Information Sheet #83

Combined Heat and Power in Generator Set Applications

Your Reliable Guide for Generator Maintenance

1.0 Introduction

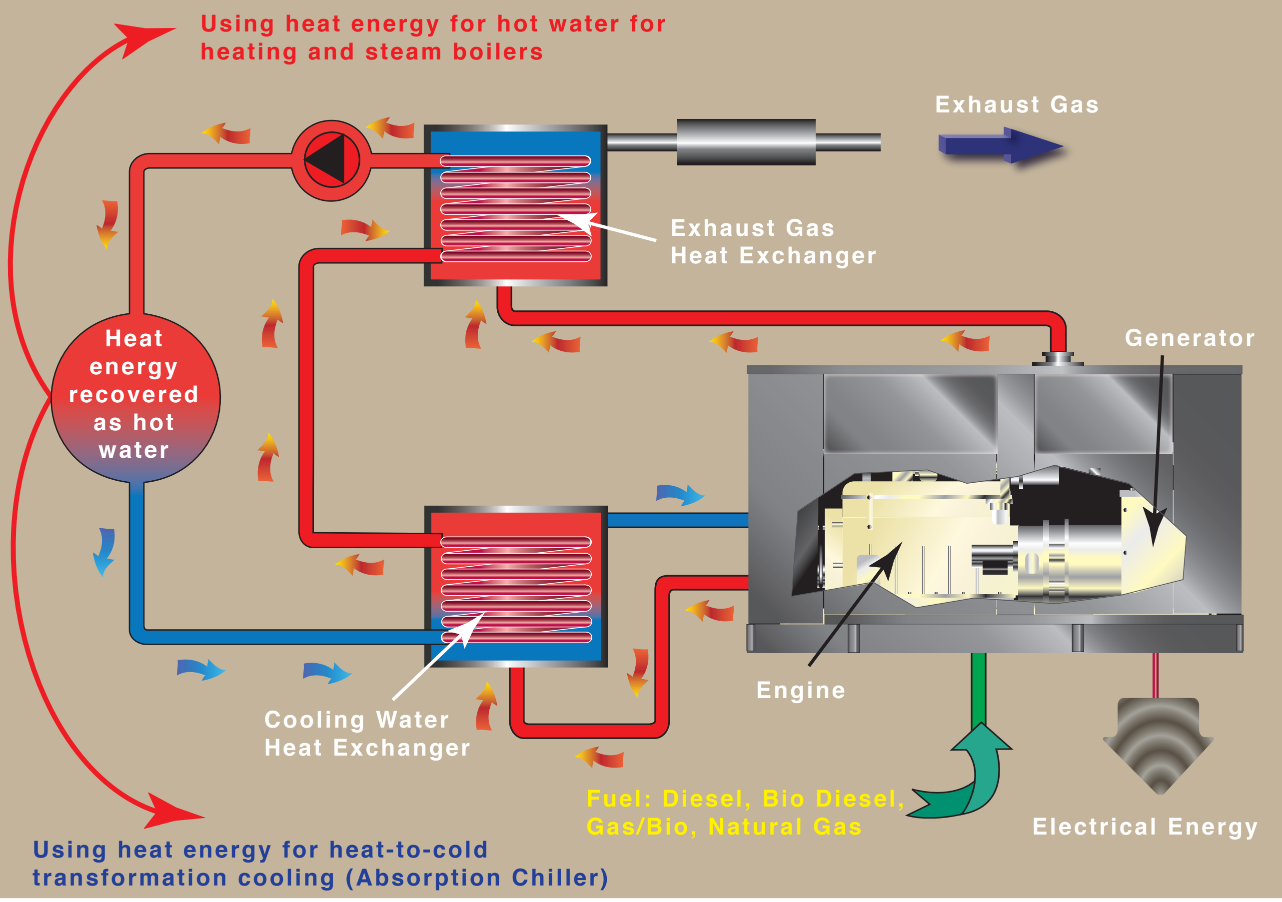
Combined heat and power (CHP), sometimes referred to as cogeneration, is where electrical and heat energy are simultaneously utilized created from a single power source running on diesel, natural gas, bio-diesel, bio-gas or other fuels on a 24/7 basis. CHP applications capture a much greater percentage of the fuel energy used in power generation for greater thermal efficiency. CHP systems frequently use gas turbine and internal combustion engines as the prime mover.

This Information Sheet discusses the application of CHP using internal combustion engines fueled by diesel, gas and a combination of the two.

2.0 Thermal Efficiency:

There are many installations with diesel or gas fueled standby generators. Higher energy costs and the need to use energy more efficiently lead power system operators to consider CHP applications. The thermal efficiency of an internal combustion engine used purely for electrical generation, without any heat recovery, can range between 25% and 40%. That is the percentage of energy in the burnt fuel that is converted to electrical power. Adding equipment that uses exhaust and cooling systems to capture the heat generated from an engine's combustion system can greatly increase thermal efficiency. BTU energy captured from cooling and exhaust systems, usually as steam or hot water, is not wasted by being vented into the atmosphere.

Diagram Showing Heat and Electrical Energy Recovery from a Generator Set with CHP Technology



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2.0 Thermal Efficiency (continued):

Depending on the technology incorporated, capturing this energy with CHP systems can raise thermal efficiencies to between 75% and 85%, producing positive economic and environmental benefits.

3.0 Types of CHP:

When heat energy from an engine generator system's combustion is recovered in addition to the electrical power generated, the process is termed Cogeneration. When absorption chillers are also added for cooling ability, the term Tri-generation is used.

In Cogeneration (CHP), engine heat energy can be recovered from:

- A Engine jacket cooling water.
- B Engine-cooling lubrication oil.
- C Engine exhaust gases.
- D Engine generator radiated heat and second stage intercooler.

Heat energy from engine cooling water and the oil cooler is captured as hot water. Plate heat exchangers used to capture the energy typically have return flow temperatures of 158 °F (70°C) to 194 °F (90°C).

Engine exhaust gases that exit the machine between 752 °F (400°C) to 932 °F (500°C) can be used directly for drying or passed into a waste heat boiler to generate steam.

Trigeneration (CHP):

Adding absorption chillers to a CHP system for recovering electricity and heat provides an economical and environmental friendly alternative to conventional refrigeration by replacing refrigeration units that require utility power. Trigeneration is advantageous in high ambient seasonal climates by using excess heat energy for cooling purposes.

4.0 Components Within a CHP System:

A system designer will consult with the generator distributor regarding recoverable heat and suitable connections. CHP system components are static, have no wearing parts and do not effect normal generator maintenance. They typically include:

- **Heat Exchangers -** Used to capture heat from coolant water and circulate it to boilers that otherwise would have required another energy source.
- **Waste Heat Boiler -** To capture a large percentage of exhaust heat.
- **Absorption chillers -** To replace utility-powered air conditioning systems.

5.0 Reasons to Consider CHP:

The principal consideration is the amount of recoverable thermal energy available. The installation's electrical kW requirements must call for a generator set of sufficient size to produce enough recoverable heat for the installation's steam and hot water demand.

The second consideration is the cost benefits. In addition to calculating the benefit from shifting heating and cooling load requirements to the generator away from a utility, a system operator should also factor in the security of having an independent power source and backup to the utility if it goes off-line.

A CHP generator set system usually runs continuously as an alternative power source to the utility supply. In some applications, and subject to utility regulations, surplus generator power can be fed back into the utility grid. In this case, the generator is continuously loaded for optimum performance as it meets the steam, hot water and cooling requirements of the facility.

Current generator electronic controls provide system designers an array of solutions for application to a generator running continuously as a Cogeneration or Trigeneration system. Utility companies will have to be consulted for providing or using surplus electrical energy, but is some cases it will actually be encouraged.

6.0 Examples Where CHP Should be Considered:

Spark-ignited engines fueled by natural gas or other gaseous fuels represent 84 percent of the installed reciprocating engine CHP capacity. Users include:

- **Industrial manufacturers** - Chemical, refining, ethanol, pulp and paper, food processing, glass manufacturing.
- **Institutions** - Colleges and universities, hospitals, prisons, military bases.
- **Agriculture and horticulture** – Greenhouses.
- **Landfills** - Utilizing biogas from anaerobic fermentation of organic matter.
- **Commercial buildings** - Hotels and casinos, airports, data centers, high-tech campuses, large office buildings and warehouses, shopping centers, nursing homes.
- **Municipal** - District energy systems, wastewater treatment facilities, K-12 schools.
- **Residential** - Multi-family housing, swimming pools, planned communities.

7.0 Cost Analysis:

Once the kW requirements of a CHP system are determined, the recoverable waste heat of the generator system also can be calculated. The resulting data allows a system designer to compare a CHP system's installation costs and fuel consumption to utility kWh costs. In some cases, high tariffs that are levied by the utility to ensure a certain level of electrical power can be avoided.

The final study will demonstrate reductions in utility costs and the time to recoup the expense of a CHP installation. Every installation is unique, but most CHP studies show that using waste heat produces energy savings of up to 35% and other potential benefits.

The utility company must be consulted regarding applicable tariffs and any considerations regarding feeding excess kWs into the grid.

8.0 Benefits of CHP:

Application of CHP technology can be major contributor to energy independence and the environment by using more of the energy in fossil fuels.

- CHP can more than double the thermal efficiency of a diesel/gas generator system. Being adjacent to where power is need also eliminates electrical losses over long utility grid distances.
- CHP can provide a high quality reliable electrical output to system loads that cannot tolerate any interruption in the utility supply.
- Increased thermal efficiency from any given unit of fuel input results in reduced overall emissions and use of less carbon fuels
- A CHP system in many cases can demonstrate a good ROI in terms of cost benefit and security

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