

Spark-ignition gas engines (SIGE) are widely used for small-scale CHP applications in buildings and industry. The gas-engines have been developed from three sources:

- Purpose-designed gas-engines
- Conversions from petrol engines developed for vehicle applications
- Conversion from diesel engines developed for marine or stationary power applications

Low Voltage generators are used up to about 2 MWe, depending on the manufacturer.

Sizes available

SIGE are available in a wide range of sizes from 5kWe to over 5MWe. The largest sizes are commonly used in hospitals and for district heating systems. Smaller sizes are suitable for individual buildings.

Heat from gas-engine based CHP

A CHP system based on a gas engine will produce heat from three main sources: the engine jacket cooling system, the oil cooler and the exhaust gases. Typically one-third of the heat is available in the exhaust and two-thirds from the engine jacket/oil cooler. The maximum temperature in the engine jacket circuit is normally about 95°C so gas-engine CHP is normally used in low temperature hot water applications. Normally a primary heating circuit is used with a plate heat exchanger installed to transfer heat to a secondary heating circuit to supply the buildings thus providing insulation from system pressures or possible contamination.

It is important to design the heating circuit so that return temperatures remain lower

than a maximum set by the CHP supplier even under part-load to avoid the CHP unit controls shutting down the unit unnecessarily. A dump radiator may be used to dissipate surplus heat and to ensure that return temperatures are maintained within limits, provided that the environmental benefit of CHP is still retained.

Gas-engines can modulate with good efficiency down to about 50% output and hence heat load following is possible. However their operational time at low loads should be limited. Multiple units provide improved flexibility and load following capability.

A further source of heat is the intercooler for turbo charged engines. The turbocharger introduces the gas/air mixture to the engine at higher pressure. The compression also results in a gain in temperature and the gas/air mixture then needs to be cooled. The temperature at which the gas/air mixture can be permitted to enter the engine varies with the engine design and exceeding this temperature can cause significant damage to the engine. Often the heat rejection from the intercooler is at too low a temperature for useful heat recovery (circa 40°C) and a small dump radiator is required.

Variants in heat recovery design

If higher temperatures of heat rejection are required it is possible to have two heat rejection circuits, one using the exhaust (to produce high temperature hot water or steam) and one using the engine jacket/oil cooler. Alternatively, by placing the exhaust heat exchanger in series in the secondary circuit after the engine/jacket heat exchanger, a higher temperature supply can be achieved, provided the return temperature is low enough. Maximum heat recovery exhaust conditions is achieved

when the exhaust heat exchanger is used prior to the engine jacket/oil cooler heat exchanger so that the low return temperature from the heating circuit is used to cool the exhaust gases as far as possible, this is not as popular as the former configuration. In both of these cases the selection of the exhaust heat exchanger material and maintenance of water quality is critical to prolong the life of the heat exchanger, as is appropriate removal of condensate from within the exhaust system.

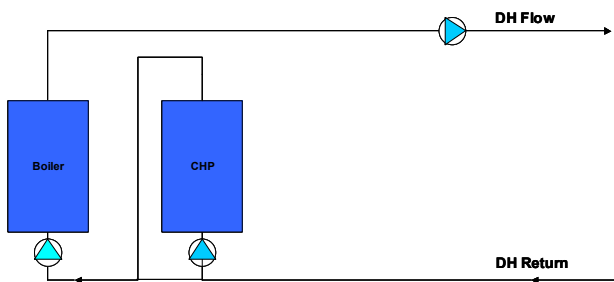


Figure A – Series Connection

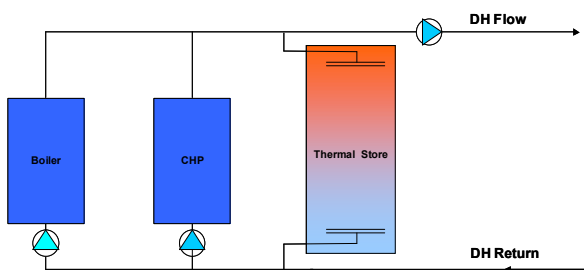


Figure B – Parallel Connection with Storage

In retrofit applications, the CHP unit is typically connected in series with the boilers by taking a supply from the return header. This helps to ensure that the CHP unit is the lead boiler. In most new designs (especially when condensing boilers are used), the CHP unit is placed in parallel with the boilers and this arrangement also enables a thermal store to be used. With a parallel arrangement more care has to be taken to ensure the design flow and return temperatures of the CHP are maintained. Control strategies for the thermal store should always be discussed with the CHP provider.

Efficiencies

The electrical efficiency of SIGE CHP increases with size from around 30% below

300 kWe and, with turbo-charged engines, 33% to 38% between 500 kWe and 2.0 MWe (all figures on GCV basis).

Overall efficiency depends partly on the temperature at which the exhaust gas leaves the heat recovery system which in turn is determined by the temperature of the heating medium. The overall efficiency is typically at 75%-85% (GCV).

Correctly sized and installed SIGE CHPs will easily meet the CHPQA Good Quality criteria.

Environmental Impacts

NO_x production is relatively high compared to gas turbines and boilers, however the use of lean-burn technology has led to significant reduction in NO_x formation. Typical emissions from a lean burn engine are 500mg/Nm³ at 5% O₂. In cases where this level is still too high catalytic convertors can be used to bring this down to 100mg/Nm³ at 5% O₂

Noise levels are high and acoustic enclosures are normally supplied as part of the package. These enclosures enable noise levels comparable to conventional boiler plant to be achieved. The engine itself should be mounted on rubber supports to minimise transfer of vibration and in extreme cases rubber mounts can be used to isolate the whole CHP package from the building. Flexible couplings should be used between the CHP unit and connecting pipework. Silencers are required in the exhaust system and in the ventilation/combustion air supply and extract from the enclosure.

Maintenance Aspects

SIGEs require regular maintenance and as a result availabilities are typically 90%-92%. It is recommended that a long-term maintenance agreement is obtained from the supplier, with a guarantee on availability. Most suppliers offer a remote monitoring service.

Practical considerations

SIGEs are bulky and heavy compared to gas turbines and a suitable plantroom space is required. The weight of a 122 kWe CHP package is about 5 tonnes and a 1400 kWe unit 15.5 tonnes for the generating set

alone. Suitable maintenance access needs to be provided around the unit. Ventilation and combustion air needs to be provided and this is best obtained from external air via ductwork.

This datasheet was produced by the CHP Group of the Chartered Institution of Building Services Engineers (CIBSE) to inform building professionals about all forms of CHP. To join or contact the CHP Group go to www.cibse.org/chp or contact CIBSE, 222 Balham High Road, London, SW12 9BS (020 8675 5211). Acknowledgements to Vishnu Barran and Gregory Zdaniuk.