Overview

Thermal power plants (including those that use fissile elements or burn coal, petroleum, or natural gas), and heat engines in general, do not convert all of their thermal energy into electricity. In most heat engines, a bit more than half is lost as excess heat (see: Second law of thermodynamics and Carnot's theorem). By capturing the excess heat, CHP uses heat that would be wasted in a conventional power plant, potentially reaching an efficiency of up to 89%, compared with 55% for the best conventional plants. This means that less fuel needs to be consumed to produce the same amount of useful energy.

Some tri-cycle plants have utilized a combined cycle in which several thermodynamic cycles produced electricity, and then a heating system was used as a condenser of the power plant's bottoming cycle. For example, the RU-25 MHD generator in Moscow heated a boiler for a conventional steam powerplant, whose condensate was then used for space heat. A more modern system might use a gas turbine powered by natural gas, whose exhaust powers a steam plant, whose condensate provides heat. Tri-cycle plants can have thermal efficiencies above 80%.

An exact match between the heat and electricity needs rarely exists. A CHP plant can either meet the need for heat (heat driven operation) or be run as a power plant with some use of its waste heat.

CHP is most efficient when the heat can be used on site or very close to it. Overall efficiency is reduced when the heat must be transported over longer distances. This requires heavily insulated pipes, which are expensive and inefficient; whereas electricity can be transmitted along a comparatively simple wire, and over much longer distances for the same energy loss.

A car engine becomes a CHP plant in winter, when the reject heat is useful for warming the interior of the vehicle. This example illustrates the point that deployment of CHP depends on heat uses in the vicinity of the heat engine.

Cogeneration plants are commonly found in district heating systems of cities, hospitals, prisons, oil refineries, paper mills, wastewater treatment plants, thermal enhanced oil recovery wells and industrial plants with large heating needs.

Thermally enhanced oil recovery (TEOR) plants often produce a substantial amount of excess electricity. After generating electricity, these plants pump leftover steam into heavy oil wells so that the oil will flow more easily, increasing production. TEOR cogeneration plants in Kern County, California produce so much electricity that it cannot all be used locally and is transmitted to Los Angeles.

CHP is one of the most cost efficient methods of reducing carbon emissions of heating in cold climates.