ENGINEERED SYSTEMS
CRITICAL FACILITIES

Combined Heat & Power Really Is The Answer

October 6, 2015

Marcia Karr

How do you provide your customers with the highest operating savings, more reliable power, and lowest emissions for today and in the future? The answer is likely to be combined heat and power (CHP). CHP enables facility engineers to accomplish the same work (electrical and thermal) using half the fuel so they can provide the best outcomes for their customers. This article highlights the evolution and value of CHP in the commercial building sector.

CHP meets the thermal and electric demand, enhances power reliability, and provides lower operating costs for your customers. Facilities that are best suited to benefit from these features include those that provide critical services like hospitals, wastewater treatment plants, and 911 operations. Other buildings that will benefit from CHP include multi-family housing, grocery stores, recreational centers, and hotels.

CHP is an integrated energy system that:

- Is located at or near a building;
- Generates electrical and thermal power;
- Recovers waste heat for heating, cooling, and dehumidification;
- Can utilize a variety of technologies and fuels, such as natural gas, digester gas, wood chips, pellets, Naphtha, coal, steam, ethanol, syngas, and many more.

Funding and legislation are in place to support the transition to CHP and away from using traditional means of meeting the electrical and thermal needs of buildings. The energy produced by CHP is planned to increase from 40 GW in 2012 to 80 GW by 2020.

This transition will help:

- Save energy users $10 billion a year compared to current energy expenditures;
- Save one quadrillion Btus (Quad) of energy — the equivalent of 1% of all energy use in the U.S.;
- Reduce emissions by 150 million metric tons of CO2 annually — equivalent to the emissions from over 25 million cars;
- Create $40-$80 billion in new capital investment in manufacturing and other U.S. facilities over the next decade.

(**Source:** DOE/EPA, CHP: A Clean Energy Solution, August, 2012. www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_clean_energy_solution.pdf)

Legislation is in place to force this shift in power production, including legislation to set maximum achievable control technology and other performance standards for boilers (Boiler MACT) and cap and trade legislation. In addition, building codes now specifically address CHP or cogeneration as viable means of providing standby and emergency power.

Boiler MACT

The Boiler MACT rule affects anyone who uses fossil fuel, including electric utilities. In the U.S., about 50% of electricity is generated with coal, and almost 64% of the fuel used to generate electricity is wasted as unusable heat due to conversion losses.

The Boiler MACT rule states that all emissions from fossil fuel-burning equipment must be as clean as the emissions produced by the top 12% of fossil fuel-burning equipment (as established when the rule was written). Many coal plants will have to make major investments to meet this requirement or cease operations; either way, the consumer will pay for this. If the same work can be done using half the fossil fuel using CHP, the building owner saves money today and in the future as energy costs rise.

You might think that your utility generates electricity with a renewable source, like hydro. But take a look at the profile of electrical generation (Figure 2) from a utility in the Pacific Northwest where hydro is prevalent. When the emissions from CHP are compared to the emissions at this utility, per the eGRID data (resulting from the Montreal Protocol), we can compare our site with the energy used for the marginal loads (in this case, natural gas). So, the comparison is between a natural gas generator that is about 30% efficient when including line loses and an on-site generator that has an overall efficiency of about 80%. Because more than half of the fuel input is lost in conversion as waste heat, building owners benefit by generating their own electricity and taking the waste heat off the genset to meet the thermal loads in their buildings.

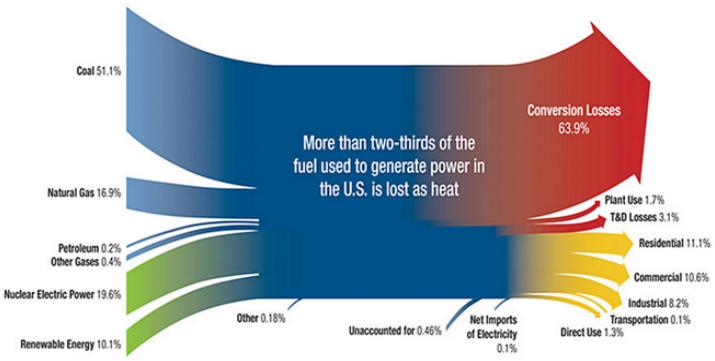

FIGURE 1. Over two-thirds of the fuel used to generate power in the U.S. is lost as heat. (Source: Northwest CHP TAP).

Combined Heat & Power Really Is The Answer

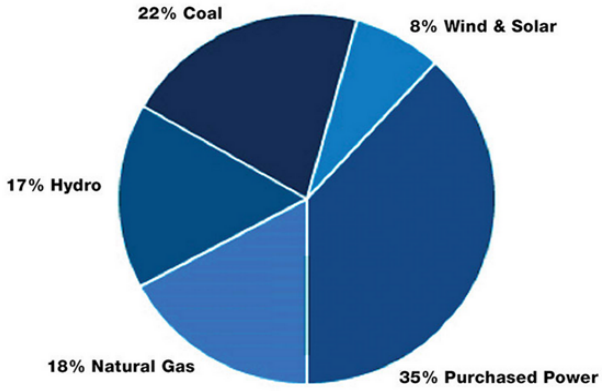

FIGURE 2. Fuel use profile for Portland General Electric in Portland, OR.

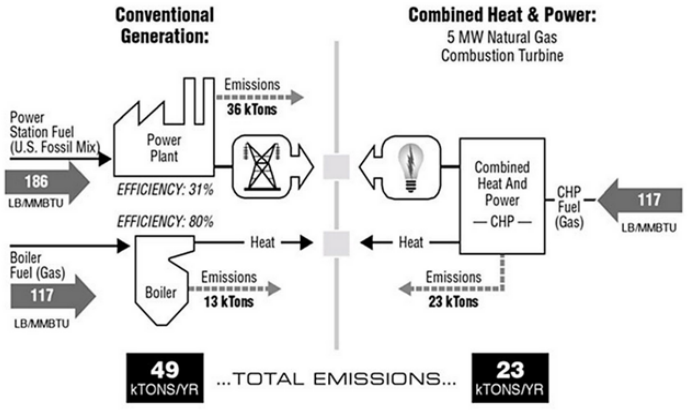

FIGURE 3. Environmental benefits of CHP. (Source: Northwest CHP TAP).

Cap and Trade

The American Clean Energy and Security Act (ACES) caps the amount of carbon a facility can emit or pay a penalty. Companies can buy or sell carbon credits. Basically, facilities will be taxed on how much they pollute. Figure 3 depicts the emissions reductions possible by designing buildings with CHP. For the electricity generated on site, emissions can be cut by about 50%!

CHP allows facilities to accomplish about twice the work with the same amount of fuel, so facilities with CHP will have carbon credits to sell. Facilities that do not have CHP will have to buy carbon credits or curtail operations.

Some cities in the U.S. have already adopted parts of this regulation. In these areas, when a developer begins pre-design discussions with the local authorities, they are told how much carbon they can emit. This limits what developers can do and forces them to consider renewable sources of power and CHP.

Building Codes

Many building codes speak to the requirements for emergency power. These codes include the following.

- National Fire Protection Agency (NFPA), NFPA 99, Section 6.4.1.1.7.1
- NFPA 110 Section 5.1.1
- National Electric Code (NEC), Article 700 and 701
- The Centers for Medicare and Medicaid Services (CMS), the organization that regulates hospitals
- Building, fire, and mechanical codes

Regulatory agencies specifically state that natural gas CHP is an approved form of power for backup and standby needs. For example, as stated in NFPA 110, Section 5.1.1:

The following sources shall be permitted to be used for the emergency power supply (EPS):

- Liquid petroleum products* at atmospheric pressure as specified in the appropriate ASTM standards and as recommended by the engine manufacturer
- Liquefied petroleum gas* (liquid or vapor withdrawal) as specified in the appropriate ASTM standards and as recommended by the engine manufacturer

  *Natural or synthetic gas

The NEC Article 700 and 701 states:

“Where acceptable to the authority having jurisdiction, the use of other than on-site fuels shall be permitted where there is a low probability of simultaneous failure of both the off-site fuel delivery system and power from the outside electrical utility company.”

The CMS, which regulates hospitals (the most highly regulated of all commercial buildings), allows the use of natural gas, provided that a letter from the natural gas company includes the following.

1. A statement of reasonable reliability of the natural gas delivery
2. A brief description that supports the statement regarding the reliability
3. A statement that there is a low probability of interruption of the natural gas
4. A brief description that supports the statement regarding the low probability of interruption
5. The signature of technical personnel from the natural gas vendor

Any piece of equipment that is used regularly as part of the normal building operations is more reliable than equipment that is idle. It is preferred to have smoke control equipment as part of the normal building operations because then we know the equipment is functioning. The same can be said for a backup power system.

CHP is part of the normal building operations. As stated in *Electrical Construction and Maintenance* by Dan Chisholm Sr., “It is a proven fact that whenever loads are switched from electric utility power to emergency power, and then back to the electric utility souse, there is an increased chance of anomalies and failures.” CHP removes the need to test the emergency system monthly because it is always on.

Fuel Sources

The natural gas infrastructure has undergone tremendous improvements over the last decade. Some natural gas suppliers actually competed to see who could replace the brittle black pipe

with flexible poly pipe (I understand the winner was a provider in Colorado). And excess flow valves are being installed so if there is a disruption, the main can be isolated. Gas utilities buy from multiple sources, so if there is a problem in one location, gas can be procured from another source.

Facility managers in rural locations are interested in biomass, such as wood chips or pellets, because it is the best option for reducing emissions compared to traditional energy sources. Biomass is a net zero fuel: while trees are growing, they absorb CO2 and emit O2 through photosynthesis; when burned, trees emit CO2 and consume O2 for a net zero environmental impact. However, energy is needed for harvesting. For these reasons, the eGrid data attributes 70% to net zero and 30% to diesel trucks, making biomass superior to any other fuel.

When does CHP make sense?

The ideal time to consider CHP for your customers is when they need to replace a boiler, chiller, or generator, or for new construction. Many customers will invest a little more money in a technology if the payback is less than five years. CHP is showing a payback of less than five years when compared to traditional designs. For example, a university that is considering replacing a boiler can use the avoided costs of the boiler to assess the feasibility of CHP.

Other monetary factors to consider are numerous incentives. When these avoided costs are considered, the payback can be between two and five years. Couple the financial value with power reliability and future carbon credits, and your customer will be very happy.

A database of case studies for CHP can be found at the CHP Technical Assistance Partnerships Northwest (*http://northwestchptap.org/ProjectProfilesCaseStudies.aspx*). This site allows you to sort by geographical location, market sector, etc. For example, selecting the market sector "Universities and Colleges," we find a couple of case studies for universities that have converted to natural gas CHP.

CHP is a proven and effective energy option that can enhance electric reliability for a facility and provide energy services before, during, and after an emergency. Buildings in the path of superstorm Sandy that had CHP were able to maintain operations after the storm. These buildings included hospitals, universities, multi-family buildings, and wastewater treatment facilities. One 250-unit apartment building was able to shelter 1,500 people after the storm because they had electricity, heat, and hot water while the power was out elsewhere.

The following websites provide CHP resources and support.

- U.S. Department of Energy, CHP Technical Assistance Partnerships Northwest – *http://northwestchptap.org/States/OtherRegions.aspx*
- U.S. Environmental Protection Agency, Combined Heat and Power Partnership – *http://www.epa.gov/chp/*.

Marcia Karr, P.E., an energy engineer with the Washington State University Energy Program, has over 30 years of experience in commercial building design, construction, and maintenance. Her positions have included providing DOE hotline support, CHP assessments and peer review of assessments, building and energy code plan reviewer, union trades supervisor, design/build engineer, field construction engineer and project coordinator, and HVAC designer (commercial and institutional). Karr is a registered Professional Engineer in Washington and Oregon, has a B.S. in mechanical engineering, and is a licensed Commercial Buildings Energy Code (NREC) Plans Examiner.