CHP: a guide for structural engineers

This briefing note provides a basic guide to the different types of CHP systems, how they are used and the design challenges they pose

Combined Heat and Power, or CHP, as it is commonly known is essentially the combined generation of heat and electrical power. Put simply, a CHP system is a system that uses fuel in a thermodynamically efficient manner to produce both usable heat and electrical energy. The effective use of both the heat and electricity generated by CHP can increase the efficiency of energy use upwards of 70% thus enabling less fuel to be used to produce the same amount of usable energy.

The CHP system can either be designed or sized to produce a set thermal output with electricity being considered as a usable by-product. Such systems are known as 'thermally led' or designed /sized to provide a certain electrical output with heat being considered as the usable by-product i.e. 'electrically led'.

CHP systems that are primary producers of heat, and from which the waste heat is recovered to generate electricity, are known as 'Bottoming cycle plants' whereas CHP systems that primarily produce electricity but then re-use the heat recovered from the process for other uses are often known as 'Topping cycle plants'.

The primary generating focus of the plant can play a major part in the location of the plant itself. The transportation of heat as hot water/liquids over long distances often necessitates costly and commonly inefficient heavily insulated pipes and pumps. Hence thermally led or Bottoming cycle CHP plants tend to be located close to the point of use of the heat as a result of the less costly and more efficient means of transmitting electricity. However electrically led or Topping cycle CHP systems can easily be placed remotely to the point of use of the electricity due to the comparatively low cost of the distribution wiring and the relatively low losses associated with transmitting electricity within a cable network.

CHP Plants are more commonly utilised on large scale industrial facilities such as steelworks, oil refineries, paper mills and chemical works.

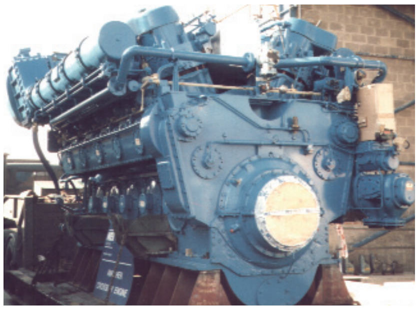
They can also be adopted to great effect on commercial mixed use developments where differing thermal/electrical loads and the energy time demand profile promotes a balancing out of energy demand thus allowing a broad population of users to benefit from an improved effective energy generation. A classic example of such a case would be a mixed use development which consisted of a snow dome adjacent to a residential development and school; the energy expelled from the operation of the snow dome could be used to heat and power the adjacent residential development and school.

CHP systems are also well suited for use with district heating systems.

CHP can also be highly beneficial in large industrial facilities that have large electrical demands and cooling loads such semi-conductor manufacturing facilities; the excess heat generated by turbine engines generating electricity can be utilised to provide heat to meet the high levels of cooling loads by means of 'absorption' cooling.

CHP systems can vary in size and type. Common systems in use at the larger scale include:

– Gas Turbine CHP plants which utilise the waste heat in the flue gas of the gas turbines;
– Gas Engine CHP plants which use a reciprocating gas engine; this is generally considered more competitive than a gas turbine up to about 5MW.



A CHP engine awaiting installation on its foundation block within a plant room *(Courtesy J. H. Morris)*

– Combined Cycle power plants which are adapted for CHP;
– Steam Turbine plants that use the heating system as the steam condenser for the steam turbine;
– Molten Carbonate Fuel Cells which have a hot exhaust and are very suitable for heating.

Smaller systems may use a reciprocating engine of some form to generate the electricity with the heat being recycled from the exhaust and the radiator. These systems can prove more economic for smaller demands due to the relatively lower cost of smaller diesel and gas engines.

An interesting example of a CHP system is the Masnedo CHP power station in Denmark which burns straw as its primary fuel and from which reclaimed heat is fed into a district heating system which heats adjacent greenhouses.

CHP micro-generation, which can be used in residential properties or small to medium size buildings, are considered to be a very effective means of reducing carbon. Different technologies such as micro-turbines, internal combustion engines, Stirling engines, closed cycle steam engines and fuel cells are in use in such systems to generate heat for use in space heating or hot water systems with the electricity by-product being used within the property or, if permitted, sold back to the grid.

How does CHP affect me as a structural engineer?

Projects on which CHP is adopted can add the following challenges to a project:

– Increased plant room provision, with associated increase in areas of higher floor loading, to account for in the structural design of the scheme;
– Increased demands on clear spans within plant room areas housing boilers and turbines;
– Increased provision of fuel storage areas and delivery systems within plant rooms, particularly when bio-fuels are adopted;
– The need to integrate turbines/generators into schemes with the associated provision of potentially complex foundation blocks and acoustic isolation, needing consideration of vibration and noise issues, as well as load carrying capability;
– In the case of district heating systems, the potential provision of extensive above and below ground pipeways and ducts to distribute heating pipework, and the associated design of such sub-structures.

This briefing is prepared by the Institution of Structural Engineers Sustainable Construction Panel. Further Information: contact Berenice Chan (email: Berenice.chan@istructe.org).

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Comment from reader:

I am involved at the early stages of a new 50MW CHP project. The Article mentioned the increased plant room provision, with ….higher floor loadings. I am researching this from various guides and manufacturers data but finding it difficult to get any initial guidance on loadings, even as an outline guide. Is any typical guidance available to help with this?

Response from Panel:

In our experience imposed floor loadings associated with plant rooms for CHP systems can vary enormously from the more commonly quoted 7.5 kN/m2 up to values as high as 25 to 30 kN/m2. However, it is for the project engineer to work with their client and colleagues within the design team to assess the need and advise the client on a project by project basis.