shentongroup
power with responsibility

Combined Heat and Power Systems – When is CHP the right renewable energy choice?

October 2014

t. +44 (0)844 888 444 5
e. info@shentongroup.co.uk
www.shentongroup.co.uk

Shenton House, Walworth Road,
Walworth Business Park,
Andover, SP10 5LH

shenton**group**
power with responsibility

When is CHP the right renewable energy choice?

With rising energy prices, finding ways to reduce the cost and increase efficiency of supplies for thermal and electrical demands is more important than ever.

A Combined Heat and Power (CHP) system can make significant improvements in both operational efficiencies and cost saving.

The classic mistake in specification is an assumption that the primary function of a CHP is to deliver electricity. A CHP system is basically a hot water machine with electricity as an additional benefit. Given rising energy prices, this benefit can be substantial.

In addition to the principle benefits of electricity and heat generation, a further significant benefit of CHP is that in certain cases, standby power and island mode running can be provided. This renders a degree of independence from the grid and in some cases, can provide a standby power capability for your building or facility.

To help understand these benefits in more detail, this shenton**group** white paper will help to guide you through the following areas in the suitability and benefits of Combined Heat and Power systems:

t. +44 (0)844 888 444 5
e. info@shentongroup.co.uk
www.shentongroup.co.uk

Shenton House, Walworth Road,
Walworth Business Park,
Andover, SP10 5LH

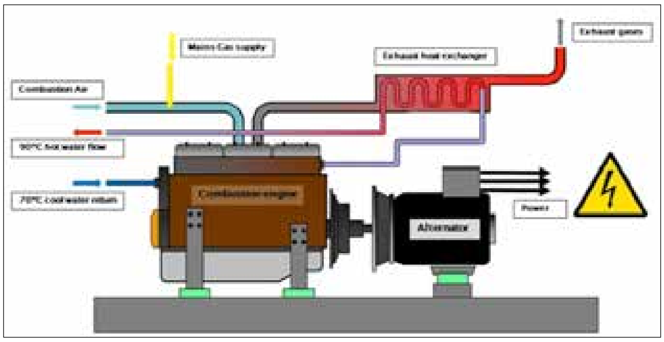
What is CHP and how does it work?

CHP is the simultaneous production of heat and electricity from a single fuel source, usually at the point of use.

With a CHP system, a fuel, usually natural gas, is used to drive a reciprocating engine. This in turn delivers electricity from the alternator.

At the same time, the heat produced by the engine working is captured from various sources, for example from the exhaust system and engine cooling circuits, to produce hot water. On some models heat is also recovered from the alternator and engine oil, further increasing efficiency.

We should emphasise it is combined heat and power - with heat output being as much as twice the electrical output - it is not possible to have the electricity without the heat.



> “CHP is the simultaneous production of heat and electricity from a single fuel source”

What are the benefits of CHP versus other renewable energy sources?

When there is such a range of energy-saving and carbon reduction technologies available, it may often be difficult to decide amongst them. It is true to say that each individual technology should be considered on its own merits, and the services of a specialist consultant may be required in order to manage the performance and financial assessments that are part of this process.

However to simplify this, it is worth remembering that if you have a use for electricity and heat energy, then CHP may well be the fastest payback, and the most financially beneficial single technology you can use.

Consider a practical example. Take for instance a natural gas CHP producing 80 kW of electrical energy and 120 kW of thermal energy. When compared to other technologies, some interesting comparisons come to light.

You would require 100's of square metres of solar PV panels to create the same electrical output – and even then, only on a sunny day. You would also not get a heat benefit.

> "CHP may well be the fastest payback, and the most financially beneficial single technology you can use"

If you considered biomass boilers to achieve the 120 kW thermal energy you would need plentiful access to a decent biomass fuel source, a large volume of storage area, and be able to tolerate regular deliveries from HGV's. This would give you heat but no electricity.

Wind turbines capable of generating 80 kW of electricity are substantial. You would have to erect a large unsightly turbine, or an array of smaller ones. Although wind energy is considered 'free' it is inconsistent, and may not always be available at the most appropriate times for your energy needs. It also gives you no heat.

So is CHP right for everybody? No of course not. But – if you have an application for electricity and heat, CHP remains fully controllable, available 24/7, and delivers substantial, consistent energy savings – whether the wind blows or the sun shines, or not. In many cases it also can be the largest single carbon reduction technology that you can install.

Where CHP systems should be specified

To give an example of the heat requirement of a building to make it appropriate, we should first repeat the fundamental principle that on average **a CHP system will produce up to twice the amount of heat energy as the electricity it generates.**

Cost effective applications for CHP systems therefore are any facility where there is a continuous need for heat energy.

Facilities such as:-

- Hospitals
- Gyms and leisure centres
- Larger hotels
- Swimming pools
- Sheltered housing or assisted living accommodation
- Residential and care homes
- Food processing plants
- Multi-occupancy residential buildings
- Mixed-use developments

For emphasis, examples of buildings where CHP is usually not suitable, or are more challenging, would be:-

- Individual dwellings
- Office buildings
- Certain types of school
- Warehouses

Although these sites may not always be exclusive, there is rarely sufficient need for heat energy for enough hours per year to give a decent return on investment.

shenton**group**
power with responsibility

What are the drivers for CHP specification?

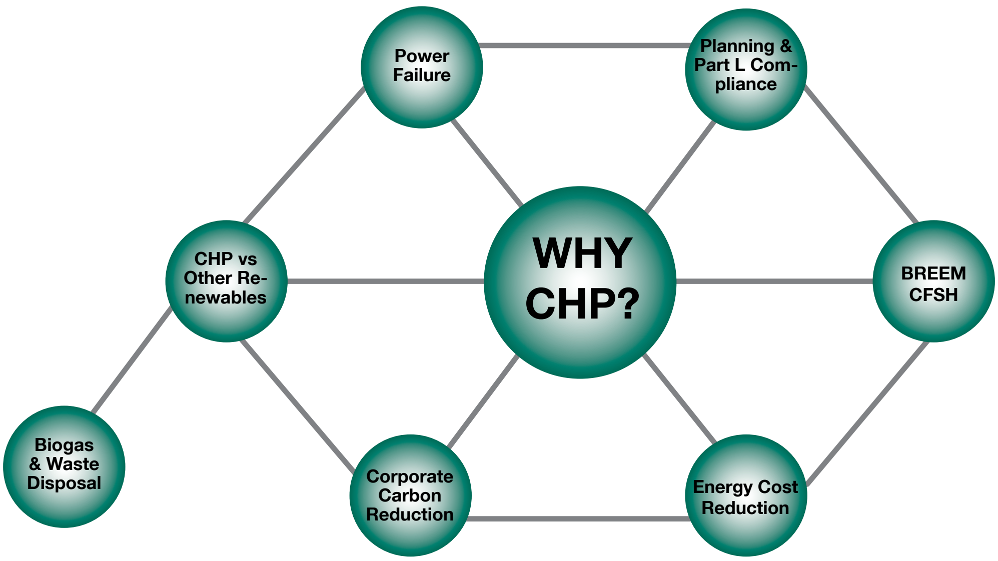
Why CHP?

For most buildings, power supply originates at a power station many miles away. Power stations are typically only 35-40% efficient.

So, before the power supply even reaches your building it's not fuel resource efficient. A good quality, well designed CHP system can produce efficiencies in excess of 95%.

Operational efficiencies aside, energy cost reduction and environmentally related reasons are usually the primary drivers behind CHP Specification. The other common drivers include:

- Energy Cost Reduction
- Energy Supply Management
- Planning Requirements
- Part L Compliance
- Achieving BREEAM or CFSH
- Corporate Carbon Reduction
- Biogas and Waste Disposal



t. +44 (0)844 888 444 5
e. info@shentongroup.co.uk
www.shentongroup.co.uk

Shenton House, Walworth Road,
Walworth Business Park,
Andover, SP10 5LH

Energy cost reduction

This should be the original classic motive for combined heat and power. For many it remains the raison d'être for CHP today. Despite numerous additional benefits arising from utilisation of CHP, it is a fundamental core business principle that, in most cases, the unit should be able to pay for itself, giving very respectable rate of return on initial capital outlay. After this period the savings accumulate year-on-year, giving tremendous benefits to the financial bottom line.

The core principle lies in what is known as the 'spark rate'. This is industry jargon for the difference in price between a kilowatt of gas and a kilowatt of grid electricity.

In simple terms, we take gas to operate the engine and we generate electrical power, recovering all the associated heat from the process. The value of the electricity generated is that it displaces electricity which would otherwise have to be purchased from the grid.

The value of the heat produced is that it displaces heat that otherwise would have to be produced by a local boiler plant.

Due to the high efficiency of CHP plant, these two energy outputs can be achieved for significantly less money than delivering them from conventional grid sources.

Energy Supply Management

Successful management of your power supply should be taken into account, not only for security of supply, such as supporting essential services, but also for peak lopping.

In certain circumstances, CHP can provide standby power to maintain the supply to carefully selected essential services circuits within a building.

Choosing a CHP system with black-start and island running mode capability enables the CHP unit to function just like a standby generator. A further benefit of this functionality is producing the standby power from natural gas, removing the need for costly onsite diesel storage and fuel transfer pipework normally associated with conventional standby power.

A common challenge for this application is ensuring the total demand of the essential services circuits does not exceed the maximum step-load acceptance of the CHP engine. Given that the primary drivers for installing a CHP (energy saving and / or carbon compliance) tend to result in a CHP sized to the base load, there is often a misconception in the minds of designers that CHP can provide standby power for the entire building.

As CHP plant is usually operated in parallel with the grid, it is important to load follow electrically and regulate its output relative to import of power from the mains. In situations where the building is already operating at the extreme limits of its electrical mains incomer, installing CHP to 'peak lop' a certain proportion of the power can be significantly cheaper than buying an upgrade to the mains incoming supply.

t. +44 (0)844 888 444 5
e. info@shentongroup.co.uk
www.shentongroup.co.uk

Shenton House, Walworth Road,
Walworth Business Park,
Andover, SP10 5LH

Part L compliance

The current UK building regulations require a certain proportion of the total energy consumption of a building to be delivered from a low or zero carbon source. There are many technologies that can be employed for this task, including wind turbines, biomass boilers, air source heat pumps, ground source heat pumps, solar PV, solar thermal, and CHP. In many scenarios CHP may be the only option available to the designer.

Common challenges with implementing other technologies often eliminate them one by one. For example, wind turbines may be disallowed due to appearance or may generate insufficient power.

There may be insufficient space in a project for a biomass boiler, and noise and access issues associated with frequent HGV deliveries of wood pellets may also preclude its use.

Air source heat pumps may have insufficient ambient temperature gradient to be able to contribute for requirements of Part L, and ground source heat pumps may have insufficient ground footprint to operate. The cost of these options may also be prohibited relative to the cost of CHP.

Solar PV and solar thermal may be impractical if insufficient roof area exists or visual planning aspects prevent its use.

This sometimes leaves CHP as the only practical choice. In any case, as Part L compliance is really a carbon reduction strategy, CHP plant still remains the biggest, single carbon reducing technology that can be implemented in this way.

Specification to support BREEAM and CFSH and assist planning

Combined heat and power plant has a serious role to play in helping developers achieve the necessary score for BREEAM or CFSH projects. CHP high energy efficiency and low carbon footprint is often the biggest single energy saving contributor to these schemes.

In some cases the ability to use the CHP may be the single defining factor to allow the scheme to go ahead. For example, if there is a condition of planning, or specific types of funding requiring that the building should achieve a minimum BREEAM score, reducing the energy consumption by implementation of the CHP may alone make the difference between the project achieving this goal or missing it.

t. +44 (0)844 888 444 5
e. info@shentongroup.co.uk
www.shentongroup.co.uk

Shenton House, Walworth Road,
Walworth Business Park,
Andover, SP10 5LH

BREEAM

BREEAM or the Building Research Establishment Environmental Assessment Method is regarded by many as the world's foremost environmental assessment method and rating system for buildings. 250,000 buildings have certified BREEAM assessment ratings with over a million registrations for assessment since it was first launched in 1990.

BREEAM sets the standard for best practice in sustainable building design, construction and operation, and has become one of the most comprehensive and widely recognised measures of a building's environmental performance. It encourages designers, clients and others to think about low carbon and low impact design, minimising the energy demands created by a building before considering energy efficiency and low carbon technologies.

A BREEAM assessment uses recognised measures of performance, which are set against established benchmarks, to evaluate a building's specification, design, construction and use. The measures used represent a broad range of categories and criteria from energy to ecology. They include aspects related to energy and water use, the internal environment (health and well-being), pollution, transport, materials, waste, ecology and management processes.

CFSH – Code For Sustainable Homes

The Code For Sustainable Homes is the UK national standard for the sustainable design and construction of new dwellings.

It aims to reduce carbon emissions, and promote higher standards of sustainable design above the current minimum standards set out by the building regulations.

The code provides 9 measures of sustainable design:

- energy/CO2
- water
- materials
- surface water runoff (flooding and flood prevention)
- waste
- pollution
- health and well-being
- management
- ecology

It uses a 1 to 6 star system to rate the overall sustainability performance of a new home against these 9 categories. The code is voluntary. It is not a set of regulations and should not be confused with the zero carbon policy or the 2016 zero carbon target.

The only circumstances where the code can be enforced are when:

- Local councils require developers to comply with the code by including a requirement in their planning policy
- Affordable housing is funded by the Homes and Community Agency that requires homes to be built to code level 3
- The level 3 energy standard is now incorporated in the building regulations

THE CODE FOR SUSTAINABLE HOMES™

t. +44 (0)844 888 444 5
e. info@shentongroup.co.uk
www.shentongroup.co.uk

Shenton House, Walworth Road,
Walworth Business Park,
Andover, SP10 5LH

Corporate carbon reduction

In the UK, the 2008 Climate Change Act established the world's first legally binding climate change target. The government aims to reduce the UK's greenhouse gas emissions by at least 80% (from the 1990 baseline) by 2050.

A significant step towards compliance is the reduction of all forms of energy consumption, which have their origin in a fossil fuel. A major contributor to these energy management requirements is the effective use of combined heat and power. Running the CHP unit on a biogas will produce electricity and heat energy from a truly renewable fuel. This is virtually 100% carbon free.

More often, especially for commercial applications within the built environment, running the CHP on natural gas will produce electricity and heat energy from what is known as a 'sustainable' fuel. Natural gas is of course still a fossil fuel. However, due to the very high efficiency of CHP plant, the production of energy (particularly electricity) by running on natural gas makes a major contribution to carbon reduction for business and large corporations.

A huge advantage in this application of CHP is that the technology is likely to pay for itself handsomely through reduced energy costs, whilst also reducing the carbon footprint of the organisation.

> "Running the CHP unit on a biogas will produce electricity and heat energy from a truly renewable fuel. This is virtually 100% carbon free."

t. +44 (0)844 888 444 5
e. info@shentongroup.co.uk
www.shentongroup.co.uk

Shenton House, Walworth Road,
Walworth Business Park,
Andover, SP10 5LH

shenton**group**
power with responsibility

Biogas & Waste Disposal

The current UK building regulations require certain CHPs suitable to run on biogas are for a completely different type of application compared to the standard energy-saving in the built environment use.

Biogas can be obtained from a number of sources all of which have benefits in that the cost of biogas itself may be an insignificant part of the economics. For example:-

Anaerobic digestion is a technology whereby material known as feedstock is decomposed in an accelerated process producing methane gas as a by-product. The feedstock for this process can often be a material which either has relatively low value (such as in animal slurry), or in some cases can even be a waste material where cost would be otherwise required to dispose of it, such as waste from food production or municipal waste for example.

In these types of applications, the financial benefits of using the CHP can be more considerable than on natural gas. Various financial incentives exist such as the Feed-in Tariff scheme (FITs), Renewable Heat Incentive (RHI) etc.

> “The current UK building regulations require certain CHPs suitable to run on biogas”

t. +44 (0)844 888 444 5
e. info@shentongroup.co.uk
www.shentongroup.co.uk

Shenton House, Walworth Road,
Walworth Business Park,
Andover, SP10 5LH

Example project with feasibility study – Sandcastle Water Park

The 26 year old boilers at Sandcastle Water Park posed a number of risks to the day to day operation of the business. Energy costs had risen to over 40% of operating overheads in the last 5 years. The management needed to reduce energy consumption without limiting customer experience. Also, the facility was approaching the limit of available mains power, thus impeding future growth.

The Problems

- On busy days boilers could not produce enough hot water to meet the demand
- A boiler breakdown reduced air and water temperatures so much, that in the winter it could take up to 48 hours to recover
- A boiler breakdown during the holiday periods would shut the water park resulting in significant loss of revenue.

The boilers were not the only issue. The investment in the water park and its new features was attracting more visitors but without the infrastructure to support the impact of the upgrades.

- The hot water storage tanks were unable to meet demand and not all visitors could have hot showers
- If the Park had to operate on 2 boilers it could only sustain a few hours of use.
- Any serious failure of the existing plant boilers and associated pumps and pipework would close the park
- Locating parts for old or obsolete plant was becoming more difficult for maintenance staff
- Limited access to the plant room via a spiral staircase for personnel and a small access panel in the roof.
- If the existing plant did suffer serious failure, the logistical and structural issues meant a straight forward replacement could take up to 5 weeks

t. +44 (0)844 888 444 5
e. info@shentongroup.co.uk
www.shentongroup.co.uk

Shenton House, Walworth Road,
Walworth Business Park,
Andover, SP10 5LH

shenton**group**
power with responsibility

Recommendations

A recommendation was made to replace the boiler plant and add a CHP unit to help reduce these risks. A Council report was completed and recommended.

> "That the boiler plant and Combined Heat and Power Unit is purchased by the Council at a cost of £606,972 and met through Prudential Borrowing. The cost of the scheme will be paid back through savings on energy costs over a period of up to 10 years and recovered by the Council via reduced subsidy."

The proposal formed part of a 'spend-to-save initiative' as the alternative option was to install new boilers, at a cost of £451,000, without delivering the same savings on day to day running of a CHP system.

The Solution

Preston Lee Chambers, working as the client's consultant, chose the shenton**group** 200k We Natural Gas Cento Indoor Acoustic unit. The thermal demand was carefully modelled to ensure heat output could be utilised.

shenton**group** worked closely with Preston Lee Chambers throughout the design and selection process and made available a number of desktop study scenario's using their 'Power Therm Savings Calculator', which included assessments of financial and carbon savings.

t. +44 (0)844 888 444 5
e. info@shentongroup.co.uk
www.shentongroup.co.uk

Shenton House, Walworth Road,
Walworth Business Park,
Andover, SP10 5LH

A recommendation was made to replace the boiler. Including the initial cost and maintenance, the return on investment is expected to be less than 3 years.

Output and resilience of boilerplant + CHP unit* :-

Existing boilerplant output = 2,250kW

New boilerplant + CHP unit output = 2,950kW

Existing boilerplant output with one = 1,500kW boiler failure

New boilerplant + CHP unit with one = 2,411kW boiler failure

* Source: Exec Report from Blackpool Operating Board

A heat dump radiator was installed to permit electrical peak lopping, even when limited thermal demand was available. This allowed future-proofing of the incoming electrical supply, by giving the mains incomer 200kW of spare head room as a result of generating it on-site.

The narrow compact footprint of the Cento design allowed lifting through the limited space via the plant room roof. During installation, modifications were made and bespoke hinges were fitted onto the CHP unit's doors to allow optimum functionality in a limited space.

The selected machine is maintained on a shenton**group** Infinium24 fixed price maintenance contract, which includes a lifetime warranty covering parts, consumables, call-outs, remote monitoring and technical support 24/7. This contract enables the client to place all maintenance risks with shenton**group**, thus giving totally predictable maintenance costs.

In addition to the Combined Heat and Power unit, high efficiency condensing boilers and rapid recovery hot water storage cylinders were also specified. System back up was also factored in to provide flexibility and resilience via 5 boilers (4 running/1 standby) + CHP unit.

A pre-tender survey was essential to progress the layout of the boilerplant, roof access requirements and structural implications.

The installation had to be complete before the summer season. Therefore the programme required works to be carried out during winter shutdown in order to limit the impact on the Waterpark's clientele.

The job was completed and the CHP unit is now providing a large proportion of the total site demand per year, to offset grid electrical and thermal energy.

t. +44 (0)844 888 444 5
e. info@shentongroup.co.uk
www.shentongroup.co.uk

Shenton House, Walworth Road,
Walworth Business Park,
Andover, SP10 5LH

shenton**group**
power with responsibility

Conclusion

The correct specification of a CHP system for the right type of application, can bring significant environmental benefits.

To find out more about design and operational considerations read our white paper:

“**Design and operational considerations to get the best performance from CHP systems.**”

t. +44 (0)844 888 444 5
e. info@shentongroup.co.uk
www.shentongroup.co.uk

Shenton House, Walworth Road,
Walworth Business Park,
Andover, SP10 5LH