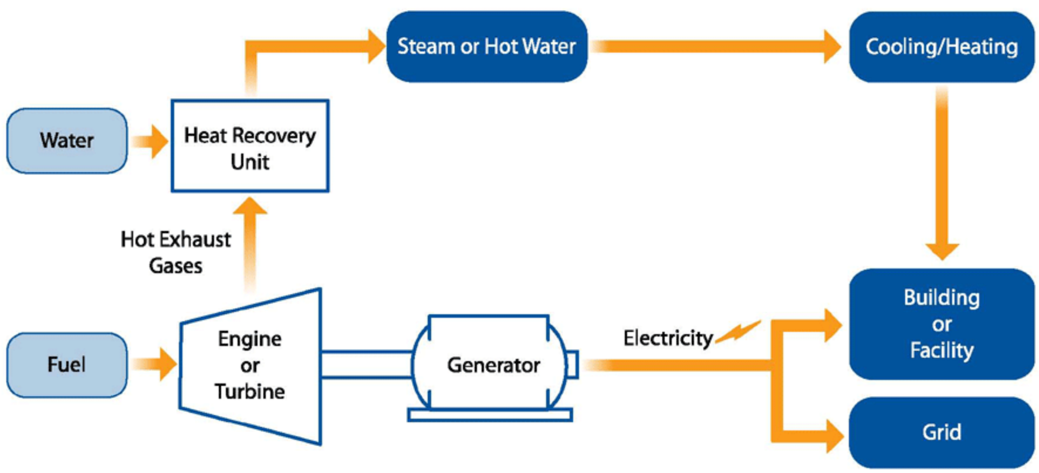
Chapter 1. CHP Defined

1.1 CHP Defined: Topping and Bottoming Cycle CHP

The average generation efficiency of grid-supplied power in the United States has remained at 34% since the 1960s—the energy lost in wasted heat-from-power generation in the United States is greater than the total energy use of Japan.[25] CHP systems typically achieve total system efficiencies of 60%–80% compared to only about 45%–50% for conventional separate heat and power generation[26] by avoiding line losses and capturing much of the heat energy normally wasted in power generation to provide heating and cooling to factories and businesses.[27] By efficiently providing electricity and thermal energy from the same fuel source at the point of use, CHP significantly reduces the total primary fuel needed to supply energy services to a business or industrial plant, saving them money and reducing air emissions.[28]

There are two types of CHP—topping and bottoming cycle. In a topping cycle CHP system (Figure 2), fuel is first used in a prime mover such as a gas turbine or reciprocating engine, generating electricity or mechanical power. Energy normally lost in the prime mover's hot exhaust or cooling systems is recovered to provide process heat, hot water, or space heating/cooling for the site.[29] Optimally efficient topping CHP systems are typically designed and sized to meet a facility's baseload thermal demand.

In a bottoming cycle CHP system (Figure 3), also referred to as waste heat to power, fuel is first used to provide thermal input to a furnace or other high temperature industrial process, and a portion of the heat rejected from the process is then recovered and used for power production, typically in a waste heat boiler/steam turbine system. Waste heat to power systems are a particularly beneficial form of CHP in that they utilize heat that would otherwise be wasted from an existing thermal process to produce electricity without directly consuming additional fuel.



Source: U.S. Environmental Protection Agency (EPA) CHP Partnership www.epa.gov/chp/basic/index.html

Figure 2. Topping cycle CHP: gas turbine or reciprocating engine with heat recovery

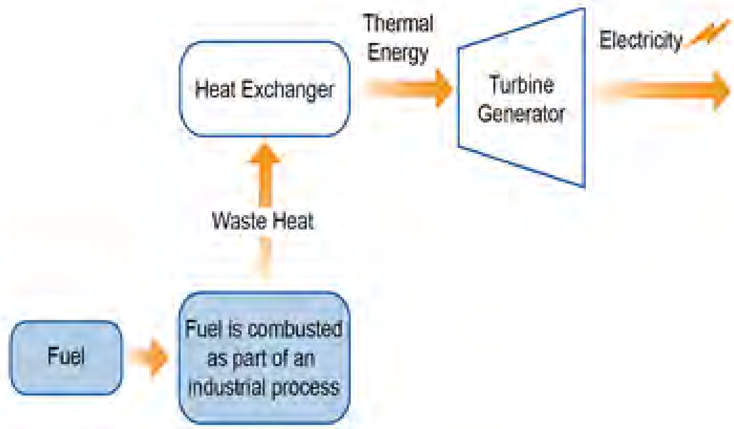
[25] Oak Ridge National Laboratory. *Combined Heat and Power, Effective Energy Solutions for a Sustainable Future*. 2008.

[26] Total system efficiency is equal to the power and useful thermal energy divided by the total fuel consumed to generate both energy services.

[27] U.S. DOE, U.S. EPA. *Combined Heat and Power: A Clean Energy Solution*. August 2012. www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_clean_energy_solution.pdf.

[28] U.S. EPA. *Fuel and Carbon Dioxide Emissions Savings Calculation Methodology for Combined Heat and Power System*. August 2012. www.epa.gov/chp/documents/fuel_and_co2_savings.pdf.

[29] In another version of a topping cycle CHP system, fuel is burned in a boiler to produce high pressure steam. That steam is fed to a steam turbine, generating mechanical power or electricity, before exiting the turbine at lower pressure and temperature and used for process or heating applications at the site.



Source: U.S. EPA CHP Partnership www.epa.gov/chp/documents/waste_heat_power.pdf

Figure 3. Bottoming cycle CHP: waste heat to power

1.2 Market Status and Potential

CHP is already an important resource for the United States—the existing 82 GW of CHP capacity at more than 4,100 industrial and commercial facilities represents approximately 8% of current U.S. generating capacity and more than 12% of total megawatt-hours (MWh) generated annually.[30] Compared to the average fossil-based electricity generation, the existing base of CHP saves 1.8 quads of energy annually and eliminates 240 million metric tons of CO_2 emissions each year (equivalent to the emissions of more than 40 million cars).[31]

While investment in CHP declined in the early 2000s due to changes in the wholesale market for electricity and increasingly volatile natural gas prices, CHP's potential role as a clean energy source for the future is much greater than recent market trends would indicate. Efficient on-site CHP represents a largely untapped resource that exists in a variety of energy-intensive industries and businesses (Figure 4). Recent estimates indicate the technical potential[32] for additional CHP at existing industrial facilities is slightly less than 65 GW, with the corresponding technical potential for CHP at commercial and institutional facilities at slightly more than 65 GW,[33] for a total of about 130 GW. A 2009 study by McKinsey and Company estimated that 50 GW of CHP in industrial and large commercial/institutional applications could be deployable at reasonable returns with then current equipment and energy prices.[34] These estimates of both technical and economic potential are likely greater today given the improving outlook in natural gas supply and prices.

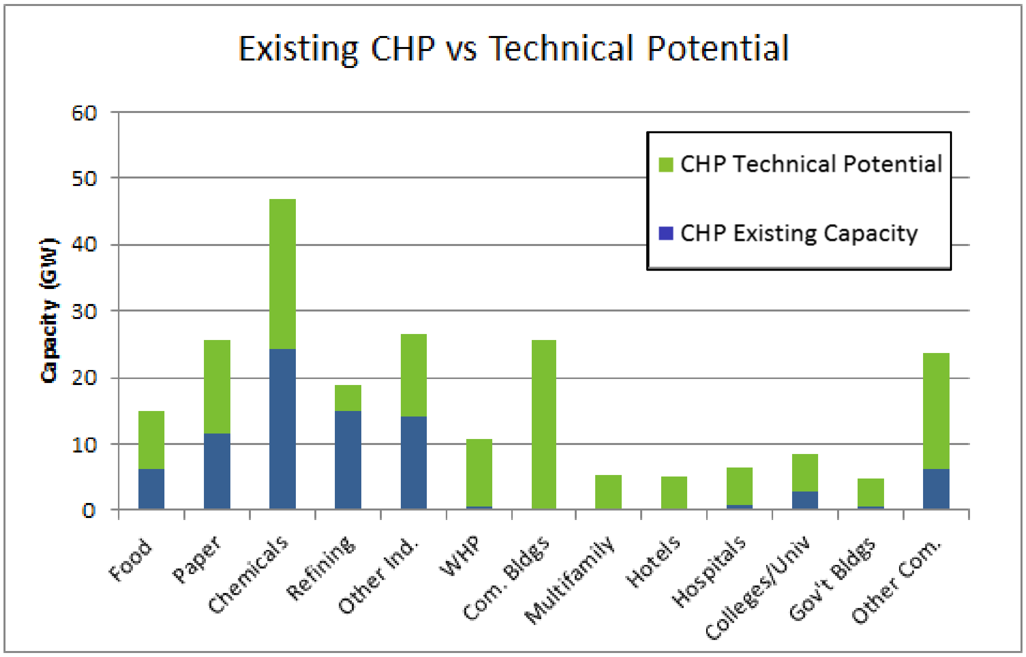
[30] CHP Installation Database developed by ICF International for Oak Ridge National Laboratory and the U.S DOE. 2012. Available at www.eea-inc.com/chpdata/index.html.

[31] www.epa.gov/chp/basic/environmental.html.

[32] The technical market potential is an estimation of market size constrained only by technological limits—the ability of CHP technologies to fit existing customer energy needs. The technical potential includes sites that have the energy consumption characteristics that could apply CHP. The technical market potential does not consider screening for other factors such as ability to retrofit, owner interest in applying CHP, capital availability, fuel availability, and variation of energy consumption within customer application/size classes. All of these factors affect the feasibility, cost, and ultimate acceptance of CHP at a site and are critical in the actual economic implementation of CHP.

[33] Based on ICF International internal estimates as detailed in the report *Effect of a 30 Percent Investment Tax Credit on the Economic Market Potential for Combined Heat and Power*, prepared for WADE and USCHPA, October 2010. These estimates are on the same order as recent estimates developed by McKinsey and Company (see below).

[34] McKinsey Global Energy and Materials. (2009). Unlocking Energy Efficiency in the U.S. Economy. www.mckinsey.com/Client_Service/Electric_Power_and_Natural_Gas/Latest_thinking/Unlocking_energy_efficiency_in_the_US_economy.



Source: Internal estimates by ICF International and CHP Installation Database developed by ICF International for Oak Ridge National Laboratory and DOE. 2012. www.eea-inc.com/chpdata/index.html.

Figure 4. Technical potential for CHP at industrial and commercial facilities

The outlook for increased use of CHP is improving. Policymakers at the federal and state level are beginning to recognize the potential benefits of CHP and the role it could play in providing clean, reliable, cost-effective energy services to industry and businesses. A number of states have developed innovative approaches to increase the deployment of CHP to the benefit of users as well as ratepayers. CHP is being looked at as a productive investment by some companies facing significant costs to upgrade old coal- and oil-fired boilers. In addition, CHP can provide a cost-effective source of new generating capacity in many areas confronting retirement of older power plants. Finally, the economics of CHP are improving as a result of the changing outlook in the long-term supply and price of North American natural gas—a preferred fuel for many CHP applications.[35]

Key to capturing this potential is the market structure for CHP at the state level. Markets with unnecessary barriers to the development of CHP will see less than the economically and environmentally desirable development of the resource, resulting potentially in higher cost resources or resources with greater environmental impacts incorporated into the nation's electricity system.

The chapters that follow provide state utility regulators and other state policymakers with actionable information to assist them in implementing key state policies that address barriers to, and promote opportunities for, CHP development. They discuss five policy categories and highlight successful state CHP policy implementation approaches within each category:

- Design of standby rates
- Interconnection standards for CHP with no electricity export
- Excess power sales
- Clean energy portfolio standards (CEPS)

Emerging market opportunities—CHP in critical infrastructure and utility participation in CHP markets.

[35] U.S. DOE. *Combined Heat and Power: A Clean Energy Solution*. August 2012. www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_clean_energy_solution.pdf. Note that the existing fleet of CHP uses a wide variety of fuels in addition to natural gas including coal, oil, landfill gas, waste heat, process wastes, wood, and other forms of biomass.