energy nz

EPS plastics

Fuel switching opportunities

EECA
DECARBONISATION PATHWAY
EPS PLASTICS

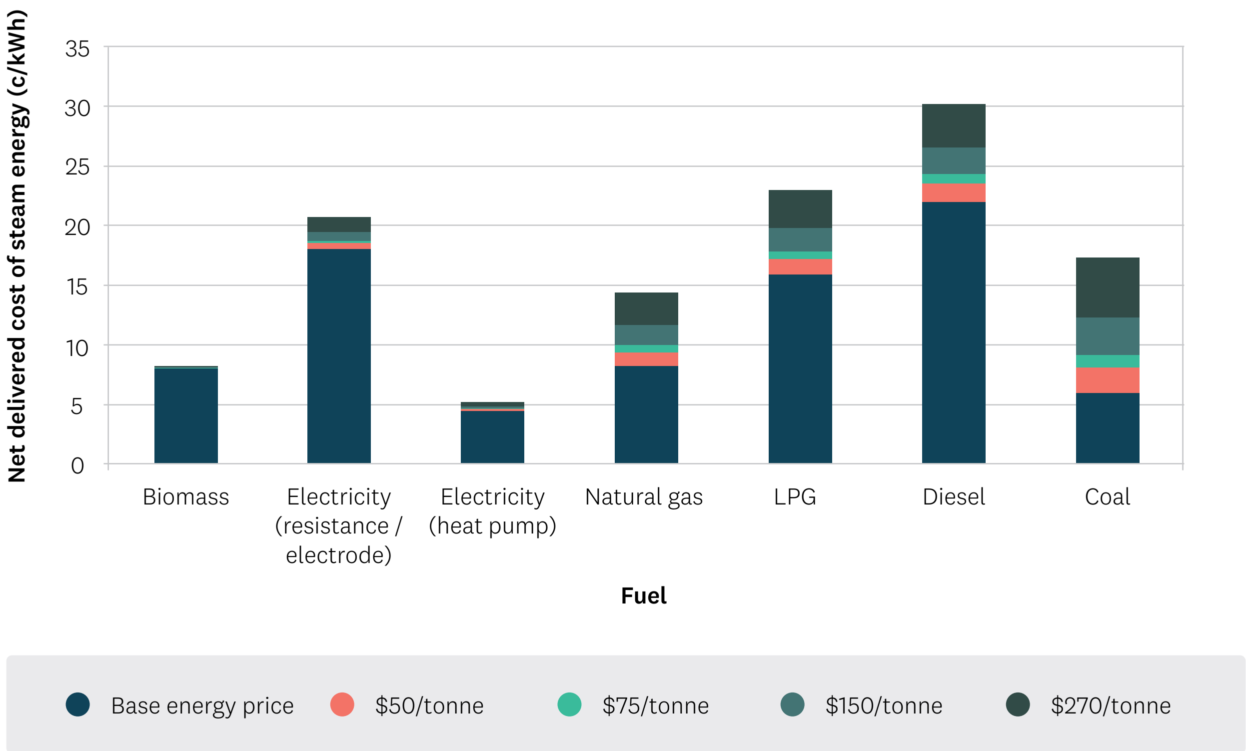
Fuel switching

Most steam systems use boilers fired with fossil fuels – coal, diesel, LPG or natural gas. Historically, these were cheap and plentiful, but their high emissions and exposure to volatile pricing means many manufacturers are looking at lower-carbon options, including electric steam boilers and biomass steam boilers.

In EPS manufacturing, steam is used to transfer all process heat for the moulding and pre-expansion processes via a central steam boiler.

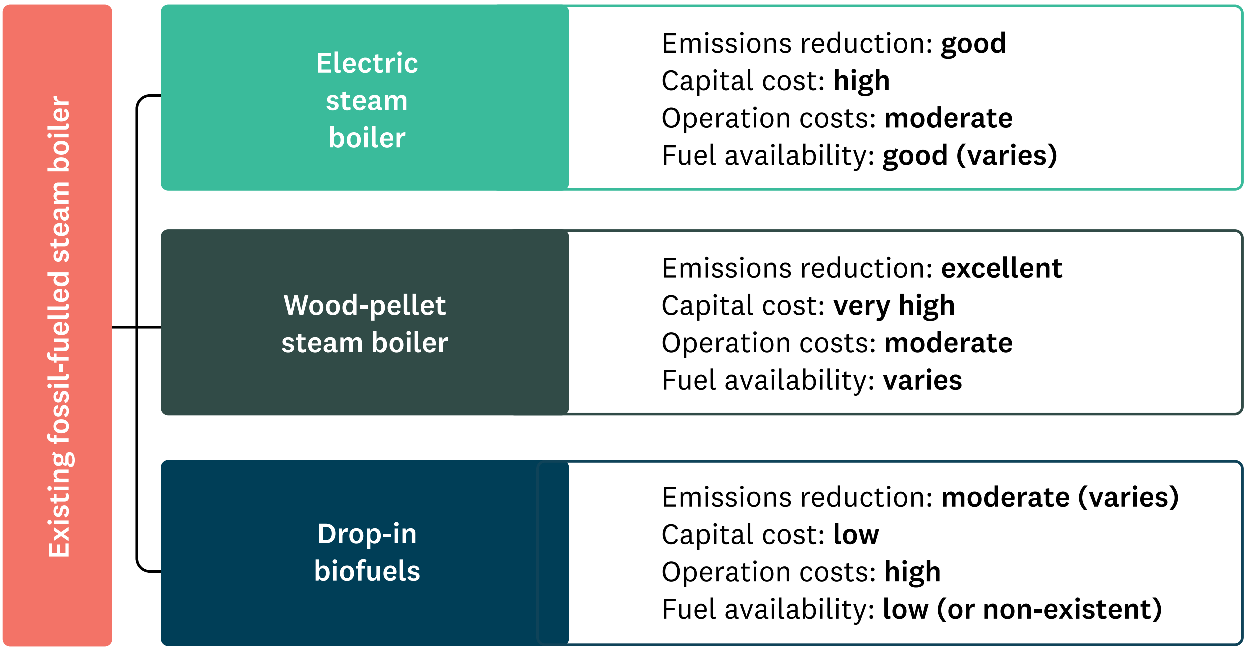
Some EPS manufacturers also use kilns for drying large blocks of formed EPS. These can be heated with either steam or electricity, and in some cases can be avoided altogether depending on the grade and required moisture content of the specific products.

The cost of steam from different energy sources is compared below. This shows how sensitive each of these are to changes in carbon pricing ($/tonne).



Graph 1: Net delivered heat energy price of different fuels

For reference, a graphic of steam system fuel switching options is presented below. These are described in more detail in the following sections.



Drop-in Biofuels:

These are fuels that are compatible with the existing thermal systems with little or no modification. The market for drop-in biofuels are in their infancy, with current supply being very limited and at high prices. As they mature, such fuels are still likely to maintain a significant price premium over other low-carbon thermal fuels, due to feedstock costs and competition with transport fuels.

Electricity — Electrode or Resistive Boiler

Electricity is a fundamentally clean medium for transporting and delivering energy, with the generation sources being the determining factor in electricity's carbon intensity. With New Zealand's predominantly renewable-sourced electrical grid, electricity is a relatively low-carbon energy source and projected to get even cleaner in future. Steam production using electricity is a mature technology and can use either electric resistive elements or electrodes. Both types share a compact form factor, near 100% efficiency, relatively low equipment capital cost, simple maintenance and fast starting characteristics.

An example of the energy breakdown, and capital cost, of replacing a diesel steam boiler with an electrode steam boiler in the EPS industry is shown in the tables below, for a nominal 1,000 kW (fuel input) fired steam boiler at an EPS manufacturing site. The costs were estimated in 2022 from discussions with NZ suppliers and are intended to be a very rough guide only, due to the large variation in project scope, production volumes and hours, etc. at each manufacturing site.

Component	Fuel Energy Input for Fired Boiler (kW)	Energy Input for Electric Boiler (kW)
Pod Moulders	230	230
Bin Moulders	210	210
Pre-expander	70	70
Feedwater Heating	130	130
Blowdown Losses	10	10
Baseload Steam Losses	80	80
Shell Losses	10	10
Purge Losses	10	Eliminated
Combustion Losses	200	Eliminated
Total	**1,000**	**790**

Table 1: Input Power — Diesel vs. Electric Boiler

Component	Annual Diesel Energy (kWh/y)	Annual Electrical Energy (kWh/y)	Annual Energy Cost* ($/y)	Annual Emissions* (t.CO2e /y)
Diesel-fired steam boiler	1,000,000	-	$190,000	1,107
Electrode Steam Boiler	-	790,000	$160,000	335

Table 2: Annual Energy Use and Cost — Diesel vs. Electric Boiler

*At a diesel price of $2.00 per L, a total electricity price of $0.20 per kWh, and current electricity grid average emissions factor of approx. 0.100 kg CO2 per kWh.

The beneficial effect on carbon emissions is substantial, with an electric steam system (at the current grid carbon intensity) likely to reduce energy-related emissions for steam generation by about 70%, and provide an energy cost saving.

Component	Total cost
1.0 MVA Supply Transformer	$400,000
Engineering and design	$100,000
Electrical Infrastructure Upgrades (Cabling, etc.)	$200,000
Purchase and Install 2 x 400 kW Electrode Steam Boiler	$320,000
Steam Piping, Feed Water Tie-ins	$70,000
Decommission the Existing Boilers	$10,000
Total	**$1,100,000**

Table 3: Indicative Project Costs — Upgrade to Electric Boiler

The project economics and internal rate of return will improve if this fuel switching project is implemented to avoid major refurbishment or replacement of the existing fuel fired steam boiler, or if external funding is secured for this project. There are numerous potential funding sources for fuel switching projects with an emissions reduction benefit, including EECA. It is strongly encouraged to research funding opportunities at an early stage.

A large part of the capital cost is associated with upgrades to the local supply and onsite electrical infrastructure. The financial impact will be different for each individual site and project. Electricity usage and loads become substantially larger than existing loads, when switching from fossil fuels to electricity. This opens up greater possibilities for securing favourable long-term pricing arrangements with an electricity retailer, particularly in the South Island. In any location, however, it is important to review all market options to optimise pricing due to the large amount of energy that will be purchased for electrical process heating.

Electricity — Heat Pumps

Heat pumps that can produce steam are currently available to the industrial market, but are still in the early stages of commercialisation and have some distinct limitations that make their suitability for the EPS sector unlikely.

The first limitation is their requirement for a very large source of concentrated (waste) heat energy at relatively high temperature, for example hot water at 80+ °C (to be able to produce steam at 120 °C or 2.0 bar.g). This concentrated waste heat source doesn’t typically exist on an EPS manufacturing site, which may only have very small waste heat sources which are more diffuse; for example, hot moist air at 50 °C.

The second limitation is their efficiency, which is relatively low at the required temperature lift (i.e. without a suitable high-temperature waste/free heat source). The Coefficient of Performance (COP, or efficiency) of a heat pump producing steam at 6.0 bar.g from a 40 °C water heat source is 1.8, or producing steam at 3.5 bar.g is 2.0. This is required to be a two-stage compression machine. Note that the cooling water system for the moulding machines is not large enough to provide this amount of 40 °C water, so a separate (air-source) heat pump may be required to provide the 40 °C water.

The system COP/efficiency of the whole steam generation system could be around 1.2 – 1.5. This relatively low COP means that the electrical power consumption of the machine is relatively high, closer to that of an electrical steam generator but with higher capital and maintenance costs.

Given the high cost and complexity in terms of design, installation and maintenance of this type of steam generation system, as well as the limited production hours in most EPS manufacturing sites (meaning limited return on the extra investment), this is very likely to be a far less attractive proposition that the simpler, lower-capital electric steam generator option. The additional electrical capacity required by the electric steam generator versus a heat pump option is unlikely to make any critical difference when comparing options for steam generation for an EPS manufacturing site — both options will require a major upgrade to electrical capacity on site.

Electricity — Infrastructure

The cost of added electrical infrastructure can vary significantly. In rare cases, the existing infrastructure is favourable and results in relatively little added cost or delay for the project. At the other extreme, the local network may not be capable of handling the added load, and may require reinforcement all the way back to the local substation or beyond. This typically involves a large delay and at least a moderate customer contribution, which can easily make a project non-viable financially.

Options to mitigate the latter issue do exist. For instance, a new electrode boiler can be sized to utilise just the network capacity that is available, while still using the existing thermal plant to generate all steam needed beyond this level. This hybrid system also allows conversion to full-electric if the required capacity becomes available at some point in the future. Retaining the full existing plant also allows potential savings by being able to switch away from electricity when market conditions offer financial rewards for doing so.

Where an electrical infrastructure upgrade is viable and required, costs depend not only on the size and nature of the upgrade needed, but also on location. Network companies are typically able to give an indication of likely upgrade costs and requirements for a particular site without needing in-depth project scoping, so this is an important early-stage step when considering electrification.

Biomass

Wood fuels in New Zealand are harvested from waste and renewable sources, so are considered virtually carbon neutral. Fuels come at a range of quality points from hog fuel (large particle size, high moisture content) through to dry processed fuel pellets. For smaller consumers with space constraints, like most EPS manufacturers, wood pellets will be the most suitable fuel.

A fuel storage silo is needed on site, as the wood pellet fuel must be protected from weather. Modern wood pellet boilers have no need for a baghouse due to the low ash content of wood fuels, and the complete burn-up of fuel inherent in the design of their combustion chamber. They also have auto-deashing, requiring less attended maintenance than, for example, older coal boilers. This reduces their OPEX costs compared to a coal boiler, but they will still be similar or more costly to maintain than a new natural gas/diesel boiler.

As an indication of project economics under the same scenario as that used for the electrode boiler above, moving to a pellet-fired biomass boiler could cost an estimated $2,000,000. Fuel cost savings were over $500,000 per year, giving economics similar to or slightly better than the electrode boiler option before considering any differences in maintenance costs. The relative economics of each option will depend greatly on the specifics of each site, and the specific fuel/ electricity supply contracts.