Benefits of Combined Heat and Power

The U.S. Department of Energy (DOE) reports that the Obama Administration recognized the benefits of Combined Heat and Power (CHP) and its current underutilization as an energy resource in the United States, and created a goal to achieve 40 gigawatts of new, cost-effective CHP by 2020. As discussed in an August 2012, U.S. Department of Energy and U.S. Environmental Protection Agency (EPA) report, Combined Heat and Power: A Clean Energy Solution, achieving this goal would:

- Increase total CHP capacity in the United States by 50% in less than a decade;
- Save energy users $10 billion per year compared to current energy use;
- Save 1 quadrillion Btu (Quad) of energy — the equivalent of 1% of all energy use in the United States;
- Reduce emissions by 150 million metric tons of carbon dioxide (CO_2) annually — equivalent to the emissions from over 25 million cars; and
- Result in $40-$80 billion in new capital investment in manufacturing and other U.S. facilities over the next decade.

Source: U.S. Department of Energy, Benefits of Combined Heat and Power

The EPA asserts that CHP offers efficiency, environmental, economic, and reliability benefits when compared to conventional electricity and thermal energy generation.

Efficiency Benefits[1]

CHP requires less fuel to produce a given energy output and avoids transmission and distribution losses that occur when electricity travels over power lines.

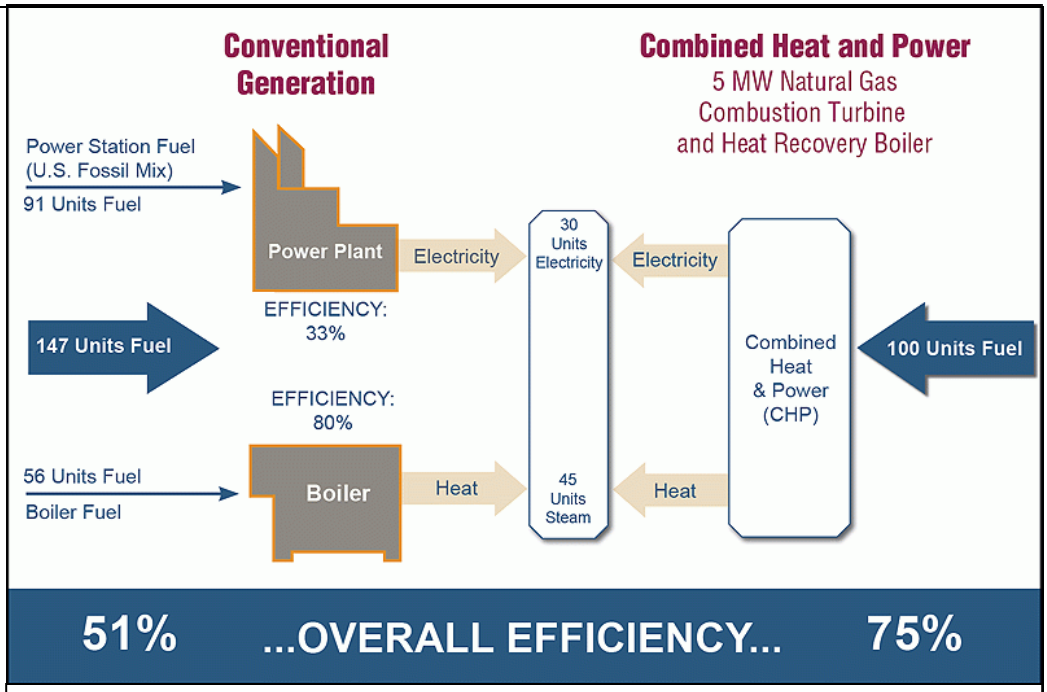
When separate services provide electricity and heat in a traditional system, then the national average is 50% efficiency. It is reasonable to expect CHP applications to operate at 65-75% efficiency in which a singular system generates both electricity and heat.[2]

By providing electrical and thermal energy from a common fuel input, CHP significantly reduces the associated fuel use and emission. The figure below compares the efficiency and fuel use of a CHP facility to the efficiency and fuel use of conventional systems providing the same service. In this case, both systems provide 30 unites of electric energy and 45 units of thermal energy to the facility.[3]

In the conventional system, the electricity required by the facility is purchased from the central grid. Power plants on average are about 33 percent efficient, considering both generating plant losses and transmission and distribution losses. Thermal energy required by the facility is provided by an onsite boiler that might be 80 percent efficient. Combined, the two systems use 147 units of fuel to meet the

[1] U.S. Environmental Protection Agency, Combined Heat and Power Partnership, CHP Benefits
[2] U.S. Department of Energy, Combined Heat and Power Basics
[3] U.S. Environmental Protection Agency, Output-Based Regulations: A Handbook for Air Regulators. p. 3-10

combined electricity and steam demand. The combined efficiency to provide the thermal and electric service is 51 percent.[4] With CHP, an onsite system provides the same combined thermal and electric service. Electricity is generated in a combustion turbine and the waste heat is captured for process use. The CHP system satisfies the same energy demand using only 100 units of fuel. This system is 75 percent efficient.[5]



Conventional Generation vs. CHP: Overall Efficiency. The illustration demonstrates the efficiency gains of a 5-megawatt natural gas-fired combustion turbine CHP system compared to conventional production of electricity and useful thermal energy (i.e., purchased grid electricity and thermal energy from an on-site boiler).

The average efficiency of fossil-fueled power plants in the United States is 33 percent. This means that two-thirds of the energy used to produce electricity at most power plants in the United States is wasted in the form of heat discharged to the atmosphere. By recovering this wasted heat, CHP systems typically achieve total system efficiencies of 60 to 80 percent for producing electricity and useful thermal energy. Some systems achieve efficiencies approaching 90 percent.

A CHP system's efficiency depends on the technology used and the system design. The five most commonly installed CHP power sources (known as "prime movers") offer these efficiencies:

- Steam turbine: 80 percent
- Reciprocating engine: 75-80 percent
- Combustion turbine: 65-70 percent
- Microturbine: 60-70 percent
- Fuel cell: 55-80 percent

Avoided Transmission and Distribution Losses

By producing electricity onsite, CHP also avoids transmission and distribution (T&D) losses that occur when electricity travels over power lines. Within the five major power grids in the United States, average T&D losses vary from 5.82 percent to 7.38 percent, with a national average of 6.18 percent (Source: Emissions & Generation Resource Integrated Database [eGRID]). Losses can be even higher when the grid is strained and temperatures are high. By avoiding T&D losses associated with conventional electricity supply, CHP further reduces fuel use, helps avoid the need for new T&D infrastructure, and eases grid congestion when demand for electricity is high.

[4] U.S. Environmental Protection Agency, Output-Based Regulations: A Handbook for Air Regulators. p. 3-10
[5] U.S. Environmental Protection Agency, Output-Based Regulations: A Handbook for Air Regulators. p. 3-10

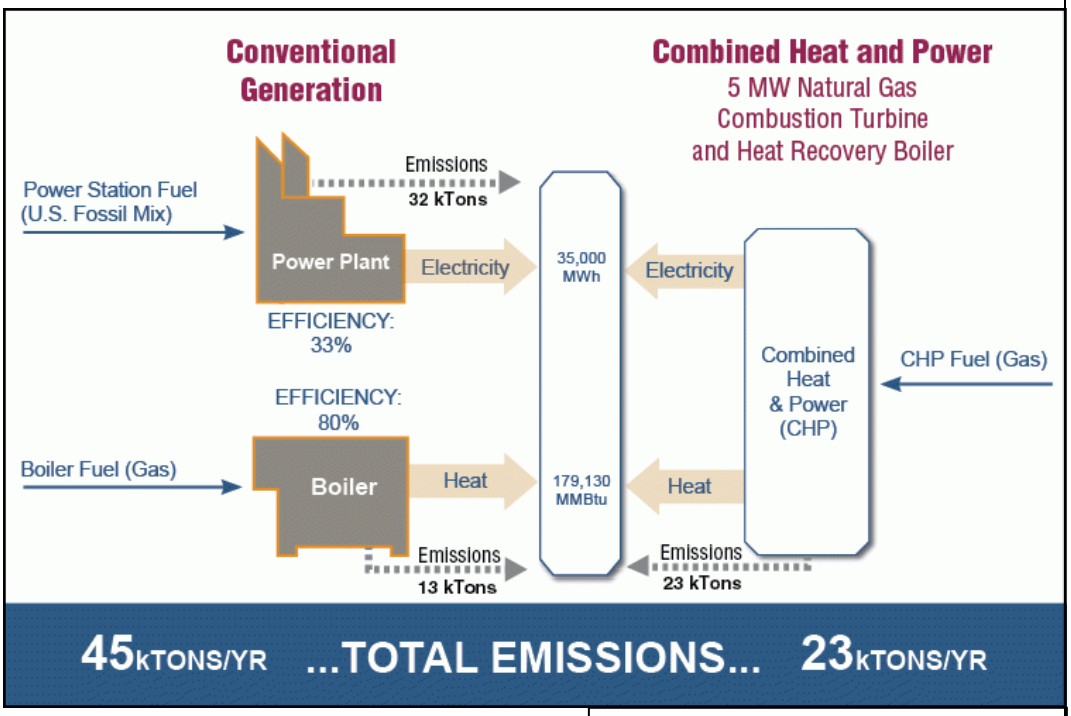
Environmental Benefits[6]

CHP systems offer considerable environmental benefits when compared with purchased electricity and thermal energy produced on site. By capturing and utilizing heat that would otherwise be wasted from the production of electricity, CHP systems require less fuel to produce the same amount of energy. Because less fuel is combusted, greenhouse gas emissions, such as carbon dioxide (CO_2), as well as other air pollutants like nitrogen oxides (NO_x) and sulfur dioxide (SO_2), are reduced. The following diagram shows the magnitude of reduced CO_2 emissions of a 5 megawatt (MW) natural gas-fired CHP system compared to the same energy output from conventional sources.

CHP Environmental Benefits Tools and Resources

- CHP Energy and Emissions Savings Calculator—compares the anticipated air emissions from a CHP system to those of a separate heat and power system.
- Fuel and Carbon Dioxide Emissions Savings Calculation Methodology for Combined Heat and Power Systems—presents a recommended methodology for calculating fuel and CO_2 emissions savings from CHP compared to separate heat and power.
- Energy Star CHP Awards—recognizes CHP projects for their superior performance.

This diagram illustrates the CO_2 emissions output from electricity and useful thermal energy generation for two systems: (1) a fossil fuel-fired power plant and a natural gas-fired boiler; and (2) a 5 megawatt combustion-turbine CHP system powered by natural gas. The separate heat and power system emits a total of 45 kilotons of CO_2 per year (13 kilotons from the boiler and 32 kilotons from the power plant), while the CHP system, with its higher efficiency, emits 23 kilotons of CO_2 per year.



Conventional Generation vs. CHP: CO2 Emissions.

The U.S. Environmental Protection Agency published a handbook in August 2014 to assist air regulators in developing emission regulations that recognize the pollution prevention benefits of CHP, and to assist CHP project owners in understanding and complying with output-based environmental regulations. The handbook is titled "Output-Based Regulations: A Handbook for Air Regulators," and is the result of a U.S. Environmental Protection Agency Combined Heat and Power Partnership.

[6] U.S. Environmental Protection Agency, Combined Heat and Power Partnership, CHP Benefits

Economic Benefits[7]

The economic benefits of any CHP project are dependent on electricity rates, system design, equipment cost and CHP operating practices. The value of the benefits will depend on the needs and goals of the investor. A feasibility analysis is conducted to determine the technical and economic viability of a project. CHP can offer a variety of economic benefits, including:

- **Reduced energy costs:** CHP reduces energy bills because of its high efficiency. By using waste heat recovery technology to capture wasted heat associated with electricity production, CHP systems typically achieve total system efficiencies of 60 to 80 percent, compared to 50 percent for conventional technologies (i.e., purchased utility electricity and an on-site boiler). The efficiency can result in less fuel be required for a given unit of energy output. Also, because CHP systems typically use natural gas which is often cheaper than purchased electricity, CHP can help reduce electricity bills. Bills are further reduced because the CHP output reduces electricity purchases.
- **Avoided capital costs:** CHP can often reduce the cost of replacing heating equipment.
- **Protection of revenue streams:** Through onsite generation and improved reliability, CHP can allow facilities to continue operating in the event of a disaster or an interruption of grid-supplied electricity.
- **Less exposure to electricity rate increases:** Because less electricity is purchased from the grid, facilities have less exposure to rate increases. In addition, a CHP system can be configured to operate on a variety of fuel types, such as natural gas, biogas, coal, and biomass; therefore, a facility could build in fuel switching capabilities to hedge against high fuel prices.

The U.S. Environmental Protection Agency offers economic feasibility tools to help analyze potential economic benefits.

Reliability Benefits[8]

In addition to reducing operating costs, CHP systems can be designed to continue operating in the event of grid outages to supply continuous power for critical functions. Interruptions of grid-supplied electricity service represents a quantifiable business, safety, and health risk for some facilities.

- The first step in incorporating CHP into a strategy to reduce business risk is to calculate the value of reliability and risk of outages for a specific facility.
- After identifying and quantifying (in monetary terms) the value of reliable power to facility operations, the costs of designing and configuring CHP technology for outage protection can be estimated and evaluated. CHP systems can be configured to meet the specific reliability needs and risk profiles of any facility.

Valuing the Reliability of Combined Heat and Power provides methods to estimate the value of CHP as electricity supply reliability measure and the merits of different design strategies.

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[7] U.S. Environmental Protection Agency, Combined Heat and Power Partnership, CHP Benefits
[8] U.S. Environmental Protection Agency, Combined Heat and Power Partnership, CHP Benefits