The Knowledge Network

COMBINED HEAT & POWER (CHP)

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About This Factfile

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The Institution of Engineering and Technology

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As engineering and technology become increasingly interdisciplinary, global and inclusive, the Institution of Engineering and Technology reflects that progression and welcomes involvement from, and communication between, all sectors of science, engineering and technology.

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Introduction

The principle of Combined Heat and Power (CHP), also known as co-generation, is to recover and put to use heat that is released during the generation of power. Each year, UK power stations typically reject over 2100 PJ as waste heat – more energy than is used to heat all homes in the UK. So if CHP could be harnessed more effectively there are potentially significant energy, environmental and economic benefits which could be realised.

CHP has always played an important role in the UK's energy supply. In the early years of the UK electricity supply industry most stations were local and supplied heat as well as power. The trend towards large power stations meant that power was no longer generated at locations that had an adjacent heat load and until the 1990's UK CHP capacity declined. However the inherent fuel efficiency of CHP provides an opportunity to reduce emissions of carbon dioxide and other pollutants and from 1990 onwards CHP was recognised as a key measure to abate emissions and a range of promotional and incentive mechanisms were put in place.

In the decade to 2000, capacity more than doubled, representing an average growth rate over the period of 8 per cent per annum. However, difficult market conditions slowed this growth rate from 2001. Despite a decreasing number of CHP schemes, the overall capacity has still been increasing slowly.

CHP capacity at the end of 2003 was about 4900 MWe producing 24 TWh of electricity and 59 TWh of heat, hence CHP currently produces 6% of the UK's electricity supplies.

From Principle to Reality

The CHP principle can be realised in many ways, using a range of fuels and prime movers and implemented in capacitates from 10 kWe to 100's of MWe. As many CHP schemes operate for decades, current UK CHP capacity comprises schemes based on old and new forms of CHP technology.

The main technologies used in current UK CHP schemes are:

- Gas Engines – converted car or truck engines using natural gas as fuel, driving a generator and recovering heat from the engine exhaust and cooling jacket. Sizes range from 10 kWe to several MWe. This form of CHP is widely used in buildings where the use of low temperature heating systems enables a high level of heat recovery;

- Gas Turbines – derived from aerospace designs these produce exhaust gas at high temperature, which is ideal for generating steam or use in a drying process. Sizes range from below 100 kWe to 50 MWe. This form of CHP is commonly found in industry e.g. the process industries such as the chemicals or paper industries, which have high demands for steam;

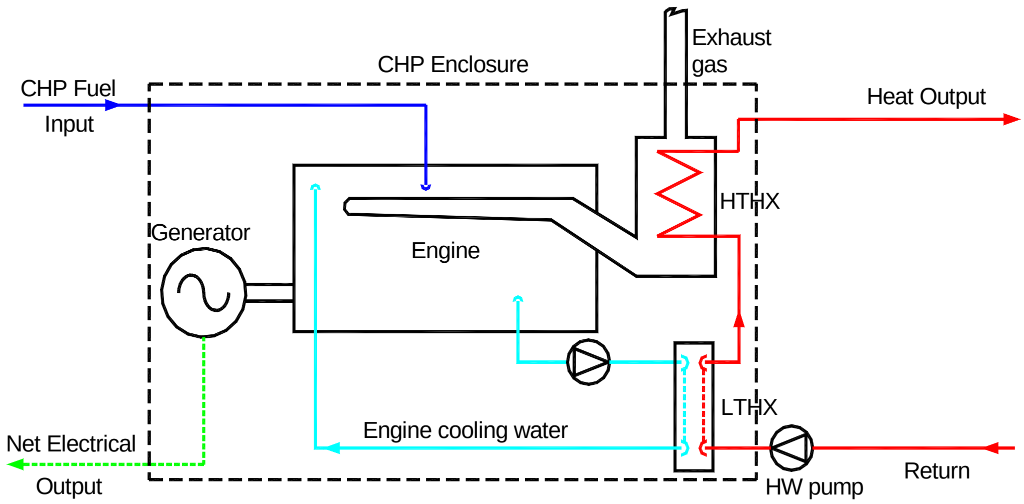
- Steam Turbines – this technology was the mainstay of CHP capacity and is based on the designs found in coal fired power stations. Sizes range from around 100 kWe to many MWe. As the heat output is in the form of steam the main applications are also in the process industries;

- Combined Cycle Gas Turbines – this combines a Gas Turbine feeding a Heat Recovery Steam Generator (HRSG) which in turn drives a Steam Turbine. Sizes range from 20 MWe to many 100's of MWe. This system offers a high power efficiency and is normally found in the process industries;

- Absorption Chilling – this technology uses heat (as hot water or steam) to produce chilled water or chilled glycol. In combination with one of the other CHP technologies this can be used to provide power, heat and chilling. Such tri-generation systems are found in buildings and on some industrial sites.

Whilst the most common fuel is natural gas, the range of fuels used by these technologies is also wide and includes:

Natural Gas	Biomass and biogas
Landfill and Sewage Gas	Solid waste, e.g. Refuse, tyres
Fuel and Gas Oils	Waste gases, e.g. Refinery off gas
Coal, lignite and coke	Waste process heat



Packaged Gas Engine CHP with single grade hot water heat output and no heat dump

Figure 1

The following figures provide typical schematics for a small scale CHP used in a building and a larger gas turbine CHP used in industry.

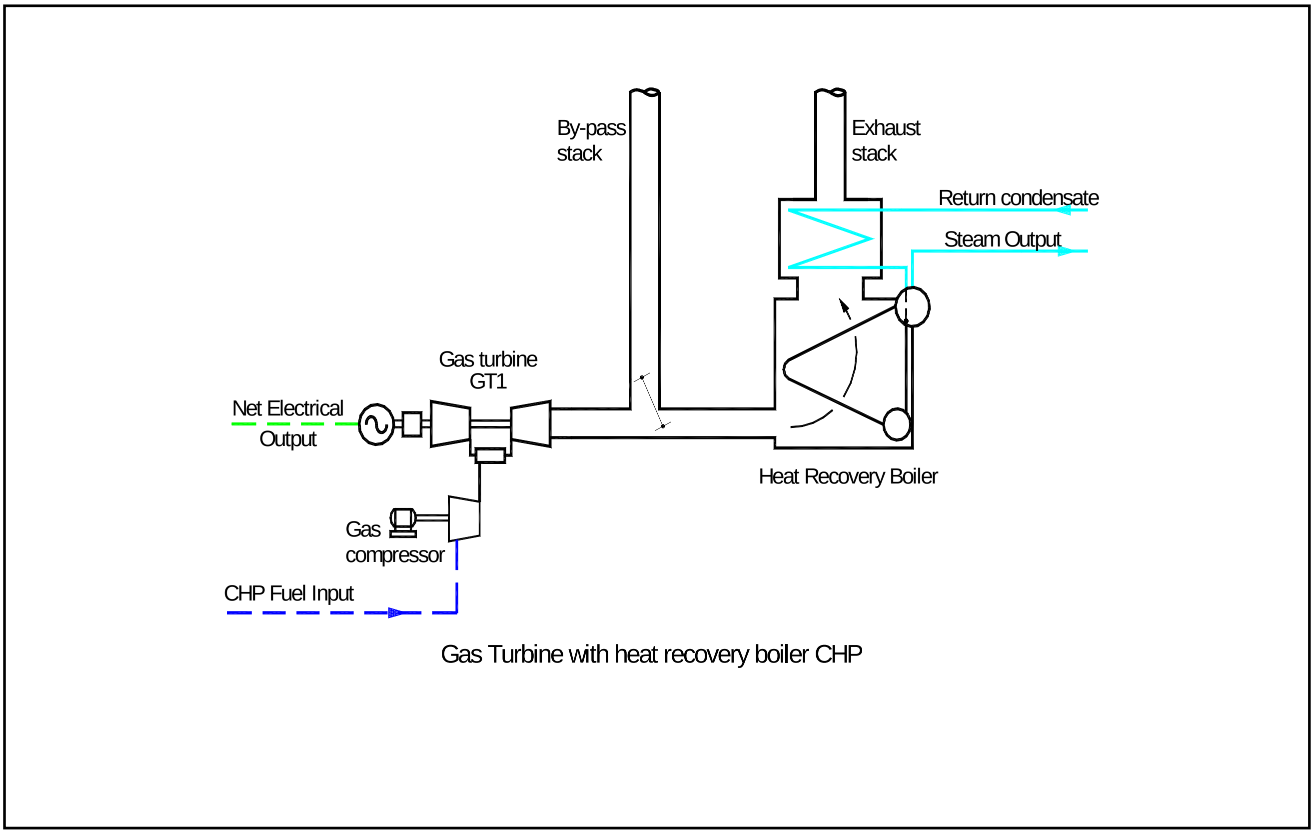


Figure 2

Economic and Environmental Performance

CHP is traditionally sized by reference to base load heat demand. This strategy will result in the highest level of heat utilisation and hence greatest environmental savings. In many cases this would lead to generation of power in excess of site requirements. As the export of electricity from CHP is constrained by economic and regulatory barriers this often results in a compromise between sizing to maximise economic benefits and sizing to maximise environmental savings.

The mis-match between economic and environmental efficiency flows from a number of energy pricing issues. One is the absence of the environmental costs of energy production from energy prices – known as the cost externalities. Another is that the value of power generation close to consumers of power is only partly recognised – known as embedded generation benefits.

In both economic and environmental terms the power output from CHP is more valuable than the heat output. Hence the Power Efficiency (ηPower) is more important than the Heat Efficiency (ηHeat) in determining economic or environmental success.

As the value of power is greater than the value of heat, many CHP schemes have the ability to reject heat, allowing the scheme to generate power at times of highest electricity prices, or allowing the scheme to run to supply essential loads during a power outage. However if the design or operation of a CHP scheme was to entail significant waste of the heat available then the environmental benefits are reduced.

To recognise the environmental and energy benefits of CHP a number of financial incentives are on offer to Good Quality CHP. These incentives include Climate Change Levy exemption for qualifying fuel input and power outputs. To ensure that the incentives are in line with the benefits offered, the UK has developed the CHP Quality Assurance programme to assess, monitor and certify CHP performance.

The use of an audited certification scheme linked to the availability of financial incentives partly offsets the mis-match between the economic and environmental efficiency of CHP within current markets and the Government continues to keep the situation under review.

Two major factors affecting the economics of CHP are the relative cost of fuel (principally natural gas) and the value that can be realised for electricity. In the 1990s, electricity prices declined in real terms. For most of that time gas prices also fell, but rose significantly in 2000 and 2001, due to structural changes in the gas market. Gas prices have risen further in 2003 and 2004, and this has resulted in significantly higher electricity prices.

The Future for CHP

As with larger scale power generation technologies, efficiency and environmental performance continue to improve. Looking ahead there is a number of likely developments to note:

- Fuel Cells, offer the opportunity for higher levels of Power Efficiency in the range 50-60%;
- Micro-CHP, a range of technologies including Stirling Engines and Fuel Cells are being developed to provide a CHP package for individual homes;
- Renewable Energy, a number of technologies is being developed which will assist the use of renewable fuels within CHP. These include the use of gasifiers to convert biomass fuels for use in gas engines, gas turbines or fuel cells.

These developments mean that it is likely that CHP systems will retain their advantages of high efficiency and low environmental impact. Hence as the environmental sustainability of energy supplies in the UK and world-wide becomes increasingly important, growth in the use of CHP will continue.

Web Links

CHP Club	http://www.chpclub.com	Advice and guidance on CHP issues
CHPQA	http://www.chpqa.com	The CHP Quality Assurance programme
CHPA	http://www.chpa.co.uk	The UK CHP Trade Association
Digest of UK Energy Statistics	http://www.dti.gov.uk/energy/inform/dukes/index.shtml	The UK Government's annual review of energy production and use, including up to date information on CHP