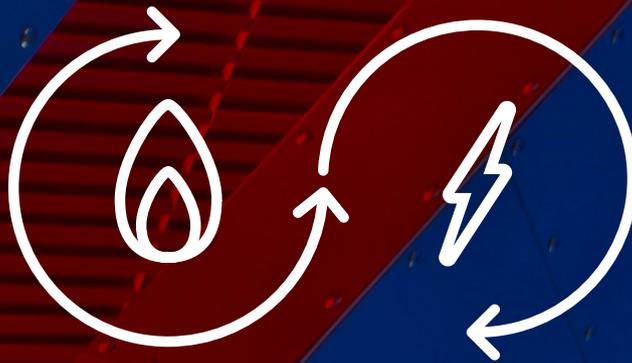


February 2018

The essential guide to small scale combined heat and power

The answer to all your combined heat and power questions in one, easy to read guide...



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About Centrica Business Solutions

With over 30 years' experience, more than 3,000 units manufactured and an amazing 27 millions tonnes of CO₂ saved by our customers, Centrica Business Solutions are the largest provider of small scale CHP units in the U.K.

We understand the power of power. As new energy sources and technologies emerge, and power becomes decentralised, we're helping organisations around the world use the freedom this creates to achieve their objectives. We provide insights, expertise and solutions to enable them to take control of energy and gain competitive advantage – powering performance, resilience and growth.

As businesses struggle to balance the demands of growth, cost control and risk with a complex competitive environment, they are under pressure like never before. At the same time, the energy landscape is changing. New energy sources are emerging, from wind and solar to high efficiency batteries, while supply is becoming decentralised, driven by new technology. These changes are putting power in the hands of customers, turning energy from a simple commodity into a critical source of competitive advantage.

What is combined heat and power?

Introduction to combined heat and power

Combined Heat and Power (CHP) converts a single fuel into both electricity and heat in a single process at the point of use. CHP is highly energy efficient and as well as supplying heat and power, it can deliver a number of positive financial, operational and environmental benefits.

CHP is a well-proven technology, recognised worldwide as a viable alternative to traditional centralised generation.

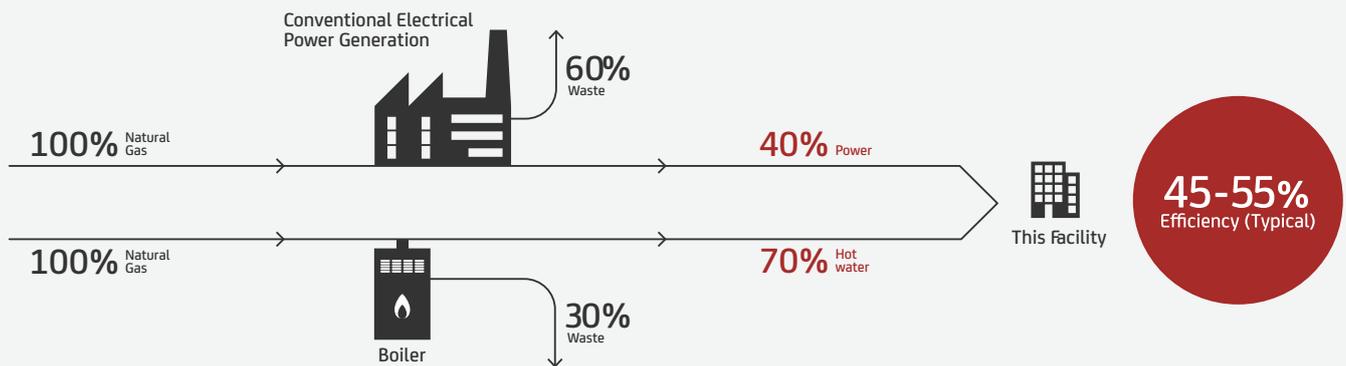
With CHP, an engine which is normally fuelled by natural gas, is linked to an alternator to produce electricity. CHP maximises the fuel and converts it into electricity at around 35% efficiency and heat at around 50%. Heat is recovered from the engine by removal from the exhaust, water jacket and oil cooling circuits.

Typically a good CHP scheme can deliver an efficiency increase of anything up to 25% compared to the separate energy systems it replaces.

CHP should always be considered when:

- Designing a new building
- Installing or replacing a new boiler plant
- Replacing or refurbishing an existing plant
- Reviewing electricity supply
- Reviewing standby electricity generation or plant
- Considering energy efficiency in general
- Exploring options towards building regulation compliance
- Reducing CO₂ emissions and environmental impact.

Typical case



Cogeneration



Combined heat and power applications

- Leisure centres
- Hotels
- Hospitals
- Universities
- Military bases
- Prisons
- Manufacturers
- Commercial premises
- Horticulture
- Airports
- Waste water treatment works
- Municipal buildings
- District heating schemes i.e. offices, residential
- Pharmaceutical
- Anaerobic Digestion i.e. dairy, onfarm.

What is combined heat and power?

Fuel options

The most common fuel option for a CHP is natural gas. This is widely available in many countries through the mains gas network and offers straight forward and sustainable access to Combined Heat and Power.

Alternatives to natural gas include biogases, bioliquids and biofuels. Using alternative fuels has its advantages. Payback on anaerobic digestion (AD) and other biogas CHP projects, such as wastewater applications, can be rapid. Wastewater CHP projects can provide rapid payback on investment – usually within 10 to 18 months. Considering that the lifespan of a typical CHP system is 10-15 years, this can provide a significant cash surplus, as well as improving environmental performance.

Developers can choose to fund capital costs of projects claiming Feed-in Tariffs (FiTs) on electricity generated from CHP engines and exported to the grid as well as benefiting from enhanced capital allowances. There is also potential for additional income via the Renewable Heat Incentive (RHI).

Biomass and biogas CHP is eligible for Renewable Heat Incentive (RHI) support. Any new application for RHI with a biomass boiler (including CHP systems) or a biogas CHP (such as part of an anaerobic digestion plant or at a waste water treatment works) must have either an RHI emission certificate or an environmental permit certifying that Particulate Matter (PM) and NOx emissions from the site do not exceed maximum permitted levels.

Biomass boilers and biogas applications that do not have a RHI emission certificate or an environmental permit will not be eligible for the RHI.

Centrica Business Solutions can offer pre-treatment technology required to clean and dry biogas from digestion processes, such as effluent and AD this would include Siloxane and H2S treatment, and a chiller to clean/treat gas prior to the engine, depending on the gas quality and feedstock.

Benefits of combined heat and power

Reduces running costs

- Reduces sites actual energy costs
- Avoidance of Climate Change Levy
- Claimable Enhanced Capital Allowances
- Stabilises energy costs over a period of time

Security of supply

- Acts as back-up generator
- Back-up heat supply
- Reduces grid dependency

Reduces CO₂

- Points for BREEAM assessment
- Meet CSR requirement
- Legislative compliance with part L2 of building regulations

Financial benefits

CHP represents a highly efficient use of fuel, which means lower energy costs for the user. In the UK, taxation benefits can be obtained through avoidance of Climate Change Levy (Good Quality CHP) and the possibility of Enhanced Capital Allowances for eligible organisations. In other countries, a range of fiscal support measures also enhance the financial benefit of CHP. Third party or supplier funding options for CHP means an organisation has the option of outsourcing the CHP system without capital outlay giving an immediate payback.

Emission benefits

In the UK, the recent amendments to the Building Regulations, Part L2A and Part L2B seek to reduce both energy consumption and CO₂ emissions by up to 28% compared to the 2002 regulations. All CHP schemes produce reduced emissions compared to the separate supply of mains electricity and traditional means of site heat production. A well designed and operated CHP plant can contribute significantly towards Part L compliance. Impacts can be readily assessed through SBEM or other energy performance modelling software packages.

CO₂ savings are calculated using the following formula:

Grid electricity CO₂ abated + Boiler fuel CO₂ abated - CHP fuel CO₂ released = Net CO₂ saving

The figures to use in this calculation are found in the Building Regulations 2000, Part L2A (2006 Edition) which are:

- 0.184kg CO₂/kWh for combusted natural gas
- 0.483kg CO₂/kWh mains electricity displaced

Economics of combined heat and power

Stages of feasibility

There are generally three stages to completing the economic viability for CHP once the project has been scoped:

- Data Collection
- Initial Feasibility Study – desktop calculation
- On-site Review – to determine installation options and cost.

Data Collection

Before a CHP unit can be correctly sized and the associated savings accurately calculated, the appropriate site data needs to be collected and validated. The minimum data requirement centres around the utility consumption of the site (grid electricity and natural gas) and the associated tariffs. Natural gas consumption doesn't have a graded tariff system. The most common source of this data is simply found on the site utility bills.

Over the last few years, the availability of half-hourly utility data is becoming more and more common. Availability of such data can improve the accuracy of a feasibility study since it can provide a greater insight into the operation of the site.

Whilst the utility consumption and tariffs are the most important pieces of data in a CHP desktop feasibility analysis, other site conditions can have a major effect on the CHP savings. Examples include the distribution of the consumed natural gas and the boiler efficiency. The thermal energy recovered by a CHP unit can only displace thermal energy generated by the boilers, therefore if any gas is used in any direct gas-fired plant (e.g. ovens) then this gas needs to be deducted. The boiler efficiency is used to convert the natural gas consumed by the boilers into useful thermal energy.

Initial feasibility study

Having collected and validated the data, a simple evaluation of whether a CHP scheme is likely to be feasible or not can be conducted. This is calculated by working out the "spark spread" - the difference between the grid electricity tariff and the natural gas tariff. If the grid electricity tariff is 9p/kWh and the natural gas tariff is 3p/kWh, then the spark spread is 3.0.

$$\frac{\text{Grid Electricity Tariff}}{\text{Natural Gas Tariff}} = \frac{9\text{p/kWh}}{3\text{p/kWh}} = 3.0$$

As a rule of thumb a spark-spread of at least 2.5 is required to make a CHP scheme viable, however this is not a strict figure. Within the table below, an example set of data is used to help determine a CHP unit size.

| | Day kWh Electricity | Night kWh Electricity | Natural Gas kWh | | Mean Day kWe | Mean Night kWe | Mean LTHW kWth |
|--------------|---------------------|-----------------------|------------------|-------------|--------------|----------------|----------------|
| January | 101,569 | 21,657 | 483,832 | | 192.7 | 99.8 | 520.2 |
| February | 93,524 | 19,081 | 415,009 | | 196.5 | 97.4 | 494.1 |
| March | 101,437 | 20,873 | 388,279 | | 192.5 | 96.2 | 417.5 |
| April | 101,006 | 20,189 | 331,167 | | 198.1 | 96.1 | 368.0 |
| May | 104,762 | 21,233 | 265,264 | | 198.8 | 97.9 | 285.2 |
| June | 101,939 | 20,897 | 229,530 | | 199.9 | 99.5 | 255.0 |
| July | 100,425 | 21,442 | 187,109 | | 190.6 | 98.8 | 201.2 |
| August | 100,789 | 21,064 | 206,916 | | 191.3 | 97.1 | 222.5 |
| September | 99,802 | 20,297 | 239,345 | | 195.7 | 96.7 | 265.9 |
| October | 100,868 | 21,238 | 300,171 | | 191.4 | 97.9 | 322.8 |
| November | 101,556 | 20,441 | 366,487 | | 199.1 | 97.3 | 407.2 |
| December | 100,457 | 20,767 | 450,435 | | 190.6 | 95.7 | 484.3 |
| Total | 1,208,133 | 249,179 | 3,863,544 | Mean | 194.8 | 97.5 | 353.7 |

Economics of combined heat and power

When determining the best CHP unit for a site, both the electrical and thermal utilisation of the CHP outputs need to be maximised in order to deliver the best return on investment. If the selected CHP unit is too small then the maximum savings aren't being delivered. If the selected CHP unit is too large then the CHP unit will be operating inefficiently at part-load, have fewer run hours and lower utilisation figures.

With smaller projects, it's likely that the site energy demands are lower during the night-time than the daytime. Therefore consideration is required to either select a CHP based on the lower night-time baseloads so it can run 24 hours per day or to size a larger CHP to run during the daytime operational hours only.

CHP quality index

The utilisation of the recovered thermal energy drives the economics of a CHP project. However this doesn't mean that sizing the CHP to match the summer thermal baseload will always provide the best overall solution. Depending on the individual site circumstances it may be more cost-effective to operate the CHP with some of the thermal energy being dissipated rather than to switch the CHP unit off. It is for this reason that the CHP Quality Index (CHPQI) metric has been designed.

This is designed to incentivise CHP design, to prevent excessive heat being rejected and discourage CHP units being operated as gas generators only.

These incentives have two primary benefits:

- Climate Change Levy (CCL) can be claimed back on the electricity generated by the CHP unit.
- CCL can be claimed back on the fuel consumed by the CHP unit.

Additionally the scheme will become eligible for Enhanced Capital Allowances (ECAs).

The minimum CHPQI figure required to achieve 'Good Quality CHP' and receive the full benefits is 105 during the design stage and 100 during scheme operation.

Economics of combined heat and power

CHP selection

CHP selection will be exemplified using the table below.

If the requirement for the CHP unit was to operate for 24 hours per day, then a 90kWe and 161kWth unit (ENER-G 90) would be an ideal selection. This is because the night-time load of the unit is approximately 95kWe.

The other key advantage is the much lower chance of any rejection of recovered thermal energy so the CHPQI figure will be healthier.

However if the requirement is for the CHP unit to offset as much of the more expensive daytime electricity as possible then the a 185kWe and 309kWth unit (ENER-G 185) would be a better selection. This selection is based on the daytime load of the unit being approximately 190kWe.

It is likely that there will be some rejection of thermal energy during the summer baseload period so a CHPQI calculation will need to be conducted to ensure this is a 'Good Quality' CHP scheme.

If the unit was selected based on the thermal baseload of the site then a 125kWe and 200kWth unit (ENER-G 125) would be a more prudent selection.

This will be the biggest unit that could be installed with no heat rejection, however the unit would only be able to operate correctly during the daytime period as it is slightly too large for the night-time electrical load.

The savings for all three units selections are presented in the following table.

| Ref | Parameter | Equation | ENER-G 90 | ENER-G 185 | ENER-G 125 |
|-----|----------------------------|-----------------------------------|-----------|------------|------------|
| A | Electrical (kWe) | - | 90 | 185 | 125 |
| B | Thermal (kWth) | - | 161 | 309 | 200 |
| C | Fuel (kW) | - | 308 | 603 | 399 |
| D | Day Hours Run | 17h/day * 365day/yr * 90% | 5,585 | 5,585 | 5,585 |
| E | Night Hours Run | 7h/day * 365day/yr * 90% | 2,300 | - | - |
| F | Day Elec Util. | - | 100% | 100% | 100% |
| G | Night Elec Util. | - | 100% | - | - |
| H | Thermal Util. | - | 100% | 91% | 100% |
| I | Day Electricity (kWhe) | A * D * F | 502,605 | 1,033,133 | 698,063 |
| J | Night Electricity (kWhe) | A * E * G | 206,955 | - | - |
| K | Thermal Utilised (kWth) | B * (D + E) * H | 1,269,324 | 1,577,208 | 1,116,900 |
| L | Gas Consumed (kWh) | C * (D + E) | 2,428,272 | 3,367,454 | 2,228,216 |
| M | Day Elec Tariff (p/kWhe) | - | 9.000 | | |
| N | Night Elec Tariff (p/kWhe) | - | 6.000 | | |
| O | Electricity CCL (p/kWhe) | - | 0.541 | | |
| P | Gas Tariff (p/kWhgas) | - | 3.000 | | |
| Q | Natural Gas CCL (p/kWhgas) | - | 0.182 | | |
| R | Boiler Efficiency | - | 80% | | |
| S | Day Electricity Savings | I * M | £45,234 | £92,982 | £62,826 |
| T | Night Electricity Savings | J * N | £12,417 | £- | £- |
| U | Boiler Gas Savings | K * (P + Q) / R | £50,487 | £62,733 | £44,425 |
| V | CHP Fuel Cost | L * -(P + Q) | (£77,268) | (£107,152) | (£70,902) |
| W | Total Utility Savings | S + T + U + V | £30,871 | £48,563 | £36,349 |
| X | CHPQI | [(249 * (I + J)) + (115 * K)] / L | 132.9 | 130.3 | 135.7 |
| Y | CCL Exemptions | [(I + J) * O] + [L * P] | £8,258 | £11,718 | £7,832 |
| Z | Total GROSS Savings | W + Y | £39,130 | £60,281 | £44,180 |

Economics of combined heat and power

Based on the 'Total GROSS Savings' alone, the ENER-G 185 offers a substantial increase in savings over the two smaller options, even though the unit is rejecting some of the recovered heat during the summer period. However in order to make the final decision over the suitability of the CHP unit for the site, the installation costs and the annual maintenance costs need to be considered.

The table also shows that the previous assertion regarding the balance between the gas costs and the electricity savings are broadly applicable in this case. For the ENER-G 185 and the ENER-G 125 the 'Boiler Gas Savings' (Ref U) and the 'Total GROSS Savings' (Ref Z) are approximately equal. This means that if there is poor utilisation of heat then the savings will be less than anticipated.

CHP Quality Index:

$$(249 \times 1,033 / 3,367) + (115 \times 1,577 / 3,367) = 130.3$$

Based on the above Quality Index Calculation the proposed unit will qualify for 100% exemption from CCL.

Site review to determine actual installation costs

If the desktop calculation modelling demonstrates a saving, it is imperative to understand the site to ensure suitability regarding interfacing the CHP, to establish the connective loads are achievable.

Installation costs can vary dramatically from site to site depending on several key factors:

- Location of CHP plant
- Gas availability
- Space allocation
- Planning implications
- Noise issues
- Local regulations
- Maintenance restrictions
- Electrical connections i.e. LV, HV, network restrictions
- Thermal integration.

Once these are established, another more detailed feasibility review is required to ensure suitability and compliance. Centrica Business Solutions can support this by providing applications engineering guidance and budget costings.

Plant optimisation

In order to optimise the CHP system, sizing the unit is critical to the success of the project. The aim of the process is to maximise the potential financial savings and ensure compliance with current legislation.

The most suitable sites for CHP generally have year round demand for heat or cooling, where the unit will be run as "lead boiler".

Viability further improves if you consider the CHP unit as a standby generator for noncritical loads or boiler replacement is considered. For units sized just above baseload, thermal modulation is possible where the unit is run at reduced output for short periods.

The baseload electrical demand of the site is the level that the sites electrical demand never falls below. It is generally the norm to provide a CHP unit that meets this criteria so that all the electricity generated by the CHP will be utilised by the site and any top-up will be provided from the grid.

There are instances where it may be beneficial to export electricity onto the grid, provided the full economics behind the scheme are identified and addressed. Electrical modulation is also a possibility to reduce the electrical output of the CHP of periods of low demand on-site.

Other factors

Other local influences that need to be established are site occupancy and the operational hours for the proposed plant, existing boiler efficiencies and future energy requirements that could be provided for.

Financing the CHP project

There are a number of financing options that can be specifically tailored to the individual requirements of each project regardless of project size, cost or complexity.

Discount energy purchase (DEP)

Centrica Business Solutions can offer to fund either all of, or any proportion there of, the costs associated with the implementation of the CHP project. This includes the design, supply, delivery, installation, commissioning and on-going operation of the scheme. Centrica Business Solutions would recover both the initial capital costs and the ongoing maintenance charges over a contractually agreed period, usually 10 years, by charging a p/kWh rate for the electricity generated by the CHP plant.

DEP benefits include:

- No capital outlay/lower risk
- No ongoing maintenance costs
- Faster implementation/immediate savings
- Long term, capped energy costs

Capital purchase

Centrica Business Solutions can provide a fixed cost for the complete turnkey package, including project design, supply, delivery, installation and commissioning. In addition to this, a service package can be offered that will operate and maintain the system throughout its lifetime. The main advantages of the capital purchase route are that the greater savings will be achievable over the product lifetime and

greater operational flexibility is available. If the capital purchase option is being considered and the customer is making a taxable profit (paid to HMRC), the project will likely be eligible for an Enhanced Capital Allowance. This mechanism allows businesses to claim a 100% first year capital allowance on investments on energy efficiency investments (such as CHP) against taxable profits during the period of investment.

Capital Purchase benefits include:

- Customers receive the full financial benefit of the energy savings
- The equipment is owned by the customer
- Unit can be used as a standby generator
- Run profile can be more easily modified to suit customer needs.

Energy savings agreements (ESA)

This process would begin with an Investment Grade Audit (IGA) of a customer's site, and identify potential opportunities covering the following aspects:

- Demand Side Measures (also known as Energy Conservation Measures) - These centre on opportunities that reduce the energy demand on site, e.g. new lighting, pumps, pipework insulation etc.
- Plant Upgrades - These opportunities look at generating the same energy demand but by using less fuel, e.g. new boilers, chillers etc.

- CHP - Once the new site demand and plant has been considered a CHP opportunity be evaluated.

Following the audit, a comprehensive report and savings calculation is presented to the customer.

Typical contract length of this agreement is 10 years. An agreed fixed monthly fee is paid by the customer to Centrica Business Solutions, and this fee is actually covered via the savings generated from the introduction of the upgraded equipment. As a result, the net cost to the customer is typically zero.

ESA benefits include:

- Guaranteed savings and levels of service delivery
- Zero capital outlay
- Proven method to reduce a sites energy consumption
- EUETS (EU Emissions Trading Scheme) and carbon reductions
- Incorporate additional low/zero carbon technology.

Integrating CHP into the building

Low temperature hot water (LTHW) systems

The most common and simplest form of heat recovery from a CHP unit is in the form of LTHW (typically 90°C/80°C). This enables heat recovery from the oil cooler, engine jacket and the exhaust gas heat exchanger, in a common primary water circuit.

CHP units can also be designed to operate at lower return temperature. There are a number of potential configuration options where the CHP can be integrated within the LTHW system, such as in-series or in-parallel.

An in-series configuration ensures that the CHP heat is utilised to its maximum capacity. This offers a number of additional benefits such as; reduction of on-site boiler dependency, which in turn, reduces boiler maintenance costs, and any potential backlog maintenance issues which potentially extends the life of the incumbent boiler set.

In some circumstances, it can be possible to use the CHP heat for domestic hot water use. This can be to supplement times when there is no or little LTHW load, such as summer months.

Steam systems

The thermal integration of any CHP unit should be carefully considered and investigated in order to achieve the maximum possible savings.

If the user requires a heat source in the form of steam then the exhaust gases (350°C – 450°C) from the CHP can be diverted directly into a waste heat recovery boiler.

Steam generation from CHP is best suited for units greater than 500kWe as the quantity of recovered energy below this value is small. The CHP provider would usually work with the boiler manufacturer to design the boiler using the details of the exhaust gas flow rates, temperature and pressure conditions of the required heat output.

Absorption cooling systems (trigeneration systems)

Absorption cooling is a technology that allows cooling to be produced from waste heat rather than traditional methods such as a vapour condensing chiller that uses electricity. Some sites that consider using this method will have a large continuous cooling demand, for example air-conditioning or process cooling. Typically these systems require a system temperature of 6°C–12°C which is particularly suitable for absorption chillers.

Absorption chillers can also be successfully incorporated into schemes that have a large electrical demand but may only have a relatively small thermal demand.

The size of the CHP unit could be maximised to meet the sites electrical load profile with the thermal energy being used to drive an absorption chiller. This would lower the sites electrical load by displacing the electrical demand of a conventional chiller.

The additional heat load would allow the plant to operate more efficiently, removing the seasonal variation element and improve the operational hours of the scheme. Most standard absorption chillers operate on either LTHW, MTHW or steam. Absorption chillers also require some form of heat rejection.

CHP technology

The equipment

Gas reciprocating engine

The most common form of smallscale CHP contains spark-ignition gas reciprocating engines. These prime movers are suited to smaller, simpler cogeneration systems of up to typically 2.5MWe in size, although multiple units can be used to deliver greater capacity.

There are two types of spark-ignition engines; naturally aspirated and turbocharged. Naturally aspirated engines are a simpler technology where the combustion air delivered to the engine is at atmospheric pressure. This is most commonly found on units under 250kWe due to the lower costs but at the expense of electrical efficiency which is around 30% (based on HHV).

Due to the lower electrical efficiency, more thermal energy can be recovered from these units.

Larger units above 250kWe tend to be turbocharged units which compress the combustion air before going into the cylinders. Turbocharged engines offer improved electrical efficiencies which can be as high as 40%.

Typically heat is recovered in the form of Low Temperature Hot Water (LTHW) with a flow temperature of up to 90°C. This is achieved through the recovery of heat from the engine block itself and an Exhaust Gas Heat Exchanger (EGHE) which recovers heat through the cooling of the exhaust gases. On large-scale systems the exhaust is sometimes diverted directly into a waste heat boiler to generate steam.

Gas turbine

The most common alternative prime mover is a gas turbine. Within the small scale CHP sector, gas turbines are a niche product due to their much higher heat-to-power ratios (about 3:1) and are relatively expensive at this size.

CHP technology

Gas engine and alternator

The engine and alternator are assembled as a unit with the drive from the engine transmitted to the alternator through a flexible power coupling. This assembly is attached to a steel sub-frame by flexible mounts with flexible connections to other mechanical equipment installed within the enclosure.

Heat recovery system

The closed primary water circuit recovers heat from the engine jacket, oil cooler and the exhaust gas heat exchanger. A thermostatic valve controls the temperature of the primary cooling system. This valve manages the warm up and cool down of the engine avoiding any thermal shocks. CHP heat is transferred to the customer's secondary water systems through a high efficiency plate heat exchanger. This plate heat exchanger hydraulically separates the primary and secondary water circuits. This hydraulic separation prevents either primary or secondary circuit contamination from the other water circuit and permits ease of maintenance and security of heat supply.

The base frame and enclosure

The CHP enclosure comprises a steel frame with sound insulated closure panels and doors. Removable/openable enclosure doors allow easy access for repair and maintenance. Ventilation air is drawn through a sound attenuator in the air inlet and pulled through the enclosure by an enclosure mounted fan. Combustion air is drawn independently into the engine through a dedicated combustion air attenuator located on the top of the enclosure.

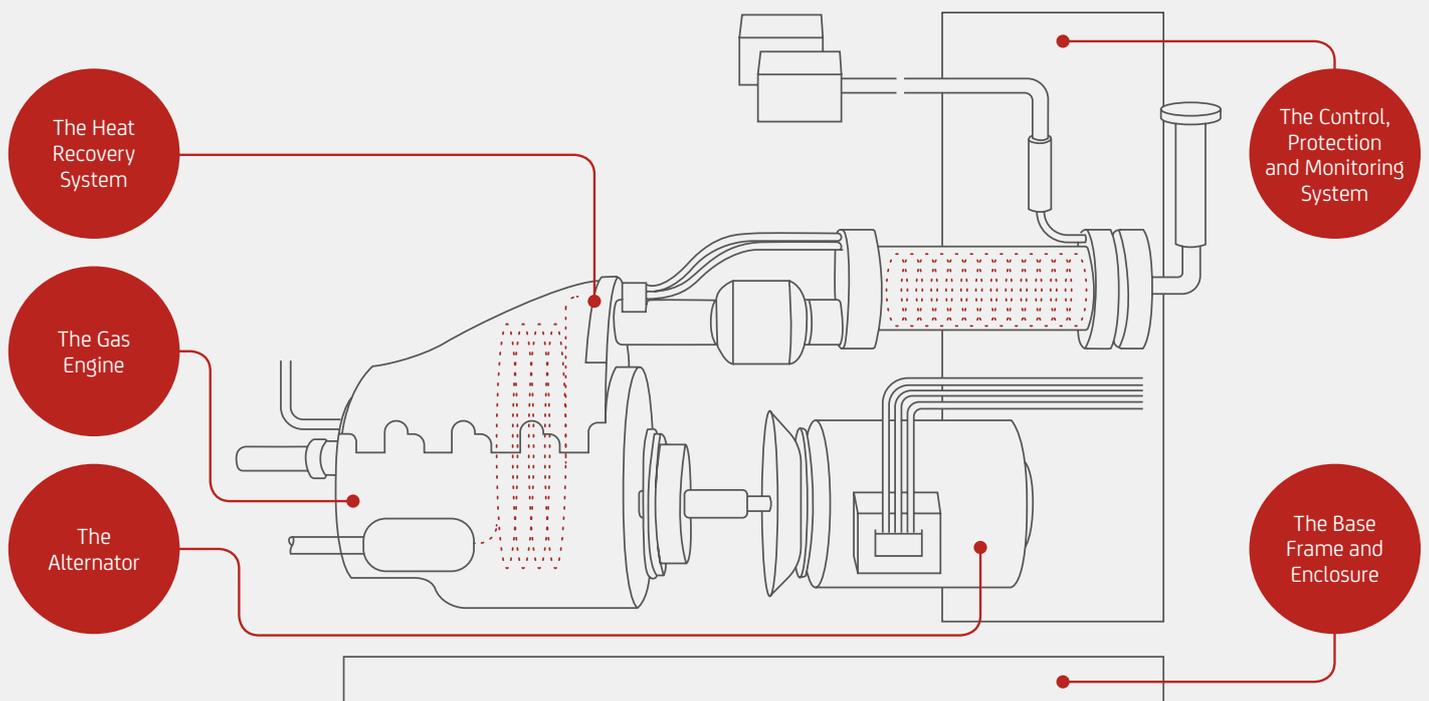
Control and protection

The unit is primarily designed to operate as a 'stand-alone' package with automatic control that requires minimal or no supervision. In exceptional cases, manual intervention or supervision can be advantageous. The unit control and electrical system is installed in a cabinet that forms part of the enclosure. It is specially designed to control and protect the CHP unit.

Principal areas of control are:

- Electric output
- Heat
- Import and export interface with grid
- Electrical isolation.

A Remote Monitoring System collects data continuously and would be connected to a central control desk. This allows remote operation and adjustment of settings when needed. The unit is usually controlled and protected by a remote monitoring and control system called E-POWER.

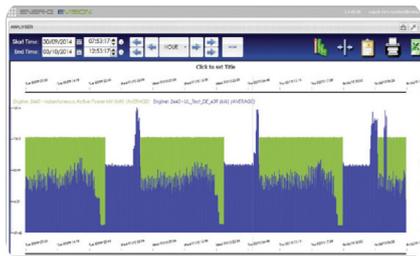
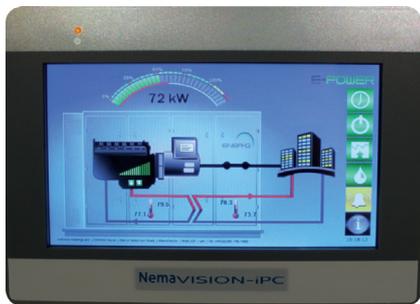


CHP technology

E-POWER

E-POWER is a unique controller specifically designed for CHP and its related plant. It allows you to monitor over 200 parameters on your CHP system and many more on your energy plant.

The flexible integrated controller offers improved safety, always-on Internet connectivity, high quality touch screen and graphics.



E-POWER is different from other Genset system controllers as it is specifically designed with optimum functionality including:

- Sophisticated data logging:
 - Trip counter
 - Restart counts
 - Immediate fault detection
 - Easy root cause analysis
 - Ignition energy
 - Knock levels
 - Spark advance
 - Enhanced synchronising
 - Designed for data collection, integration and metering
 - Assists in reducing on-site costs
 - Two integrated safety circuits ensuring total peace of mind
 - Touchscreen Human Machine Interface (HMI)
 - Always optimised heat production and utilisation.
- The E-POWER system can easily expand into:
- Boiler controls; ensuring your boilers are fully optimised and integrate with your CHP
 - MBus metering.

E-VISION

E-VISION is the platform that collects, collates and reports all the energy generated from the CHP system and any connected related plant.

It is a fully integrated platform that allows the control of multiple energy systems located at one single site or at multiple sites.

- Built-in customer access
- Excel based reporting
- Online reporting and analysis
- Secure Cloud based servers
- Worldwide access
- Enables wider building control
- Assists in reducing on-site costs
- Shows demonstrable savings
 - Carbon Reduction
 - Financial
- Monitoring of boiler and chiller heat usage
- Optimisation of thermal store – controlling the flow and return
- Controls the modulation and firing of boiler/heating plant.

In the UK, CHP units should be designed and constructed to the following standards and regulations:

| | |
|-------------|--|
| G59/3 | Electricity Councils Chief Engineers Regulations |
| IGE/UP/1 | Soundness testing and purging of industrial and commercial gas installations |
| IGE/UP/2 | Gas installation pipe work, boosters and compressors on industrial and commercial premises |
| IGE/UP/3 | Gas fuelled spark ignition and dual fuel engines |
| IGE/UP/4 | Commissioning of gas fired plant on industrial and commercial premises |
| 2006/95/EC | The Low Voltage Directive |
| 2004/108/EC | Electromagnetic Compatibility |
| 2006/42/EC | New Machinery Safety Directive |
| BS7671 | IET Wiring Regulations |
| 94/4/EC | ATEX Directive |
| BS EN 60034 | General requirements for rotating electrical machines |
| ISO3046/1 | Reciprocating internal combustion engines – performance |



ENER-G CHP in action

Alton Towers Reducing costs, improving sustainability

Better performance

The 550-acre Alton Towers site includes a conference centre, four hotels that can accommodate 2,500 guests, and Europe's largest waterpark – which needs to heat 1,000m³ of water and pump 66m³ of air/second.

Centrica Business Solutions provided a consolidated package, acting as manufacturer, installer and service provider. A CHP unit was installed on site, alongside the waterpark, generating up to 850kW. If there

are any issues with the CHP, Centrica support ensures they are dealt with quickly – and the unit returns to peak efficiency.

Right result

The CHP unit generates power at source so energy efficiency has increased to 80%, and with a direct lowering of the resort's carbon levy, there is the added attraction to investors of a more sustainable business. Centrica Business Solutions funded the unit and installation, saving the resort's capital budget, which allowed it to invest in customer-facing attractions.





ENER-G CHP in action

Newcastle United Fielding a premier league carbon footprint

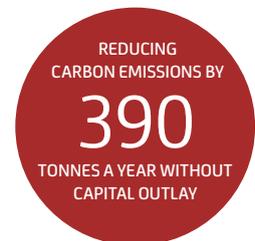
Better performance

The club were already offsetting more carbon than they emitted through boiler optimisation, burner management, lighting upgrades, smart building and energy monitoring. But to take their carbon saving to the next level, they needed a permanent, cost-effective solution.

Due to the space constraints of the stadium, we delivered their new CHP system in parts and rebuilt it in situ.

Right result

The ENER-G CHP unit is now helping the club reduce their CO₂ emissions by an additional 390 tonnes per year. And thanks to the cloud-based monitoring system which provides a two-way communication channel between the unit and service centre, we can monitor the energy levels in real time to make sure the club are always getting the best performance.



Glossary of terms

Absorption Chiller - Absorption chillers use heat instead of mechanical energy to provide cooling. Therefore they can be combined with a Cogeneration (CHP) unit to provide Trigeneration.

ADE - The Association for Decentralised Energy is the leading advocate of an integrated approach to delivering energy locally, designed around the needs of the user. ADE works within the UK, to promote the wider use of Combined Heat and Power and District Heating schemes.

BEMS - Building Energy Management Systems.

Biogas - Biogas is generated when bacteria degrades biological material in the absence of oxygen, in a process known as anaerobic digestion. Since biogas is a mixture of methane (also known as marsh gas or natural gas) and carbon dioxide it is classed as a renewable fuel.

Building Management Systems - Controls associated with space heating, air conditioning, hot water service and lighting in buildings.

Calorific Value - Amount of heat generated by a given mass of fuel when it is completely burned. It is measured in joules per kilogram.

Carbon Reduction Commitment (CRC) - Scheme designed to improve energy efficiency in organisations.

Catalyst - A catalyst provides a means to further reduce exhaust emissions for NO_x and CO₂.

Climate Change Levy - The Climate Change Levy is a UK only tax on energy use in industry, commerce, agriculture and the public sector. Tax is levied on a p/kWh basis.

Carbon Dioxide (CO₂) - odourless gas which is harmful to the environment.

Cogeneration - Also referred to as Combined Heat and Power or CHP - onsite generation of electricity, heat and/or cooling for the public and private sector.

Combined Heat and Power (CHP) - See Cogeneration.

COP - Coefficient of Performance (COP = chiller load/ heat input).

DECC - The Department of Energy and Climate Change works to make sure the UK has secure, clean, affordable energy supplies and promote international action to mitigate climate change.

Discount Energy Purchase - Cogeneration technology supplied, installed and maintained by Centrica Business Solutions with no capital cost incurred to the client. The energy produced from the unit is then sold at a discounted rate to the client.

DNO - Distribution Network Operator.

ECA - See Enhanced Capital Allowances. **Electrical Efficiency** - Electrical output in relation to fuel input.

Enhanced Capital Allowances - Capital allowances on plant and machinery are generally given at 25% a year on a reducing balance basis. However, with ECAs, businesses can write off 100% of the cost of energy saving equipment against their taxable profits within the first year of investment. Businesses claim the allowance on their income tax or corporation tax returns. This applies to the UK only.

E-POWER - Control and monitoring system dedicated for use in Centrica Business Solutions Gensets/CHP Units.

ESPC - See Energy Services Performance Contracting.

EUETS - The European Union Emission Trading Scheme is the largest multinational greenhouse gas emissions trading scheme in the world and is the main pillar of EU climate policy.

Feasibility Studies - Carried out free of charge by Centrica Business Solutions to determine the viability of our technologies in a particular application.

G59 - Recommendations for the connection of embedded generating plant to the DNO's distribution systems and the provision of standby generators.

HHV - Higher Heat Value.

HVAC - Heating, Ventilation and Airconditioning.

Island Mode / Standby Cogeneration - Ability of the Cogeneration unit to operate independently from the grid.

kWh - Kilo Watt Hour.

LTHW - Low Temperature Hot Water.

MTHW - Medium Temperature Hot Water.

MWh - Mega Watt Hour.

NO_x - Nitrogen oxides (NO_x) act as indirect greenhouse gases by producing the tropospheric greenhouse gas 'ozone' during their breakdown in the atmosphere.

Operation and Maintenance - Services and aftercare of CHP Units.

Parallel Grid Mode - This is where the Cogeneration unit runs in parallel with the grid.

Part L - Part L of the UK Building Regulations deals with the conservation of fuel and power in buildings throughout the UK. It is part of a broad wave of European legislation which seeks to encourage industry-wide adoption of energy efficient practices and waste minimisation techniques as the embodiment of the EU Performance of Buildings Directive, the legislation is only in its infancy. However it is already having a significant impact on the UK building industry.

Sound pressure level (dB(A)) - A weighted sound pressure level at a certain distance from the source.

Spark Spread - The difference between electricity price and gas price – can affect the viability of the cogeneration system.

Standard Reference Conditions - Standard conditions for ambient air, ambient air pressure, relative humidity, cooling water temperature referred to when defining engine output, fuel consumption etc.

Thermal Efficiency - Quantity of heat produced in relation to fuel input.

Total Efficiency - Sum of the electrical and thermal efficiency in relation to the fuel consumed.

Trigeneration - The absorption chilling unit uses waste heat available from the CHP system in the summer months to provide chilled water.

UK Emissions Trading Scheme - Based on the international Kyoto Summit on Climate Change agreement, this describes the UK's National Emissions Trading Scheme designed to reduce a range of greenhouse gases, 80% of which is carbon dioxide.

CIBSE accredited CPD courses

We are a CIBSE approved Continued Professional Development (CPD) presentation provider. With a wealth of experience our range of presentations focus on all subjects related to CHP and best practice in CHP design, installation, financial benefits, sustainability and legislation.

Our introductory presentations explain the fundamentals of CHP and our more advanced presentations delve deeper into numerous technical solutions such as load profiling, heat interfaces, tri-generation, site integration, control strategies, fuel systems and many more.

As the only British based CHP manufacturer we consistently design, install, maintain and finance CHP projects for many different organisations in a range of market sectors.

This allows us to tailor presentations to the audience by illustrating local case study examples of CHP, their lifetime benefits and savings and their chosen funding options.

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Useful contacts and further information

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| CIBSE CHP Group | www.cibse.org/chp |
| Association for Decentralised Energy (ADE) | www.theade.co.uk |
| Energy Saving Trust | www.est.co.uk |
| The Carbon Trust | www.carbontrust.co.uk |
| DECC | www.decc.gov.uk |
| CHP Quality Assurance | www.chpqa.com |
| Climate Change Levy | www.gov.uk/topic/business-tax/climate-change-levy |
| Enhanced Capital Allowances | www.eca.gov.uk |



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Centrica business Solutions

In a changing energy landscape, we help our customers unlock the power of power to realise their ambitions. We're already helping more than 1,500 businesses around the world, from retail and manufacturing to health and education:

Powering Performance: Improving business performance

Powering Resilience: Enabling businesses to stay on 24/7

Powering Growth: Unlocking new sources of value and advantage for business

We build intelligent, end-to-end energy solutions to power performance, resilience and growth for our customers through:

Insight: Leveraging 'big data' to help customers manage energy performance across all their equipment and devices

Optimisation: Redesigning how businesses use energy to improve operational efficiency

Solutions: Providing power sources and systems to help customers take control of their energy supply and manage demand

Centrica Business Solutions is part of Centrica – a global energy and services company dedicated to satisfying the changing needs of its customers. With the acquisition of Panoramic Power and ENER-G, we're helping more and more customers gain competitive advantage from energy, building intelligent end-to-end energy solutions that power performance, resilience and growth. Through Centrica, we also provide energy trading services and supply energy through British Gas in the UK, Bord Gais in Ireland and Direct Energy in the USA.

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