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What is combined heat and power, CHP?

Combined heat and power refers to recovering waste heat when electricity is generated and using it to create high temperature hot water or steam. Steam or hot water can then be used for space heating, producing domestic hot water, or powering dehumidifiers and water chillers for air conditioning.

Why is there so much interest in CHP?

There are two different driving forces behind CHP. First, recent problems in electrical supply and distribution have heightened concerns about availability and cost of electricity. These have led in turn to interest in distributed generation and subsequently use of waste heat from power generation. The Department of Energy is interested in CHP because of "resource efficiency." If coal or natural gas is burned at a power plant to produce electricity, less than a third of the energy content of the fuel is delivered to customers as useful power. The "resource efficiency" is less than 33%. If a CHP plant captures 68% of the energy in the exhaust gas and for space heating or hot water, the resource efficiency becomes 78% (0.33 + 0.68*0.67). Much more of the fuel energy content is used, fossil fuels consumption and CO2 emissions are reduced.

Is CHP the same as cogeneration?

CHP and cogeneration are basically the same thing, although cogeneration has been identified with district heating and large utility owned power plants or industrial power production and plant operation. CHP is generally a smaller scale, privately owned operation. It frequently refers to generation of heat and power for university campuses, military bases, hospitals, and hotels. New technologies for small scale power production are opening opportunities for CHP in medium and small sized buildings.

What is the difference between CHP, CCHP, BCHP, DER, IES?

Many new terms and acronyms are entering common usage that mean basically the same thing, generation of electricity near the customer's facility so that waste heat can be recovered and used. The terms differ in where the emphasis is placed. CCHP stresses that combined cooling, heating, and power production occur, whereas combined heating and power in CHP may or may not use the recovered heat for cooling purposes. BCHP is just CHP applied to a building as opposed to a district heating system or industrial process. DER is distributed energy resources, the use of small generating facilities distributed close to the consumers either with or without heat recovery.

IES is an integrated energy system that recovers waste heat from on-site or near-site power generation to provide hot water, steam, heating, cooling, or dehumidifying air for buildings.

Why can't I use my backup generator for on-site power production?

The primary problem with using backup generators for on site power generation concerns their emissions, NOx and SOx, although noise and durability can also be problems. Most urban areas limit the maximum number of hours that IC engine driven backup generators can be operated each year because of their NOx and SOx emission levels. Generators for CHP systems can operate upwards of 8000 hours per year which greatly exceed backup generator usage, typically limited to less than 200 hours per year. Some models may be able to handle such high usage, others may not.

Backup generators have been around for decades, what is new about on-site power generation?

Recent developments have pushed to make on site power generation cleaner, cheaper, and quieter. Backup generators typically use internal combustion engines with a multitude of moving parts and relatively high emissions of pollutants NOx and SOx. Microturbines have been developed which have very low emissions of pollutants and extremely few moving parts making them attractive from an environmental and maintenance point of view. Gas turbines are also being marketed in smaller capacities so that they have appeal beyond large utilities and factories. Fuel cells continue to be developed with a promise of higher efficiencies and lower emissions than any other source of electricity and heat. Finally, strides are being made to reduce emissions from IC engine driven generators to reduce their environmental impact.

What types of power generators can I buy?

The most common type of on site power generation is using an IC engine-driven generator. They are available in a broad range of capacities and can have very high efficiencies. A couple of manufacturers are producing microturbine generators and there are products under development by additional companies and in additional sizes from the current manufacturers. Gas turbine generators are sold for applications requiring greater capacities and one brand of fuel cell is available. Many different companies are in the process of developing fuel cells for on site power generation and more products will become available.

How are generators classified, what is a kW?

Generators are classified by the “combustion” system and their rated electrical output. Combustion refers to whether an IC engine, microturbine, gas turbine, or fuel cell is used to convert the fuel to mechanical energy. It is in quotes because while most of these technologies use a combustion process, fuel cells use a chemical process without combustion. The electrical output or capacity is the number of kilowatts (kW) or megawatts (MW) of power generated. A kilowatt or megawatt is a measure of the rate of energy use or production. How much energy is consumed or produced is measured in kilowatt- or megawatt-hours. One kilowatt is equal to 1000 watts. A 100 watt light bulb has an electrical load of 0.100 kilowatts; if the bulb is left on for 10 hours it consumes 1000 watt-hours or 1.0 kilowatt-hours (kWh).

What are gas turbines?

A gas turbine burns a gas or liquid fuel to produce rotary motion, the turbine blades spin about a central axis. The turbine and air compressor are mounted on a central shaft; the electric generator can be mounted on the same shaft or on a second shaft and driven by a gear drive. The rotary motion requires fewer moving parts than the reciprocating action of an IC engine and consequently produces fewer vibrations and needs less maintenance. Gas turbines were developed for marine engines in boats and jet engines in airplanes as well as in large industrial turbines for utility power generation. The smaller gas turbine generators are aeroderivatives, descendants of jet aircraft engines.

What are microturbines?

Microturbines are a fairly recent innovation bringing the advantages of gas turbines to markets for smaller applications. They employ an air compressor and turbine blades on a single shaft. Some employ a recuperator to boost their efficiency and air bearings to reduce maintenance costs. Products are available ranging from 30 kW to 75 kW of capacity; this range will eventually expand to include 200 to 300 kW generators.

What is a recuperator and why is it important?

A recuperator is an internal heat exchanger that is used to recover energy from the turbine exhaust and use it to pre-heat inlet air. Using some of the exhaust energy to heat the air before mixing it with the fuel for combustion allows the same combustion temperatures and generating capacity to be reached using less fuel. Recuperators can double the efficiency of microturbine generators.

What is an HRSG?

A heat recovery steam generator, or HRSG, is used to recover energy from the hot exhaust gases in power generation. It is a bank of tubes that is mounted in the exhaust stack. Exhaust gases at as much as 1000°F heat the tubes. Water pumped through the tubes can be held under high pressure to temperatures of 370°F or higher or it can be boiled to produce steam. The HRSG separates the caustic compounds in the flue gases from the occupants and equipment that use the waste heat.

What are fuel cells?

Fuel cells are devices that use a chemical reaction to produce an electric current at very high efficiencies. They are frequently compared to batteries where the chemicals needed for the reactions are stored within the battery itself. Fuel cells differ in that they are connected to a source of fuel, almost always molecular hydrogen. Hydrogen is combined with oxygen from the air to produce water and electric current; electrons flow between the cathode and anode of the fuel cell through an external circuit and while positive chemical ions flow in the opposite direction within the fuel cell itself. Fuel cells are categorized by the substance used for ionic flow in the fuel cell; phosphoric acid (PAFC) proton exchange membranes (PEMFC), solid oxide (SOFC), molten carbonate (MCFC), etc.

Can I buy a fuel cell?

There is only one fuel cell suitable for CHP applications is commercially available in the spring of 2001. It is a 200 kW phosphoric acid fuel cell. Many other products are under development worldwide but are not yet on the market.

What is a reformer?

Generally speaking, fuel cells use molecular hydrogen as their fuel and oxygen from the air to produce electricity. A reformer is a device that allows a fuel cell to use a hydrocarbon fuel like natural gas or propane as the fuel. It uses a catalyst, water, and heat to break down the hydrocarbon releasing hydrogen as fuel to the fuel cell and carbon dioxide to the atmosphere.

What is a desiccant dehumidifier?

Dehumidifiers, naturally, remove humidity from the air. Normally this is done by cooling finned tubes in a heat exchanger below the dew point temperature so water condenses and drips into a condensate pan or drain. This process is energy intensive because it requires cooling the tubes and air below temperatures that are comfortable for air conditioning. Desiccants are chemical compounds that have an affinity for water vapor, in a sense they absorb it like a sponge. A desiccant dehumidifier employs desiccants deposited on honeycombed surfaces to provide lots of area for water vapor to be absorbed. Blowing air through these surfaces remove moisture from it before it enters the building and reduces humidity levels. Liquid desiccants are also available in spray systems.

How do desiccant dehumidifiers use waste heat in a CHP system?

Desiccant materials can be heated to remove water vapor from them. This is done in a practical application by building the desiccant into a wheel that rotates through the building supply and exhaust air. For example, supply air being brought into a building is passed through the left side of the wheel where it absorbs water vapor. Exhaust air is heated and blown through the right side of the wheel and then vented outdoors removing water vapor from the desiccant. The wheel is rotated slowly so the desiccant passes through both supply and exhaust air flows. Steam or hot water from a HRSG can be used to provide the heat needed to heat the exhaust air and regenerate the desiccant.

What is a chiller?

Most small buildings like homes use a forced air distribution system to provide hot or cold air for comfort conditioning. Large buildings frequently use a hydronic distribution system and pump chilled water to air handling units to provide cool air for air conditioning. A chiller is the machine that cools water to around 44°F for distribution to the air handling units.

What is an absorption chiller?

Absorption chillers use heat and a chemical solution to produce chilled water. A gas burner is usually used to produce the heat with a mixture of lithium bromide and water as the chemical solution. Recovered waste heat in the form of hot water or steam can be used to power an indirect-fired absorption chiller (they use electricity for solution pumps, but only a small fraction of the electricity that electric motor driven chillers require).

What are single- and double-effect absorption chillers?

Without getting technical, the number of “effects” in a chiller reflects the number of times energy is used. A single-effect machine uses heat just once to produce chilled water. A double-effect machine contains heat exchangers to recover heat left over from the first stage of cooling to produce additional refrigerant vapor and more cooling. Double-effect is more efficient than single-effect. Triple-effect chillers are under development.

What is a cooling tower?

Every type of air conditioning or refrigeration process is a means of moving heat from where it is not wanted to medium where it can be rejected. The radiator of a car is a dry, finned-tube heat exchanger that is used to reject engine heat to the outdoor air efficiently. A cooling tower is essentially a wet heat exchanger used to reject heat from a chiller or excess heat from a HRSG. The water spray over tube banks in a cooling tower is more efficient at rejecting heat than a dry heat exchanger. It allows lower operating pressures in the chiller and greater efficiencies.

What is power conditioning?

Utilities in the U.S. distribute electricity at standard conditions with specifications for voltage, frequency, and type. Consequently most of our electrical appliances are designed for 60 Hz, alternating current. Power conditioning is the process of taking whatever electricity is produced by a generator and converting it to meet the industry standards so it can be used without damaging whatever is plugged in, be it a hair dryer, television, or computer. Power conditioning is an essential part of on site power generation.

What is NOx and why is it called a pollutant?

NOx is an abbreviation or acronym used to refer to nitric oxide (NO) and nitrogen dioxide (NO2). Both of these chemical compounds contribute to urban smog and can contribute to acid rain so their emissions are carefully controlled by government agencies. They can be formed during high temperature combustion from nitrogen in the air. Careful control of the combustion process or treatment of exhaust gases is needed to keep emissions low.

What is SOx and why is it a pollutant?

SOx encompasses a group of chemical compounds of sulfur and oxygen, but it predominantly it refers to sulfur dioxide, SO2. Sulfur dioxide is formed during combustion from sulfur compounds in the fuel and oxygen in the air. Liquid and solid fuels like gasoline and coal contain sulfur compounds and cause SOx in the flue emissions; SOx is not an issue with gaseous fuels like natural gas and propane. Sulfur dioxide dissolves in water forming sulfuric acid, the principal constituent of acid rain. SOx emissions are strictly regulated.

What is SCR?

SCR stands for selective catalytic reduction and is a process for removing NOx from exhaust gases in order to meet pollution control requirements.