How manufacturers can decarbonise heat

Technology mini guide two of three:

Electrification of heat

verco
a bip company

Understand your options for decarbonisation technology

verco
a קול company

“For industrial organisations, implementing decarbonisation technology is almost always the largest step to decarbonisation. It typically accounts for 50-70% of site emissions.

For most industries, there are an overwhelming number of solutions, possibilities and combinations to choose from on the path to decarbonisation.

Knowing what the options are is the first step and so we have created these mini guides to help you become more familiar with the potential solutions.”

Thanos Patsos, Associate Director, Head of Deliver for Zero, Corporates

Options overview

verco
a kol. company

In this guide we compare several electrification options and outline the key considerations, benefits and risks.
Browse the other guides in this series to find out more about low carbon fuels and renewable thermal.

Electrification of heat

- Heat pumps
- Electric boilers

Low carbon fuels

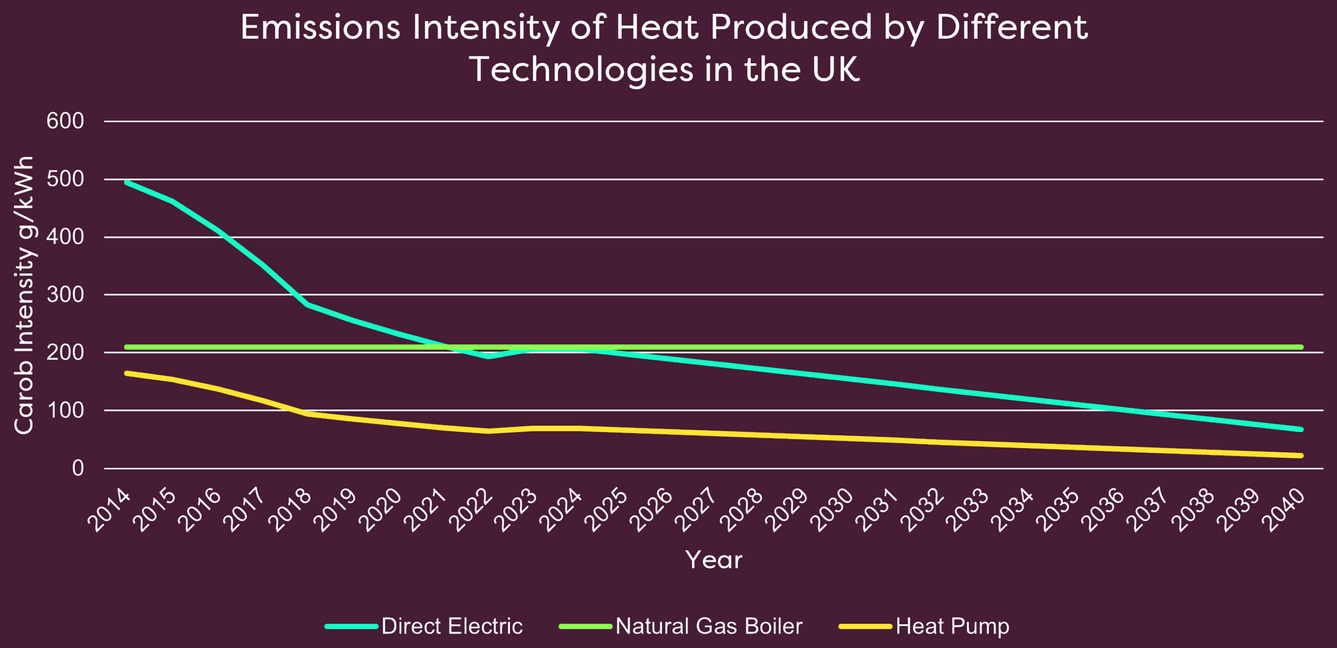
- Hydrogen
- Biogas
- Biomass

Renewable thermal

- Deep geothermal
- Solar thermal

Electrification of heat

verco
a קול. company



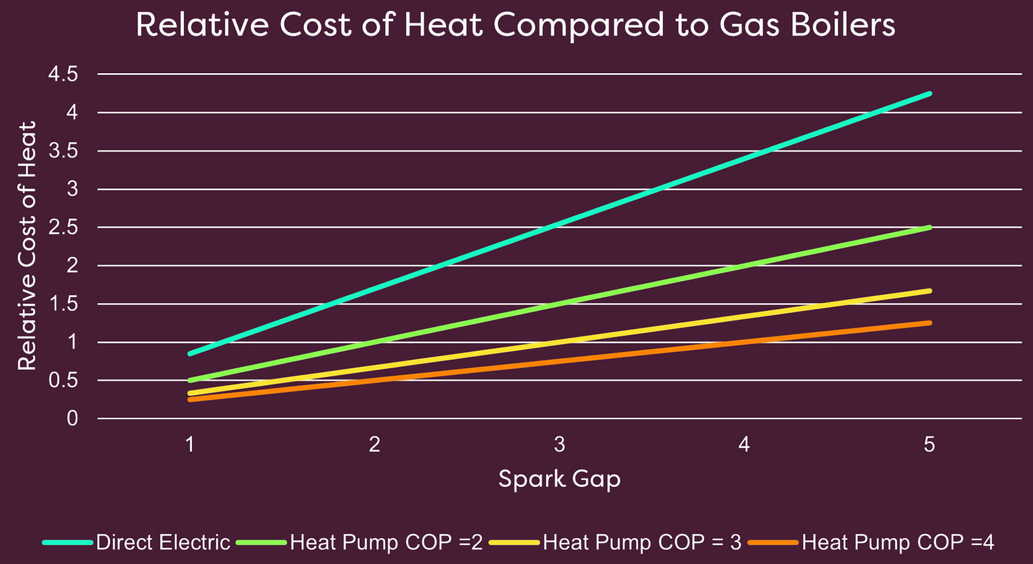
Increase in renewable electricity production means that electricity is becoming a lower carbon source of heat than fossil fuels.
Switching from gas to electricity is increasing in popularity in the decarbonisation of industrial heat.

The level of decarbonisation (gCO2/kWth reduction) will partly depend on the relative carbon intensity of electricity and current fuel source for heating and the type of electrification technology chosen.

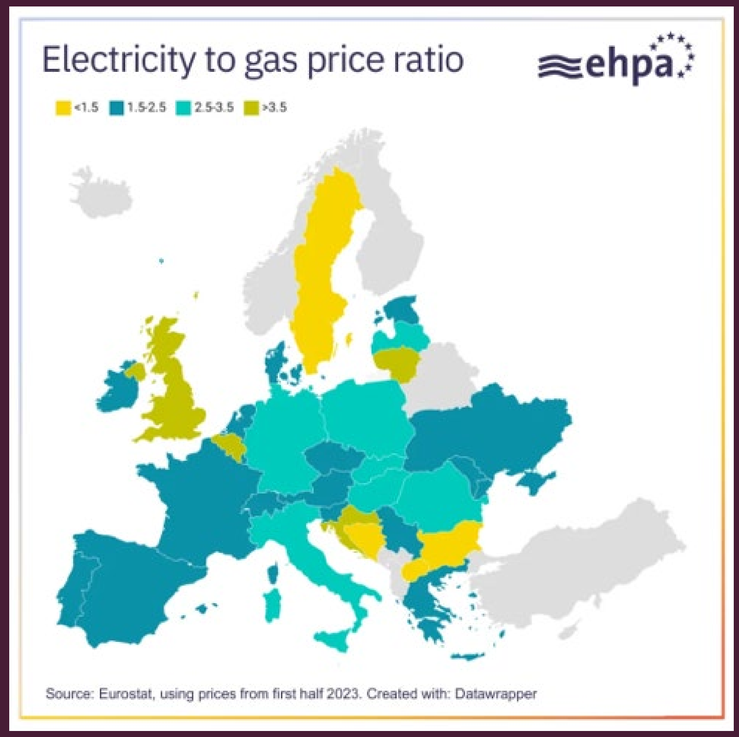
Note: Historic UK Grid emission factors have been used for the period 2014 to 2023 and a linear extrapolation to a predicted grid intensity of 67 g/kWh in 2040.

Cost of heat electrification

The business case for an electrification solution will be dependent on the system efficiency, the relative prices of electricity and existing fuel source.



In general, if the fuel: electricity price ratio is lower than the system COP the solution will provide operational cost savings.



Graph shows electricity:gas price ratio

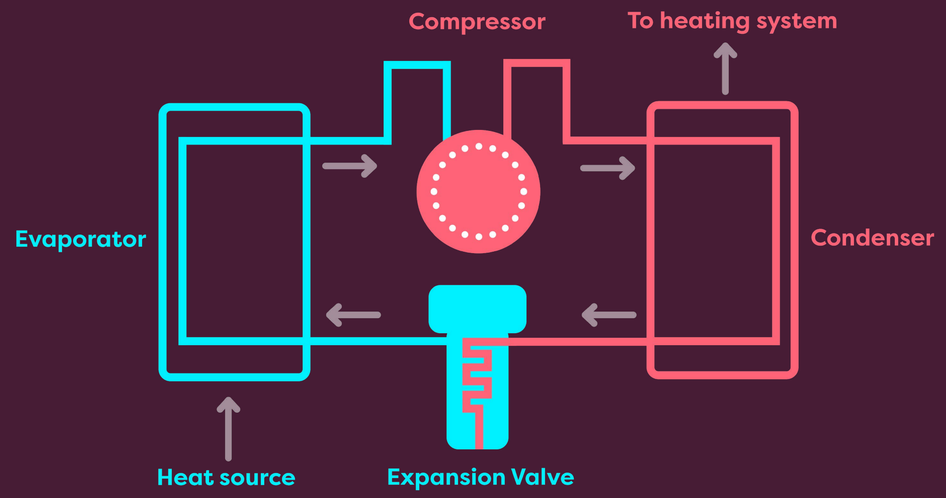
Based on Eurostat energy prices 2023.Graphic taken from The European Heat Pump Association: In which countries does the electricity price work for heat pumps? – European Heat Pump Association

Heat pumps overview

How a Heat Pump Works

A heat pump uses the refrigeration cycle to transfer heat from a colder heat source and then elevates (or 'pumps') the heat to a higher temperature for use in heating applications. Typical heat sources for a heat pump include air, the ground or waste heat.

The performance of a heat pump is measured in terms of the 'Co-efficient of Performance' (COP). This is the ratio of heat output to energy used by the heat pump to run the compressor and other components. The higher the COP the more efficient the heat pump.

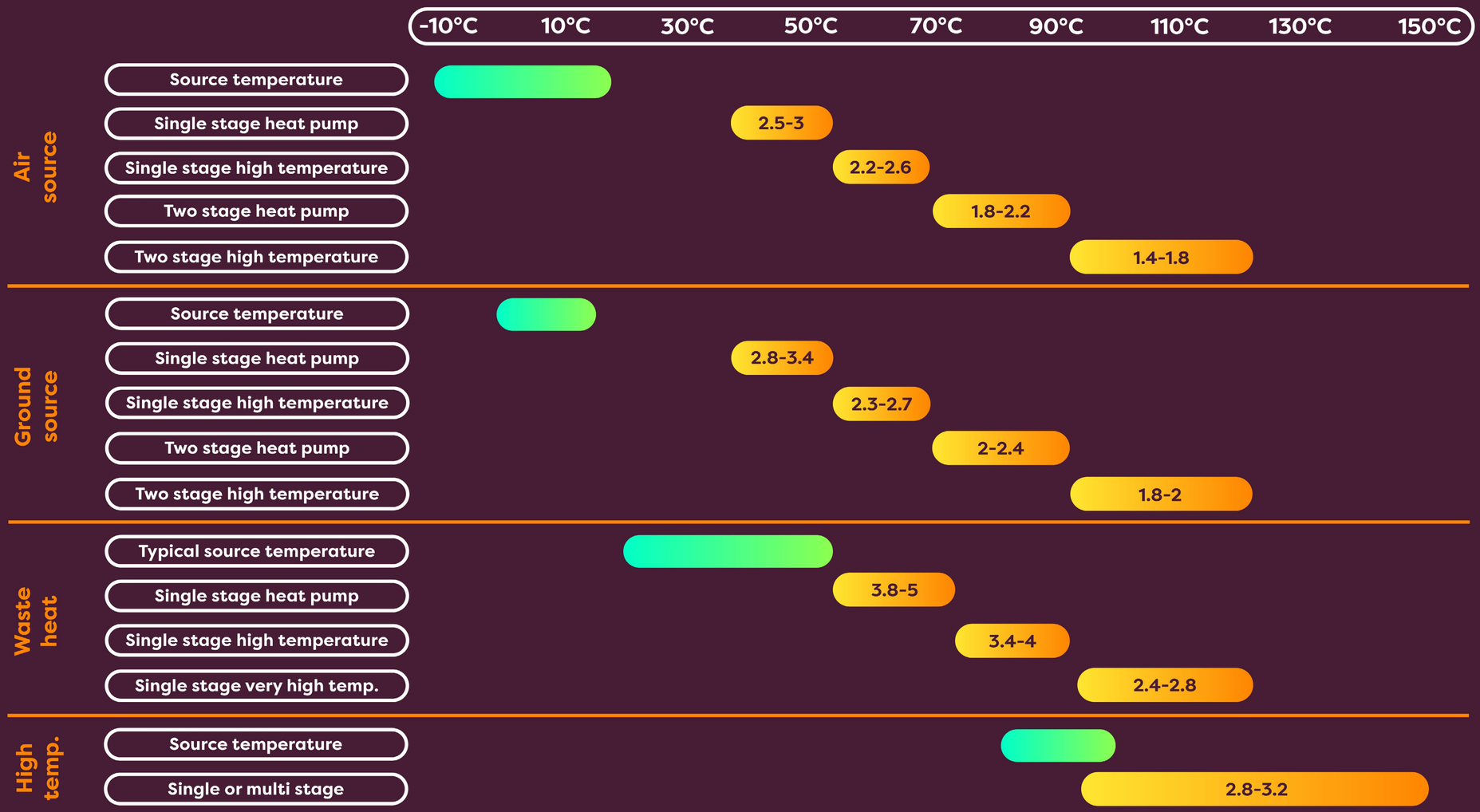


Key considerations

- Identification of heat source and operating temperatures is critical.
- Space planning - plant footprint will be higher than traditional boiler systems.
- Temperature difference between heat source and heat output is a limiting factor.
- Higher temperature lifts can be provided by operating multiple stages of heat pumps in series at a lower overall COP.

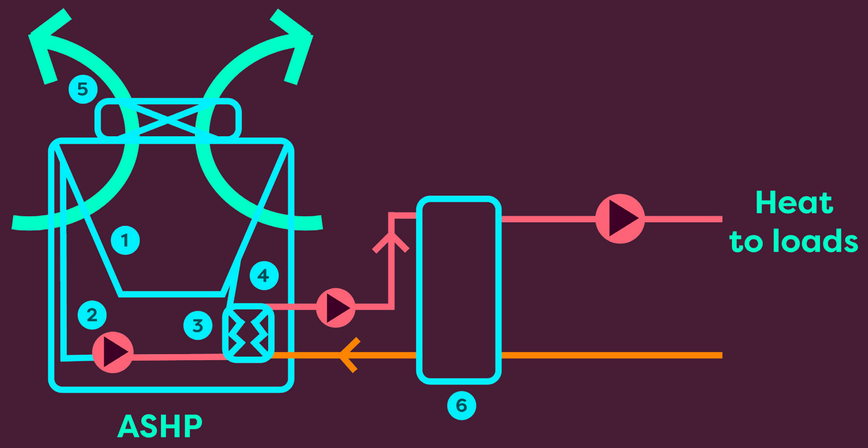
Heat pump operating ranges

verco
a kiwa company



Air Source Heat Pump (ASHP)

verco
a kvl. company



1. Evaporator coils
2. Compressor
3. Condenser
4. Expansion valve
5. Fans
6. Buffer tank

Air source heat pump uses fans to pull air across evaporator coils and extract heat from the air.

Heat delivered typically as low temperature hot water (LTHW) to meet process and heating loads.

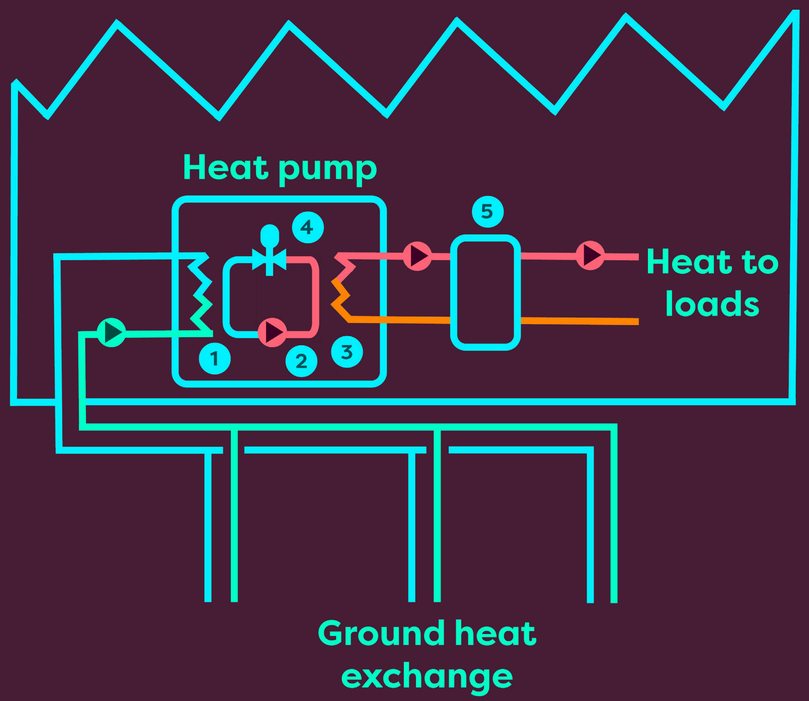
Efficiency decreases as temperature of LTHW increases.

Maximum temperature of heat a limiting factor. Higher temperatures can be achieved with additional heat pumps in series.

Technology maturity	In widespread use and readily available.
Potential net zero carbon impact	Good option for low temperature heat demands.
Fuel availability	Grid electricity readily available although capacity may be limited in some areas.
Capex	Higher Capex than conventional gas plant.
Opex	‘Spark gap’ dependent but potential for low fuel costs.

Ground Source Heat Pump (GSHP)

verco
a kvl. company



1. Evaporator
2. Compressor
3. Condenser
4. Expansion valve
5. Buffer tank

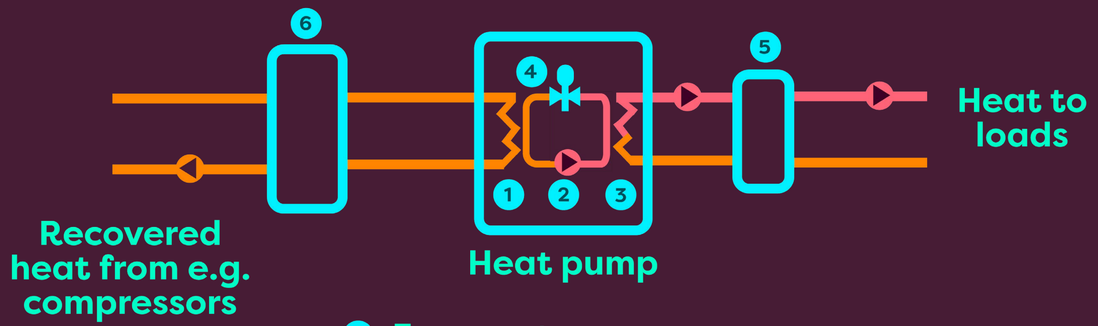
Ground source heat pumps extracts heat from the ground with a network of heat exchange pipework or direct from aquifers.

Similar heat distribution and temperature considerations to ASHP.

Significant space and ground works required for the ground heat exchanger array.

Technology maturity	In widespread use and readily available.
Potential net zero carbon impact	Good option for low temperature heat demands.
Fuel availability	Grid electricity readily available although capacity may be limited in some areas.
Capex	Higher Capex than conventional gas plant and air source heat pumps.
Opex	‘Spark gap’ dependent but potential for low fuel costs.

Waste Heat Source Heat Pump



1. Evaporator
2. Compressor
3. Condenser
4. Expansion valve
5. Buffer vessel
6. Heat recovery buffer vessel

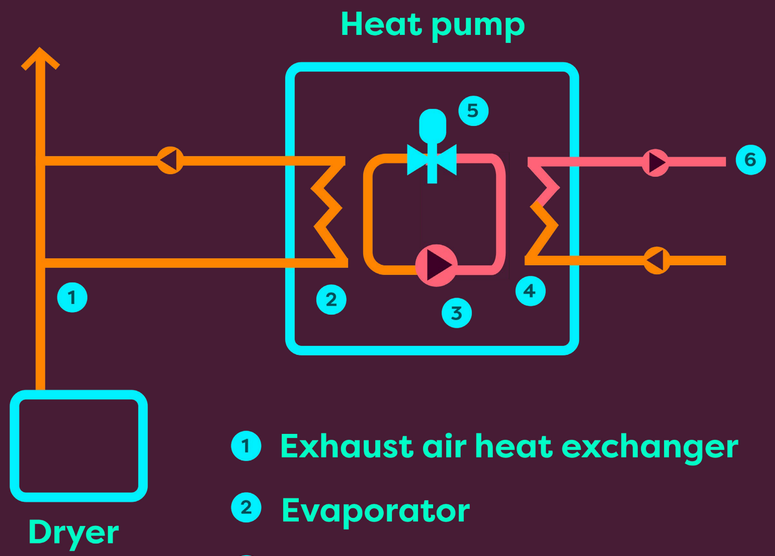
Waste heat pump systems use rejected heat as a heat source to deliver heat at higher temperatures.

Potential waste heat sources include compressors and refrigeration systems.

Typical operating temperatures are around 40°C for waste heat and 85°C on the output side. Higher temperatures can be achieved at lower COPs and with hotter waste heat sources.

Technology maturity	In widespread use and readily available but not as common as ASHP or GSHP.
Potential net zero carbon impact	Good option for sites with waste heat.
Fuel availability	Grid electricity readily available although capacity may be limited in some areas.
Capex	Higher Capex than conventional gas plant and air source heat pumps. Heat recovery systems attract additional cost.
Opex	'Spark gap' dependent but potential for lower fuel costs than ASHP/GSHP.

High Temperature Heat Pumps



1. Exhaust air heat exchanger
2. Evaporator
3. Two stage compressor
4. Condenser
5. Expansion valve
6. Steam or superheated water to heat loads

High temperature heat pumps are available to deliver heat at up to 150°C using high temperature heat sources.

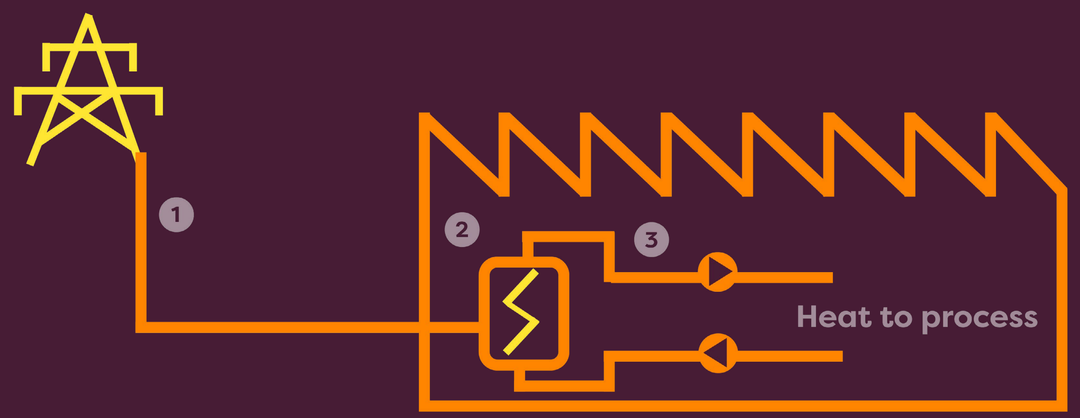
Potential high temperature heat sources include oven exhausts or thermal oxidisers.

Heat delivered as steam or superheated water.

Additional implementation costs associated with heat recovery systems.

Technology maturity	Emerging technology - not in widespread use.
Potential net zero carbon impact	Can decarbonise a wide range of heat demands up to 150°C.
Fuel availability	Grid electricity readily available although capacity may be limited in some areas.
Capex	Higher Capex than conventional gas plant and air source heat pumps. Additional costs involved to collect waste heat.
Opex	'Spark gap' dependent but potential for lower fuel costs.

Electric boilers



1. Grid electricity
2. Electric boiler
3. Heat distribution, LTHW/MTHW or steam

Electric boilers are similar to traditional boilers but operate on electricity through resistive heating elements or electrodes.

Heat can be delivered to LTHW systems or as steam.

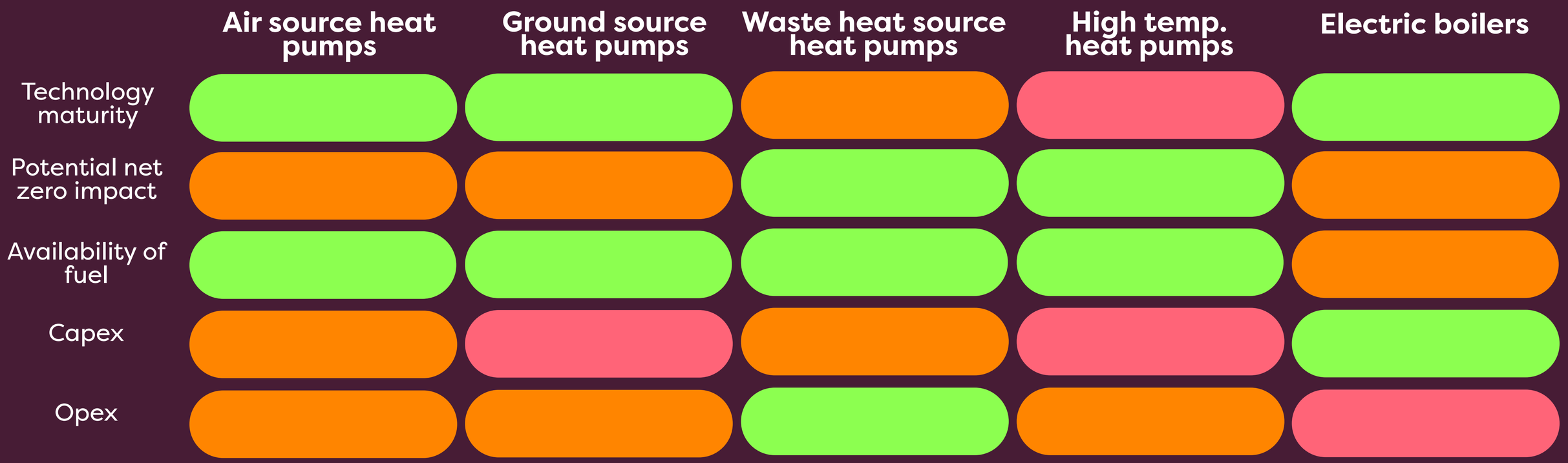
Can be used at small scale to deliver heat to isolated loads or high temperature loads.

Capex investment significantly lower than heat pumps but opex much higher.

Technology maturity	Established technology.
Potential net zero carbon impact	Emissions in line with grid carbon factor.
Fuel availability	Grid electricity ready available. Greater peak capacity needed than heat pumps.
Capex	Lower Capex than heat pumps and comparable with gas boilers.
Opex	Much lower efficiency than heat pumps and electricity costs results in high Opex.

Electrification of heat comparison

verco
a kpn. company



Expert overview

“In regions with a large spark gap it is critical that systems are designed to achieve as high a COP as possible to deliver operational savings alongside reductions in carbon emissions. Understanding the temperature profile of your processes is a key starting point for moving to heat pumps and more nuance is needed in design over traditional steam boiler systems.

Utilising waste heat sources within industry (such as from refrigeration and compressors as well as higher temperature sources such as ovens) is becoming increasingly understood and can result in very high system efficiencies. Alternatively, electric boilers provide a convenient source of heat across a wide temperature range and are ideal within a decarbonised grid. However, current electricity prices and grid capacity can limit their application to situations such as isolated, high temperature processes.”

Matt Dickinson, Principal Consultant,
Deliver for Zero, Corporates

How we can help

Take a look at the other mini guides in this series:

Renewable thermal mini guide

Low carbon fuels mini guide

Low-Carbon Heat Investment Blueprint

This cost-effective service will provide you with:

- A tailored and evidence-backed assessment of viable heat decarbonisation solutions.
- Investment cost range, carbon and cost savings from each solution.
- A clear direction on progressing to a concept solution design or business case.

Browse the service document to find out more