still needs to be managed appropriately and feed water treatment is required. Electric steam systems still have operator and inspection requirements.

Application Note

Electric steam generators are used in diverse process-heat applications including: hospital sterilisers, autoclaves, laundries, dry cleaners, steam jacketed pans for heating food, pharmaceutical, cosmetic and chemical products, humidification to air conditioning systems for humidity control, steam injection to bakery and pastry ovens, dairies, tool steel, cable making, research, horticultural soil sterilising, apiaries and steam rooms.

Electric steam generators are well suited to applications with rapidly-varying loads and where there is need for fast response adjustment of steam output. Electric options can reduce costs by producing steam or hot water at the point of use.

Electrode and electric steam boilers are best suited to:

- high energy intensity in small plants, where operating simplicity offsets fuel costs
- processes where the high steam costs, distribution losses and thermodynamic losses of an older steam system justify a distributed electric steam system
- variable loads where the rapid response of electric boilers minimises waste
- sites where steam loads with electrical capacity and demand peaks
- sites where electric boiler steam loads are matched to existing electrical supply capacity
- distributed steam loads where a number of smaller electric steam generator boilers can match demand and avoid central steam system distribution losses.

Common Applications include:

Food processing

An electrode boiler's high turndown capability and ability to match steam output with demand makes the technology ideal for food processing where accurate temperature control is important.

The heating loads of food, dairy and meat processing plants vary significantly depending on the type of process, if the site processes continuously or in batches, and the product characteristics. For batch processes or changing product or shift patterns, the rapid start up (about five minutes) of electrode steam generators avoids the start-up fuel costs, idling fuel-use and labour expenses of combustion boilers. Electrode boilers can respond quickly to load changes and offer precise temperature control, increasing the efficiency of the steam system under real-world operating conditions.

Health care

Health care facilities depend on steam boilers for sterilisation services, a critical function that must have a reliable steam supply. Traditionally this need for sterilisation has shaped hospital campus heating systems, basing them around central steam plant. As these sites change from central steam supply to more efficient space and water heating systems, sterilisation services are often provided by scaled down steam systems, or packaged electric steam generators.

For smaller steam requirements, such as outpatient facilities, a packaged modular electric steam generator offers a more compact footprint and minimises installation costs. These kits include all ancillary plant and feed water systems, blowdown controls, and water conditioners. A resistance type electric boiler is also an option for smaller loads. These are compact designs that require little supervision or maintenance.

Economic considerations for electrode and electric steam boiler applications

Indicative capital and operating costs of electric steam and hot water generators

This section distinguishes small boilers at a few hundred kW with operating pressures around 9.0 bar(g) from large industrial process boilers operating at up to 40 bar(g). The construction, capital costs and operating regimes are quite different in application, but both types are suitable for electrode steam generator options.

Boiler utilisation

At the core of the design of a steam system is the steam demand patterns and the utilisation of the boiler and steam distribution system. High utilisation (continuous shift operations) warrant investment in high capital cost plant that can use lower-cost fuels. Low utilisation applications (only a few hours per day or short peaks) struggle to pay back the higher capital cost of combustion boiler installations and operate at lower efficiency due to poor part-load efficiency.

Figure 5 & 6 show this utilisation – efficiency trend for steam distribution systems. Large plants with continuous use maintain low system losses, but at lower than 40% use, steam distribution system efficiency starts to drop more rapidly.

Boiler combustion efficiency is also affected by utilisation and capacity loadings. While electrode boilers maintain their high efficiency at lower utilisation, boiler efficiency starts to drop off below 40% capacity.

As system utilisation drops the capital cost proportion of the overall cost increases and so low utilisation applications are better suited to low capital cost options such as electrode and electric boilers.

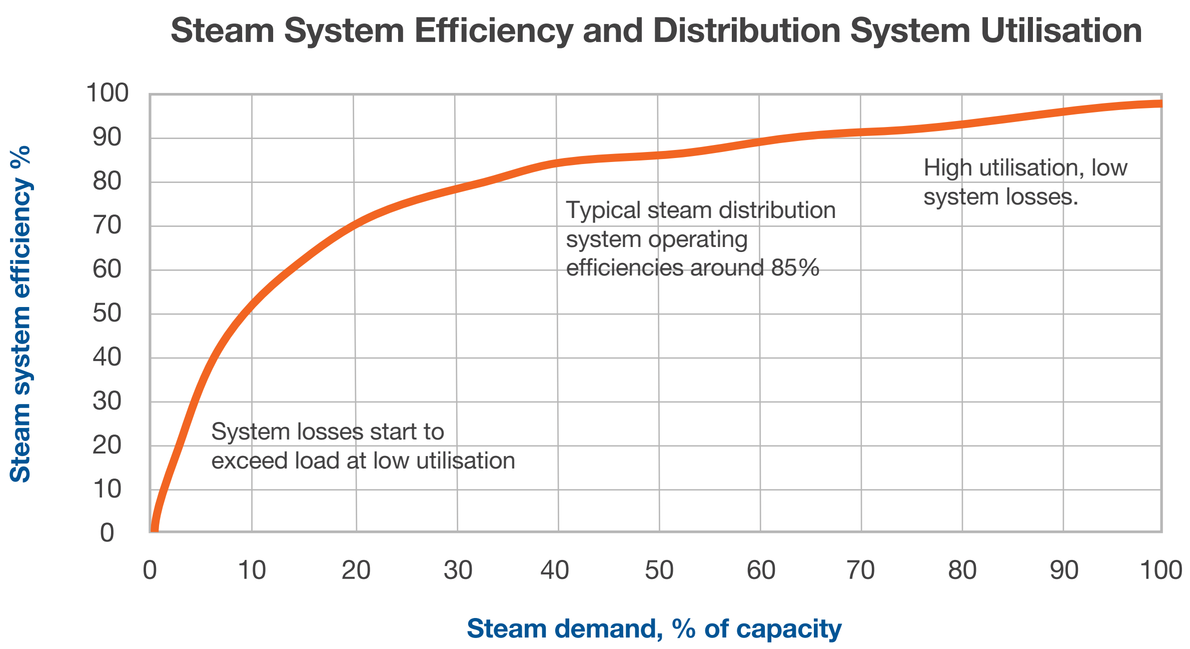

Figure 5. Steam system efficiency at part load utilisation

Source: ec.europa.eu/energy/sites/ener/files/documents/Report WP2.pdf

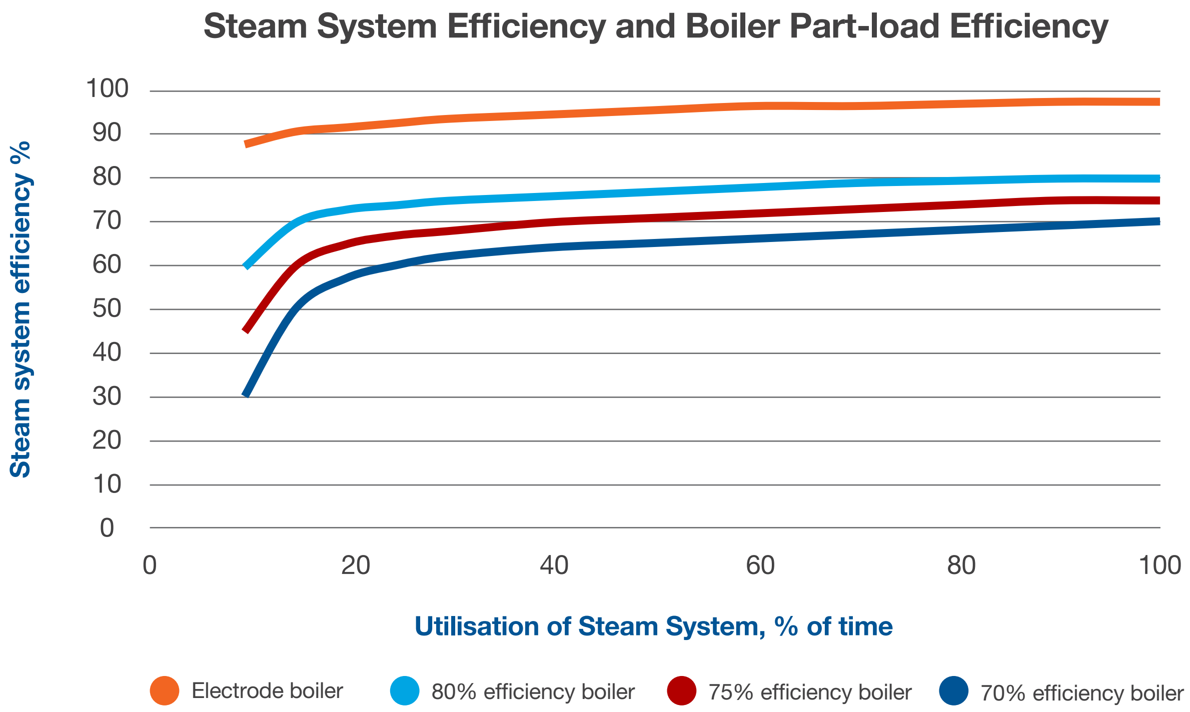

Figure 6. Boiler utilisation and efficiency

Source: Derived from Paules W. R. A Unique DSM Opportunity. EPRI industrial Centre of Excellence Meeting 2010.

Capital costs – Fuel costs and emissions

Trade-offs also exist between capital, fuel costs and emissions. *Table 1* shows the indicative cost of various fuels (2017).

Energy carrier	Unit cost	Cost $/GJ
Coal	$120/t at 20 GJ/t NCV	6
Light Fuel Oil	$0.68 / litre	18
Diesel	$0.80/ litre	21
Industrial natural gas		7
Commercial natural gas		15
Industrial electricity	127 $/MWh	35
Commercial Electricity	167 $/MWh	46

Table 1. Indicative energy prices

Figure 7 summarises the capital cost of heat plant boilers by fuel type, with the costs per GJ of the different fuels. The horizontal axis shows the range of energy costs on a common $/GJ basis (*Table 1*)[3].

- The vertical axis shows different boiler type's budget capital cost per kW .
- The size of the bubbles indicates each fuel's relative emission factor[4].

These prices, and emissions are typical averages and indicative only. Prices vary by locality, quality and delivery options.

Electricity, even if more than 80% is from renewable sources, still has associated CO_2 emissions from thermal and geothermal generation (the outer light green circle). But this will reduce as low-carbon generation replaces retiring fossil-fuelled plants (the inner spot). Solar options have the lowest emissions, no fuel costs, but higher capital costs.

There are clear trade-offs with fuel unit costs and capital costs, and any application requires a full life cycle analysis of the various fuel costs and capital costs for a given heat demand application.

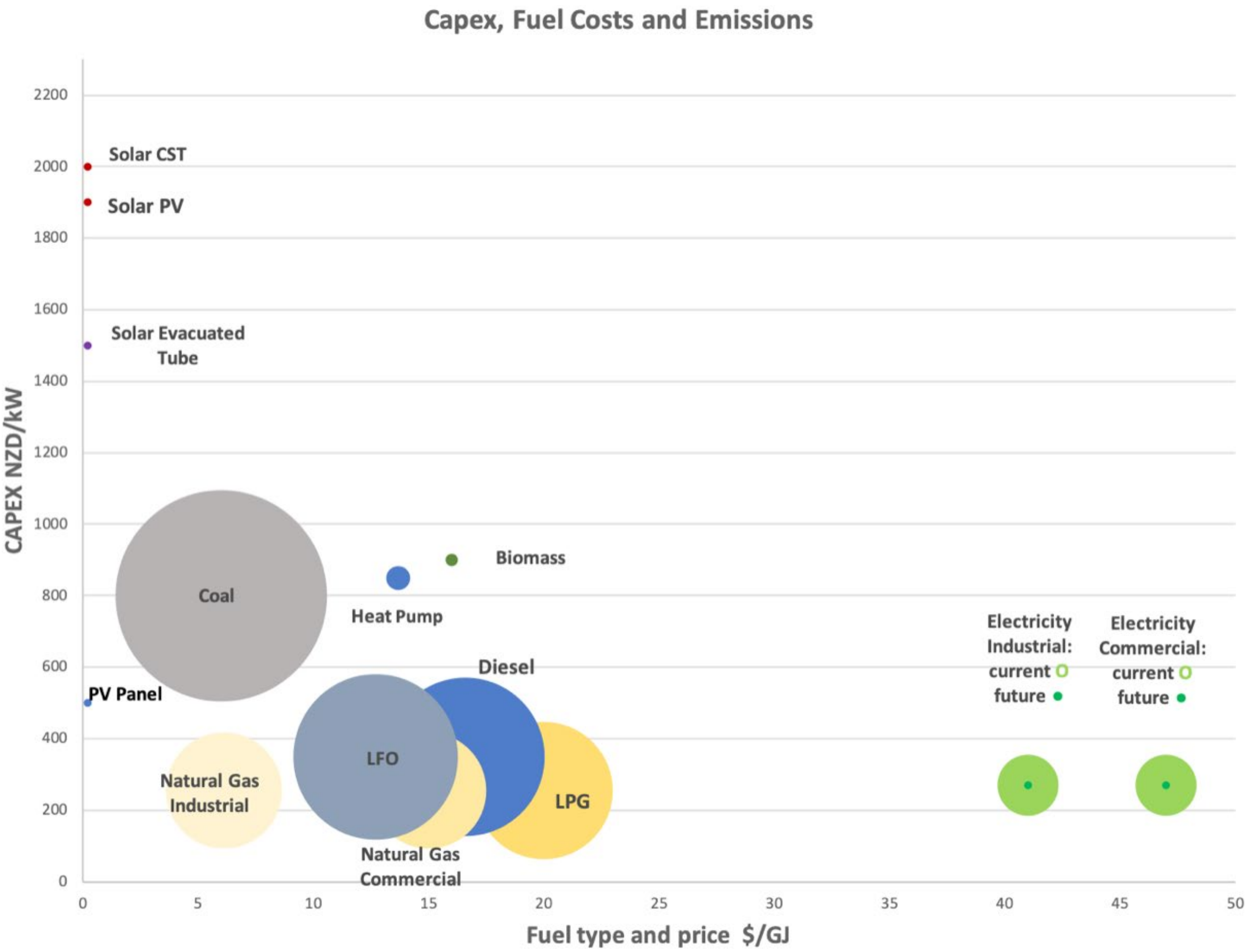

Figure 7. Capital costs - Fuel Costs and Emissions

Source: Derived from data by MfE, RCR Energy, authors.

3. www.mbie.govt.nz/assets/Data-Files/Energy/energy-quarterly-statistics/a4d7f03060/prices-statistics.xlsx
4. See www.mfe.govt.nz/sites/default/files/media/Climate Change/voluntary-greenhouse-gas-reporting-2015-year.pdf for more details on emission factors.

Small low-pressure boiler costs

Each potential application of the technology will have different operating conditions, operational efficiency opportunities and duty cycles, so cost and benefits vary considerably. As a general rule, steam requirements under 300 kW / 440 kg per hr are more economical in terms of initial cost and maintenance with an electric boiler.

Over 300 kW capacity, the lower energy cost of diesel/gas starts to offset the higher installation and maintenance cost of a fuel-fired boiler. *Table 2* outlines the basic capital, installation and transactions costs for a range of smaller steam generators up to 9 bar(g) operating pressure.

All prices in NZ$ excl. GST	150 kW electrode boiler	300 kW electrode boiler	150 kW diesel	360 kW diesel
Packaged boiler	$55,000	$65,000	$45,000	$75,000
Blowdown tank, feedwater tank, flue stack, water treatment plant.	Included in boiler package	Included in boiler package	$27,000	$27,000
Basic boiler cost	$55,000	$65,000	$72,000	NZ$102,000
Cabling and switch gear.	$40,000 for a large switch board, and $300 per metre of cable).	$40,000 for a large switch board, and $300 per metre of cable).		
Boiler house/oil tank, seismic foundations.[5]	$10,000	$10,000	$100,000	$100,000

Table 2. Typical electric vs diesel boiler capital costs
Source: Kelford Engineering, authors.

Steam demand 220kg/h (fuel only)	Electrode boiler Industrial electricity	Electrode boiler Commercial electricity	Diesel boiler (75% effy)	Gas / Coal Industrial (80% effy)	Gas commercial (80% effy)
Energy unit price	$0.12 /kWh	$0.17 /kWh	$1.13 /litre	$6-7 /GJ	$15 /GJ
Energy price $/GJ	$32.3 /GJ	$46 /GJ	$21 /GJ	$6-7 /GJ	$15 /GJ
Hourly cost $/h	$18	$25	$18	$5	$14
Steam cost $/kg	$0.08 /kg	$0.12 /kg	$0.08 /kg	$0.02 /kg	$0.06 /kg

Table 3. Fuel and steam costs for Electrode, Diesel and Gas steam boilers

Operating costs

The fuel cost of steam.

A 150 kW electrode or electric steam boiler running at full capacity of 220 kg/h will cost around $25 per hour in energy costs at an electricity price of $0.17 per kWh, giving a steam cost of $0.12/kg steam. *Table 2* compares this to a diesel and LPG boiler. These costs are exclusive of other operation and maintenance costs.

Note that these figures are indicative, as many aspects of boiler system design, installation, and operation can significantly affect operating efficiency and costs.

5. All boilers, regardless of energy source need a seismic resistant concrete pad designed and certified by a consultant civil engineer or inspection and certification of existing floors as suitable for the boiler.

Operating and maintenance costs.

These vary considerably from plant to plant and can't be generalised. Relative differences between electrode and fuel boilers include:

- an electric powered boiler won't need resource consent for emissions
- the annual maintenance [survey] costs for electric boilers is usually about half that of a fuel-fired boiler. As electric boilers are very simple, there is the possibility of undertaking some of the work in-house. This is not usually the case with a fuel fired boiler
- the inspection cost at survey from a boiler inspector is usually less with electric boilers as there is less equipment to inspect and less to go wrong, because they are simpler.
- the price of electricity relative to other fuels for steam is central to the economics of electric boilers. *Table 2* shows electricity relative to steam supply costs and the corresponding fuel cost for systems allowing for distribution and boiler efficiencies

Economic options for electric boilers are likely to be in:

- sites with low electricity costs
- steam systems with below normal distribution system efficiencies and above normal operating costs
- thermal storage or demand management options to offer cost management and network integration benefits

Large high pressure boiler costs

Large electrode boilers are substantially cheaper than solid fuel boilers (*Figure 8*). Large scale boiler plant has been historically dominated by low cost coal and industrial gas fuel options. Over the past decade, industrial electricity prices have trended down and with availability of large scale electrode steam generators and electricity pricing that promotes demand responsiveness, electricity can be an economic option.

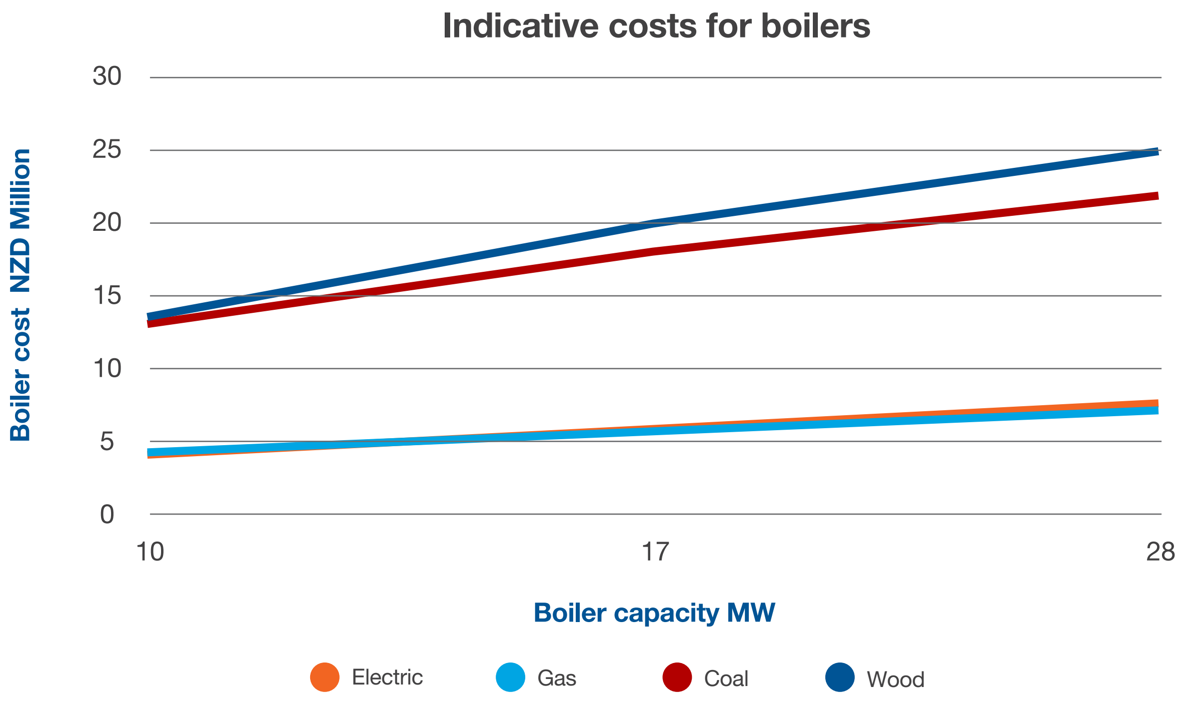

Figure 8. Indicative turnkey costs for large boilers.

The above indicative boiler costs include estimated costs for HV power connection costs, contribution to HV upgrade, related plant, engineering & approvals, allowance for boiler house, foundations & civil works and contingencies.

Electric boiler steam production costs depend heavily of the cost of electricity. *Table 4* show steam costs for a range of electricity prices.

To estimate operations and maintenance (O&M) costs for large electrode boilers allow for one week per year downtime for two days maintenance. Maintenance and spares are estimated at around 1% to 0.7% of turnkey capital costs. This is similar to gas boilers, and compares favourably to the six weeks annual downtime for large coal and biomass boilers where maintenance and spares costs are between 1 and 1.2% of turnkey capital costs.

Electricity Unit Price	$50 /MWh	$70 /MWh	$90 /MWh
Steam cost	$39 /t	$47 /t	$55 /t

Table 4. Steams costs for large electrode boilers

Greenhouse gas emissions reductions

Electric steam and hot water boilers will not directly produce any greenhouse gas (GHG) emissions although some of the electricity consumed may have been generated from non-renewable sources that produce GHG. Because the proportion of non-renewable generation in New Zealand is low, the GHG emissions impact of using electric steam generators will be lower than using natural gas or other fossil boilers.

GHG rule of thumb comparison:

Electricity

CO_2 = kWh consumed x 0.12 kg CO_2-e /kWh[6]
So for every 100 kWh of electricity used
12 kg of CO_2-e is emitted.

Gas

CO_2 = kWh of gas consumed x 0.19 CO_2-e /kWh
So for every 100 kWh of gas used 19 kg of CO_2-e is emitted. This does not take into account the lower efficiency of using fossil fuels.

In summary, raising steam and heating water by electricity can be efficient and competitive with other types of boilers and they can provide additional benefits due to their compact size and clean operation. Because electricity steam and hot water boilers are efficient, and electricity emits approximately half the CO_2 of using gas combustion, they can reduce CO_2 emissions by more than 60%.

6. This value changes depending of the electricity systems generation mix.
www.mfe.govt.nz/publications/climate-change/guidance-voluntary-greenhouse-gas-reporting-2016-data-and-methods-2014

Design of electrode and electric hot water generator systems

Because there is no combustion space, and no fuel or ash handling systems are required, electric steam and hot water generators are more compact than combustion boilers. This can be a significant benefit if space is limited.

Selection

Step 1

Fundamental to successful system selection is establishing an accurate picture of the end-use heat demand. This is not just the current boiler's fuel input or estimated steam output but also the temperatures and heat rates that are required, and the timing and duration of the loads. Ideally for larger sites with multiple heating and cooling process-streams the heat demands will be optimised using process integration techniques like pinch.

Rationalising the system should also be considered. For example, if steam demands can be separated from lower temperature demands there may be opportunities to use heat pumps or heat recovery to minimise steam demand.

Step 2

Identify and evaluate all opportunities to minimise steam inefficiencies and losses, and the economics of alternatives to steam heating. Asses:

- if steam is the best heating medium for the product and process,
  or if direct electric heating methods (RF, IR, heat pumps) better suited to process requirements
- options to spread heating loads
- the benefits of smaller distributed heaters compared to a central system
- recovering and reusing heat

Step 3

If steam makes economic sense, identify suitable electrode or electric boiler options and establish the capital, installation and transaction costs.

Step 4

From the demand load profile and boiler selection, determine the electrical demand profile and assess how this affects the site demand, and the electricity network and energy costs:

- Does this fit within the site's available electrical capacity?
- Will the boiler operate at peak electric demand times, or can it be managed to avoid them?
  Use the same measurement / metering frequency as the electricity tariffs, most likely half-hourly if necessary

A rule of thumb for estimating an electric boiler's installation and connection cost is to allow about $40,000 for a large switch board, and $300 - $1,000 per metre of cabling.

If a new building is required, this cost could be approximately $4,000 per square metre.

Step 5

Asses if the electrode-boiler can operate in parallel with existing heat sources. This improves system resilience, and allows electrical peak load reductions by using the non-electrode boiler.

The design, approvals and a contingency cost will be needed on top of these budget prices for the final total installed cost, see the next comparison section. Large boilers can be delivered and installed in eight or nine months from order but installing a larger electricity supply may be the limiting factor.

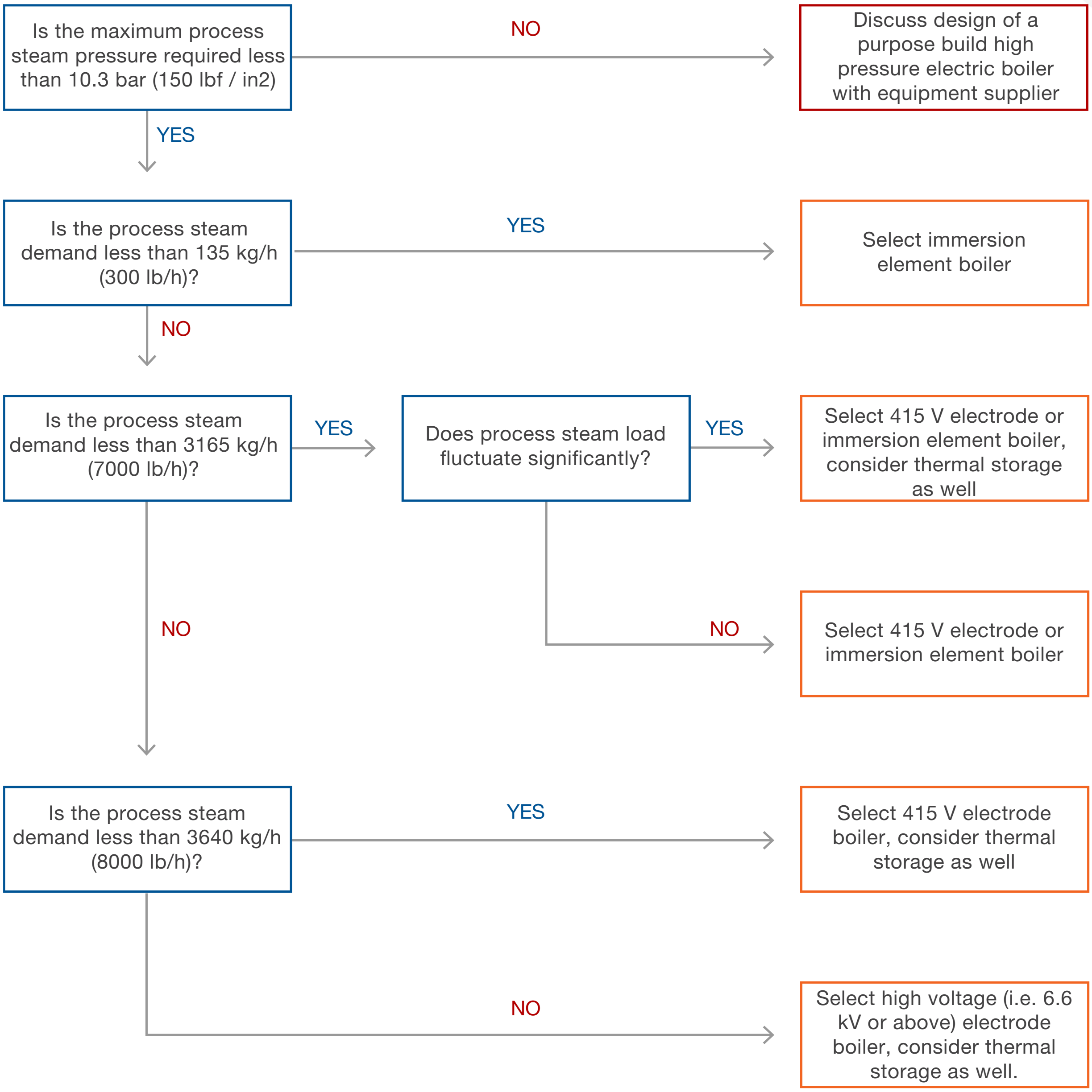

Figure 9. Steam system selection guide

Water treatment

For electrode steam and hot water generators, control of water quality is particularly important for:

- maintenance of the electrical conductivity of the water
- prevention of excessive scaling and/or corrosion from materials in the water

Electrical conductivity of water can be adjusted by applying a suitable chemical. Use of demineralised water is ideal for feed water to prevent scaling and corrosion.

Safety and standards

All boilers are subject to the Health and Safety in Employment Act 1992 and the Approved Code of Practice for The Design, Safe Operation, Maintenance and Servicing of Boilers.

https://worksafe.govt.nz/topic-and-industry/machinery/working-safely-with-boilers/

Culinary steam

This is the standard of steam required for direct injection into food products. Culinary steam can be produced from carbon steel vessels but consideration of the water treatment chemicals is needed. There are many examples of electrode boilers providing culinary steam.

Water quality

Check with the boiler manufacturer, but generally if the water quality complies with the section of BS2486 applicable to 40 bar(g) fire-tube boilers then the quality and conductivity should be adequate for electrode boilers.

Electrode boilers have special earthing and bonding requirements

Where an electrode steam generator or water boiler is not piped to a water supply or in contact with any earthed metal, it is said to be 'insulated' and different requirements apply.

Unmanned operation

Electrode boilers are subject to the Pressure Equipment Cranes and Passenger Ropeways Regulations (PECRR) and subsequently the Codes of Practice:

The NZ Boiler Code of Practice does not apply to electric or electrode boiler:

- Part 1 General Requirements, Clause 1.1 Purpose and Application - It does not apply to electric and electrode boilers.
- Clause 1.2 Scope - Heat recovery steam generators (HRSG), waste heat boilers, electric and electrode boilers designed and built to the ASME Boiler and pressure vessel code section VIII Rules for construction of pressure vessels or NZS BSPD 5500 Specification
- Part 7 Small Boilers (<500kW) Note: Electric and electrode boilers shall be designed and built to an appropriate acceptable pressure vessel standard. Such equipment is covered by the Approved Code of Practice for Pressure Equipment (Excluding Boilers).

The NZ Pressure Equipment Code of Practice

- Clause 1.3 Definitions, Pressure Vessel, (3) Includes vessels heated by electricity or by a hot gas or liquid.

Note: For electric and electrode boilers refer to the Approved Code of Practice for the Design, Safe Operation, Maintenance and Servicing of Boilers.

The limitations for a shell boiler being run in unattended operation are ≤ 6 MW and ≤ 17 bar(g).

Case studies

Case Study: 5.3 MW electrode boiler Tillamook County Creamery Association (TCCA) USA.

Source: Cleaver Brooks Case study CB-8474

TCAA is a farming cooperative manufacturing ice cream, yogurt, butter, sour cream, dried whey, and cheeses. Its facility runs continuously producing 40,000 t of cheese and other products.

TCCA's former boiler room consisted of two 700 hp fire-tube boilers on No. 2 oil. The instability of oil prices was driving up energy costs. There is no natural gas pipeline. Tillamook PUD's distribution was at 25 kV, so an electrode boiler that can accept 25 kV without transformation was chosen. Eliminating a transformer of this size substantially reduced project costs and simplified installation.

The Cleaver-Brooks/ACME CEJS-400-150PSI-5.3 MW-25 kV electrode boiler was installed in May 2009 and began operating on June 27 2009. Onsite installation was completed in six days, minimising onsite costs. Reduced diesel consumption along with reduction in corresponding emissions by 80% saw the boiler paying for itself in less than two years.

cleaverbrooks.com/reference-center/resource-library/case-studies/pdf/
CB-8474 Tillamook Cheese Case Study-Electrode.pdf

Case study: 150 kW electrode boiler, Skellerup Industries

Skellerup's earlier positive experience using a small electrode boiler led it to select one for its new facility. This needs high-quality steam for an irregular process demand. Siting an electrode boiler near where the steam is used was the obvious solution as it avoided the capital and operating costs of an extensive steam distribution system. The boiler was also a low capital and low life-cycle cost option, and its steam costs are about the same as that from a packaged 900 kW oil boiler serving a steady heat demand elsewhere on site. The boiler is connected directly to the main 440 v switchboard and its electrical load is only 3% of its capacity and 6% of site's current maximum load with the boiler's intermittent load not obvious against the site's demand profile. Importantly, the boiler enables production of the high product quality necessary to meet client expectations.

Case study: 31 MW Electrode Boiler Installation, RR Donnelley, Spartanburg, SC USA.

Commercial printer R. R. Donnelley faced increasing competition from overseas printers and paperless transactions over the internet. Energy costs had risen significantly with the recent increase in natural gas pricing.

Analysis of Donnelley's steam usage and comparison with the cost of steam with natural gas to that of making steam with electricity highlighted a case for electric boilers. The boiler supply contract included all design, procurement, construction services, start-up and training in a turn-key lump sum contract. The installation included: Precision Model HVJ-438 33 MW electrode boiler capable of producing 104,000 lb/hr of steam at 12,500volts, a new 15 m x 17 m foundation, 10 m high building, 110 m. 33,000 kW electrical feed buried and encased in a concrete duct bank, control system tied directly into the existing boiler control system. The project saved enough in gas costs to pay for itself in less than 18 months. Source: Peregrine Corporation USA

www.peregrinecorp.net/UserFiles/CaseStudies/62/FullCaseStudy.pdf

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