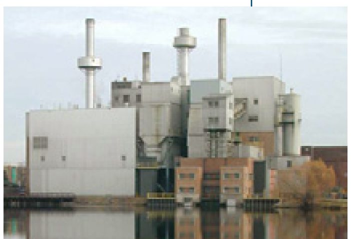
Combined Heat & Power/District Energy



COMBINED HEAT AND POWER (CHP), also known as cogeneration, is based on the simple idea of recovering and utilizing the waste heat created from the generation of electricity. Typically 60 percent or more of the energy used to produce electricity in central-station power plants is wasted. CHP is utilized by industries or institutions that have a use for the waste heat produced from electrical generation, such as for industrial processes or space heating. District energy systems also achieve efficiencies by centrally producing the heat and/or cooling for multiple customers in a concentrated area, like a city center. When district energy systems include CHP, they can achieve the highest efficiencies. While CHP and district energy systems can utilize renewable energy fuels, they often use fossil fuels. Due to the increased fuel efficiency, even use of standard fossil fuels can have environmental benefits.

By using waste heat, CHP can realize system efficiencies as high as 80%, nearly three times the efficiency of a typical coal power plant.

Minnesota currently has the potential to generate 1,600 to 2,100 MW through CHP at existing facilities.[1] CHP can reduce air emissions from combustion since less fuel is burned when electricity and thermal energy are generated together. CHP also reduces the discharge of hot waters from cooling towers into community lakes and rivers because the water is reused. CHP and district energy are an opportunity for communities and local businesses to expand production of local energy and most efficiently use renewable or fossil fuel resources.

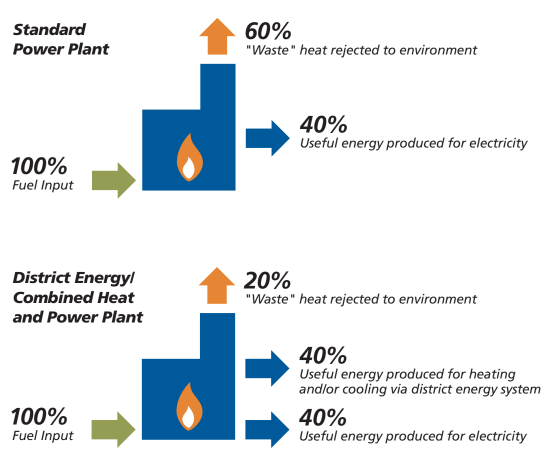
CHP AND DISTRICT ENERGY BASICS

CHP is actually a range of technologies that simultaneously produce electricity and useful thermal or mechanical energy from a single energy source. Typically, a CHP system first uses a gas turbine or reciprocating engine generator set to generate electricity. The thermal energy generated by the turbine or engine is recovered and recycled as usable steam or hot water. Since CHP systems are based on capturing and recycling this otherwise wasted thermal energy, a CHP system must be located at or near the facility or buildings that will be utilizing both the electricity and heat generated by the CHP system.

A district energy system traditionally refers to centrally producing heat and/or cooling for multiple customers in a concentrated area, such as a city center, a university campus, or a hospital complex. Normally, a district energy system is a prime candidate for adding CHP.

When CHP is incorporated into an industrial, commercial, institutional, or district energy application, system efficiencies as high as 80% can be realized, compared to typical coal power-plant efficiencies of about 30%. These increased efficiencies can provide energy cost savings and lower emissions, while providing higher reliability of electric service.

The advantage of efficiency in a CHP system



Source: U.S. Department of Energy

CASE STUDY:

District Energy St. Paul: CHP District Energy Fueled by Biomass

DISTRICT ENERGY ST. PAUL, INC., is a private, non-profit, community-based corporation located in downtown St. Paul. District Energy owns the largest hot water district heating system in North America in addition to a rapidly expanding district cooling system.

Since 1999, Market Street Energy Company (a District Energy affiliate) and Trigen-Cinergy Solutions have been working to build a CHP system that will burn urban wood waste to produce electricity while simultaneously generating energy for St. Paul's district heating and cooling needs. The new CHP plant, which will be operational in 2003, is a 25 MW wood-waste fired facility that will supply over 75% of the thermal energy required by district heating and cooling customers in downtown St. Paul. The 25 MW of electricity will be supplied to the local grid under a 20-year contract with Xcel Energy, and helps Xcel meet a mandate to produce 125 MW of biomass power.

A substantial portion of the wood waste used for CHP will come from downed trees, tree trimmings and branches from around the Twin Cities area. Using this material has several benefits. First, by turning regional wood waste into a useful product, the system will help keep energy dollars in the local economy, instead of importing fossil fuels. Second, using wood waste will help solve the ongoing environmental challenge of wood waste disposal, using approximately half of the 600,000 metric tons of wood waste generated in the metro area annually. Lastly, the project will significantly reduce air pollution by displacing 80% of the coal and oil District Energy currently burns every year, thereby reducing sulfur dioxide emissions by roughly 600 tons per year and reducing carbon dioxide emissions by roughly 280,000 tons per year. This efficient use of a renewable energy resource should serve as a model for communities looking to take similar steps.

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In January 2003, construction is almost completed at the new combined heat and power plant in Saint Paul

District Energy Tour Participants from left to right: Anders Rydaker, District Energy; Secretary of Energy Spencer Abraham; President George Bush; Jim Rogers, Cinergy; EPA Administrator Christine Todd Whitman; Mayor (now U.S. Senator) Norm Coleman; and Michael Burns, District Energy

Improves the environment

Works well with agriculture

Helps with reliability concerns

Recycles waste materials and waste heat

Offers community economic development

Improves energy independence, local control, and energy security

Promotes learning about energy

CHP TECHNOLOGY OPTIONS

Combustion turbines (simple cycle and combined cycle), reciprocating engines, and steam turbines are the primary technologies used to generate electricity for CHP systems. Fuel cells and microturbines are also suited for CHP, but can be expensive options.

If a facility is already producing steam from a boiler, it may be a candidate for a type of steam turbine called a back pressure turbine. Many industrial facilities generate steam at high pressures and during the industrial process will drop the pressure through pressure reducing valves. In these applications, a back pressure steam turbine is a relatively inexpensive way of utilizing the pressure drop to generate electricity onsite. Installed costs can be as low as $600 per kilowatt of capacity for the addition of a turbine to an existing boiler system.

Heat-recovery systems are also essential components of CHP systems, so that the waste heat can be recycled for use in industrial processes or in space conditioning the facilities. Absorption chillers can convert hot water or steam into chilled water for air conditioning. A desiccant dehumidifier can be utilized to remove moisture from the air which in turn can reduce air conditioning loads and provide better indoor air quality. In a CHP system, the recovered heat can be utilized to regenerate the desiccant material in the dehumidifier.

HOW DO YOU DETERMINE IF A CHP SYSTEM MIGHT BE APPROPRIATE?

The Minnesota Planning report[2] lists several factors to consider:

Consistency and Size of Thermal and Electric Loads Constant, level loads are best for a CHP system, since the CHP system can run as close to continuously as possible, increasing the economic payback. If the facility is closed for a portion of the year, or has widely varying thermal or electric loads, a CHP system is less likely to make economic sense. It is usually most cost effective to size a CHP system at less than peak demand so that the system is able to operate as much as possible at full capacity.

Planned New Construction or Upgrades It is best to plan CHP projects for new construction sites or sites in need of upgrades. These technologies are easier to incorporate with newer facilities that are likely to be more reliable and require less maintenance. If the avoided costs for upgrades or replacements can be put back into the CHP project, the project becomes more cost effective.

Cost of Purchased Power If the cost of power is high, it will make on-site generation more cost competitive.

Value of Sold Electricity If excess power can be sold at a sufficient price, it becomes more economical. Incentives can also help – the federal Investment Tax Credit (ITC) provides a 10% ITC for qualifying facilities; Production Tax Credits (PTC) are also under consideration by Congress.

Available and Affordable Fuel Supply If there is an opportunity to use lower-cost, easily accessible fuels with CHP as compared to current fuels used for thermal production, CHP presents an option to avoid higher costs.

CHP IN THE INDUSTRIAL SECTOR

There are several industrial facilities in Minnesota that have already incorporated CHP systems into their onsite operations. The paper industry in particular has significant experience operating CHP facilities and utilizing their biomass residuals (waste wood) to power their operations.

Companies with CHP systems include Blandin Paper (Grand Rapids), Boise Cascade (International Falls), and Champion

Sites Identified by MN Planning Study with CHP Potential[3]

GOOD PROSPECTS WITH GOOD DATA:

- Rahr Malting Company (see case study on page 40)
- Chippewa Valley Ethanol Company (Benson)
- St. Mary's Duluth Clinic
- Duluth Steam Cooperative

POTENTIAL PROSPECTS, BUT DATA INADEQUATE FOR ASSESSMENT:

- Seneca Foods Corp. (Rochester)
- Hormel Foods Corp. (Austin)
- St. Olaf College (Northfield)
- Crown Cork and Seal (Faribault)
- Froedtert Malt (Winona)
- Dairy Farmers of America (Zumbrota)
- Heartland Corn Products (Winthrop)
- US Steel – Minnesota Ore Operations (Mountain Iron)
- Boise Cascade (International Falls), potential for additional capacity

Existing CHP/District Heating Plants in Minnesota

PUBLIC UTILITIES:

- Willmar (see case study on page 68)
- Hibbing
- Virginia (see case study on page 68)
- New Ulm

OTHERS:

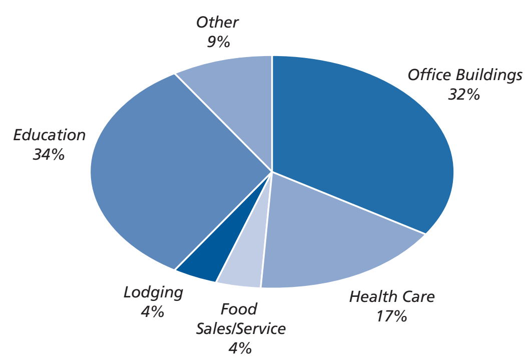
- District Energy St. Paul Inc. (see case study on page 68)
- University of Minnesota (Twin Cities)
- Franklin Heating Station (Rochester)
- St. John's University (Collegeville)

International (Sartell). The paper industry is not alone in its smart business use of CHP; several other industries including mining and agri-processing industries also reuse their waste heat to achieve more efficient energy use.

CHP IN THE COMMERCIAL AND INSTITUTIONAL SECTORS

Many people are not aware of the huge potential for increasing Minnesota's use of CHP in commercial and institutional buildings – altogether, there is the potential to generate over 1,100 megawatts of electricity (about 1/10th of Minnesota's current generating capacity) as well as serve heating and cooling loads.

Minnesota's potential to generate power in the commercial/institutional sector (1165 MW total)[4]

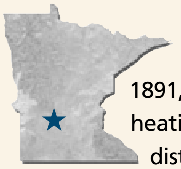


Institutional buildings are a large source of this potential. Schools and colleges have large heating loads that can be served by CHP systems. CHP paybacks tend to be in the 4 to 7 year range, which is more acceptable to the long term planning horizon of an institutional owner than a private for-profit company.

Buildings that need highly reliable or back-up power, such as hospitals, computer data centers and telephone switching centers, are an especially attractive possibility. A CHP system can serve as a backup power system that will pay for itself, rather than simply be an expense.

CASE STUDY:

Willmar Municipal Utilities CHP District Heating System



WILLMAR MUNICIPAL UTILITIES, established in 1891, currently provides district heating to 325 local customers. Its district heating system was built in 1913, and in 1982 the system was modernized to utilize hot water, rather than steam, to provide heating. Willmar's transition to hot water was based on Northern European technology and designed by engineers from Sweden. In making the upgrade to hot water, Willmar Municipal Utilities achieved higher efficiencies.

As part of the 1982 renovation, Willmar Municipal Utilities rebuilt the entire district heating distribution system. The district heating program started out serving only the commercial, institutional, and industrial buildings in the core business district, but began expanding in 1983 and continued expanding until 1990 to include its current customer base – 108 commercial, institutional and industrial facilities and 199 single family homes. When natural gas prices fell in the late 1980's, interest in district heating fell off, and there have been few expansions since.

Bart Murphy of Willmar Municipal Utilities said that for Willmar, "all the pieces just came together to make the expansion work." Although the upgrade was very capital intensive, they already had a heat source in place, and local citizens already had a good understanding of district energy. Existing customers liked the concept, so they didn't mind making a minor investment for the upgrades. In 1981, when they were planning to expand, the pricing was right for district heating because it would have cost significantly more to remove the whole system and connect every building to its own natural gas heating system.

See You in Willmar! Willmar Lakes Area Kandiyohi County

While Willmar still uses coal in its system, there are other systems experimenting with other fuel sources, including various biomass materials.

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CHP AND DISTRICT HEATING

District heating does not necessarily have to produce both heat and power, but often this is the case. It is also not limited to just downtowns, but can also include "campus heating" of educational and other multiple-building facilities. St. Johns University near St. Cloud has a CHP campus heating system that uses a coal and waste wood fired steam unit. The Mayo Clinic in Rochester is also supplied by a CHP system.

Waste heat from local processing facilities also presents and opportunity for community-wide heating and cooling systems. This would both promote private-public cooperation and decrease the energy usage of the entire community.

The West Central Research and Outreach Center (see page 11 in chapter. 2) and the University of Minnesota Morris are working with DENCO, a farmer-owned ethanol plant, to utilize the waste steam heat that DENCO would generate. The University of Minnesota-Morris would use this waste steam in a district energy system that would serve its needs and those of a new elementary school while allowing DENCO to recover some of its costs.

Installing district energy systems is not without obstacles. These systems require significant capital investment to create the necessary infrastructure support. This means that district energy systems need community support, but district energy presents a real solution for improved energy efficiency and presents a tangible way for communities to reduce their fuel consumption.

END NOTES

[1] Minnesota Planning, *Inventory of Cogeneration Potential in Minnesota*, St. Paul, MN, August 2001. Generally includes facilities with larger than 1MW generating potential. Another study referenced in the above report concludes that the potential of small CHP systems (under 1MW) in MN is 842MW.

[2] ibid.

[3] ibid.

[4] *The Market and Technical Potential for Combined Heat and Power in the Commercial/Institutional Sector*, Onsite Sycom Energy Corporation, for the US Department of Energy's Energy Information Agency, Washington D.C., Jan. 2000.

PHOTOGRAPHS

page 67 – Virginia Public Utilities (upper), U.S. Department of Energy (lower); page 68– Nancy Toohey/ District Energy St. Paul; page 71 – Willmar Area Visitors and Convention Bureau; page 73 – Virginia Public Utilities

CASE STUDY:

Virginia Department of Public Utilities: CHP at a Local Utility

VIRGINIA DEPARTMENT OF PUBLIC UTILITIES is located in Virginia, Minnesota along Minnesota's iron range. The utility was originally founded in 1892; the city of Virginia purchased the utility in 1912 and then began producing electricity and steam. The current power plant operates a 30-megawatt CHP power plant that consists of three boilers and four turbines and burns primarily western coal and natural gas, depending on the boiler.

Electricity is produced by the power plant to fulfill the demands of the steam system. The steam district heating system supplies 2,500 customers including the downtown business area, city public buildings, and south side and north side commercial and residential areas while the electric system serves over 5,800 customers. Recent construction activities have forced the closing of steam lines to particular neighborhoods, reducing the number of homes served by steam heat. Overall however, the CHP district heating system in Virginia has proven to be a long lasting, and energy efficient success.

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Virginia District Heating facility

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HELPFUL RESOURCES FOR COMMUNITIES

All web links listed here are available (and updated if necessary) at www.mnproject.org (click on "publications")

Inventory of Cogeneration Potential in Minnesota. Published by Minnesota Planning in August 2001. (www.mnplan.state.mn.us./eqb/pdf/2001/CogenInventory.pdf)

Opportunities to Expand Cogeneration in Minnesota. Written by Center for Energy and Environment and released in August 1996. (www.mncee.org/ceedocs/mmua_guide.pdf)

Midwest CHP Application Center. Located in Chicago and partially funded by the US Department of Energy, this is a premier center for technical assistance on CHP, such as determining the feasibility of CHP at a particular site. Contact: John Cuttica, 312-996-4382. Check their website for CHP evaluation tools. (www.CHPCenterMW.org)

Deployment of Distributed Energy Resources: Sources of Financial Assistance and Information. Published by the Federal Energy Management Program in January 2002. (www.eren.nrel.gov/femp/techassist/pdf/der_$available_1_24_02.pdf)

Consumer Energy Information: EREC Reference Briefs: Cogeneration or Combined Heat and Power. U.S. Department of Energy, Energy Efficiency and Renewable Energy Network. (www.eren.nrel.gov/consumerinfo/refbriefs/ea6.html)

Combined Heat and Power: Capturing Wasted Energy. A primer on combined heat and power technologies. R. Neal Elliott and Mark Spurr, 1999. Summary available at: (www.aceee.org/pubs/ie983.htm)

District Heating Planning in Minnesota: A Community Guidebook. Minnesota Department of Energy, Planning and Development, 1981. (www.hud.gov/offices/cpd/energyenviron/energy/library/ces/policyanalysis/c7.pdf)

Environmental Protection Agency: Combined Heat and Power. Provides general technology information as well as success stories from around the country. (www.epa.gov/CHP/index.htm)

District Energy Library. Website operated by the University of Rochester, providing a wide range of information on district energy and CHP including numerous links and publications. (www.energy.rochester.edu)

Minnesotan's for an Energy-Efficient Economy: Cogeneration. This website provides numerous links to pertinent information. (www.me3.org/issues/cogen/)