Introducing CHP

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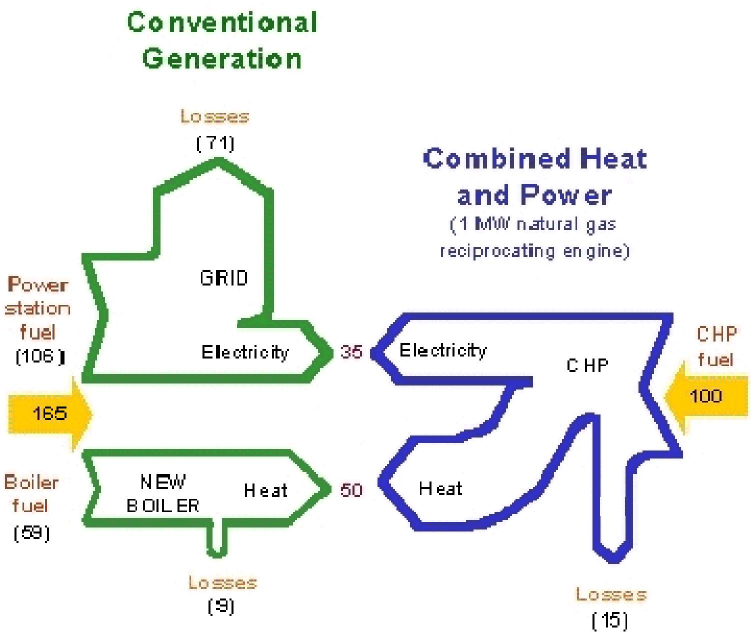
Background

The traditional model of power generation and distribution is based on the central thermal power plant feeding an electrical grid consisting of high voltage transmission lines and low voltage delivery networks. This traditional model involves inherent overall inefficiencies.



The main source of inefficiency in power generation is due to "waste heat" that must be rejected by the thermal power plant (2nd law of thermodynamics). As a result, coal-powered plants typically deliver only about 30% of the energy contained in the fuel as electricity to end users. The situation is improved somewhat with combined gas cycle power plants, which can deliver up to 50% of the fuel's energy to end users.

CHP - Making Use of Waste Heat

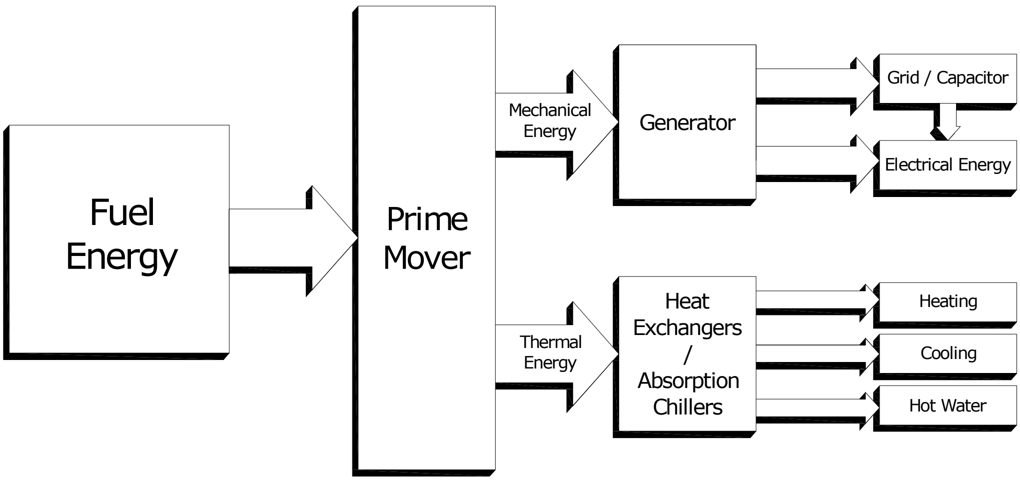
The low efficiency of conventional power generation and delivery process has pushed the industry to consider on-site or near-site power generation (often referred to as DG – distributed power generation) with the beneficial use of waste heat for heating, domestic hot water, or other thermally-activated equipment (i.e., sorption chillers, or desiccant dehumidifiers). This method of power generation is broadly labelled as CHP – combined heat and power. Basically, CHP produces both electric or shaft power and thermal energy onsite or near site, converting as much as 85% of the input fuel into useful energy, as shown on the sankey diagram to the right.

In its simplest form, CHP refers to combined heat and power (or co-generation), which means using the waste heat from the prime mover to satisfy the heating and/or domestic hot water needs of buildings or processes. However, sometimes CHP has also been used to denote combined cooling, heating, and power (CCHP), or tri-generation, as depicted on the next graphic.

Benefits

If used appropriately, CHP significantly increases resource energy efficiency and reduces CO_2 emissions.

CHP systems can also improve power reliability by reducing or eliminating a building's dependence on the electric power grid, which is especially important in times of natural disasters or grid black outs. However, designing a CHP system to operate as a standby generator (island-mode) is difficult and not



common, especially for retrofit applications.

CHP System

A CHP unit comprises the following main components:

- Prime Mover
- Synchronous generator
- Heat Recovery System(s)
- Digital Control System
- Acoustic enclosure

A number of CHP prime movers are offered on the market:

- Reciprocating engines (5 kW_e - 20 MW_e)
- Microturbines (25 kW_e – 500 kW_e)
- Combustion turbines (500 kW_e – 100 MW_e)
- Steam turbines (50 kW_e – up)
- Fuel cells (1kW_e – 10 MW_e)

Depending on the prime mover, CHP systems can be powered by a variety of fuels:

- natural gas (most common)
- LPG
- diesel/petrol
- biofuel
- biogas
- hydrogen
- biomass
- municipal waste or refuse derived fuel (RFD)
- coal
- oil

The prime mover and fuel is carefully selected following a detailed feasibility study and sizing process. Common factors affecting the selection will be the electrical and thermal load profile, temperature at which heat must be generated, fuel availability, any CO_2 emission reduction requirements, footprint, maintenance regime, cost, emissions, noise, and start up time.

Applications

Several variables must be considered in determining an optimum CHP configuration (if it exists at all) for a particular building or a scheme. These are the building heating, cooling, and DHW demand profiles, electrical demand profile, utility pricing and contractual arrangements, availability and pricing of CHP fuels, possibility (and pricing) of reselling electrical power back to the grid, and, not the least, integration with existing services. Non-monetary aspects of systems should also be analyzed. These include power reliability and quality, grid independence, security, maintenance, and noise issues.

The economic viability of a CHP system dramatically improves the longer the system operates (typically at least 4000 – 5000 hours per annum) and the more of the engine's waste heat is utilised (ideally 100%). Therefore, buildings with a considerable and consistent demand for thermal energy are the most appropriate for CHP applications in order to get the best return on investment. Typically, larger mixed-use schemes are more likely to offer a continuous thermal demand profile. Nevertheless, heat utilisation can be increased with enabling technologies such as thermal storage, absorption chillers, or desiccant dehumidifiers.

Operation

Optimal CHP systems are sized to the expected base heat load of the building or scheme to ensure maximum heat utilisation and full-load operation. Historically, there have been problems with oversized CHP systems and this should be avoided in most circumstances. In some cases, CHP has been used to provide additional electrical supply capacity where the costs of an upgrade to the existing mains supply are prohibitive. This means the unit is sized electrically and if the thermal capacity is too high, some of the unused heat is rejected via heat rejection radiators.

The CHP unit is connected both thermally and electrically to the building's traditional infrastructure. Thermally, the CHP is connected to the boiler header return and can operate either in series or in parallel with the boilers, depending on the design of the overall system.

On the electrical side, connection is commonly made to the LV panel, although alternatively can be done through the HV ring through a step up transformer. The CHP unit can act as a standby generator but this is not common and can be difficult to implement. In such case, if properly coupled with the BMS, the electricity produced can be targeted to life critical systems.

The prime mover should be capable of modulating its output to the generator depending on heat demand, whilst remaining synchronised with the (distribution network) mains three phase supply.

Financial Aspects

Compared to conventional methods of heat and power generation, the installation of a CHP system does have higher capital costs. However, life cycle costs will be advantageous, depending on the "spark gap" - the difference between the CHP fuel price and electricity. CHP payback shortens with increasing spark gap, i.e. the electricity price is high and the gas (or other fuel) price is low.

Depending on fuel CHP may benefit from a number of financial incentives:

- Climate Change Levy exemption
- Enhanced Capital Allowance
- Feed in Tariff or Renewable Obligation Certificate
- Renewable Heat Incentive

CHP systems can also be installed under a supplier finance arrangement which requires no capital outlay from the client or through an ESCO company as part of outsourcing of utilities generation.

Bibliography

Additional information can be obtained from:

1) CIBSE AM12 *Small-scale combined heat and power for buildings*
2) GPG176 *Small-scale combined heat and power for buildings*
3) GPG234 *Guide to community heating and CHP*
4) www.cibse.org/chp
5) www.chpa.co.uk

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 Gregory Zdaniuk and Huw Blackwell.