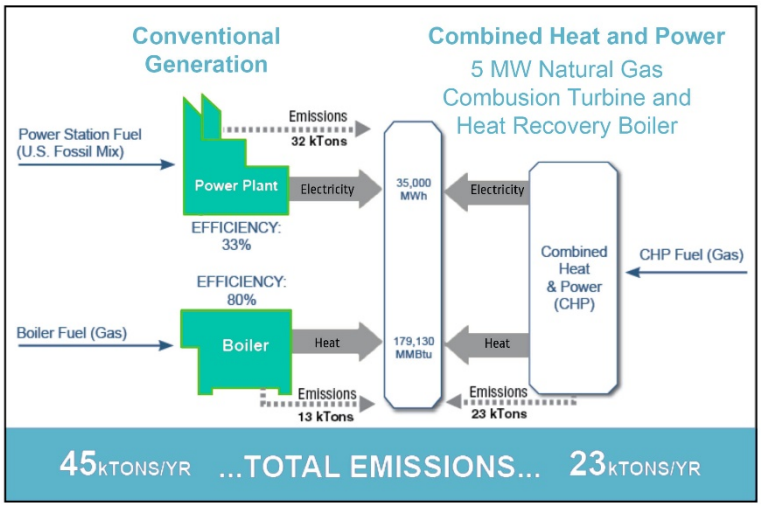
Combined Heat and Power (CHP) and Waste Heat to Power (WHP): Smart Solutions to Reduce Greenhouse Gas Emissions

Combined heat and power (CHP) and waste heat to power (WHP) systems can be used to cost-effectively reduce greenhouse gas (GHG) emissions in three important areas: the electricity, industrial, and building sectors. The electricity sector accounts for approximately 28 percent of total U.S. emissions.[1] The industrial sector posted the largest emissions gains in 2018 at 55 million metric tons, due mostly to growth in industrial activity.[2] Finally, emissions from residential and commercial buildings increased by 10 percent in 2018 to their highest level since 2004.[3] As a result, these three sectors offer some of the greatest opportunities to deploy CHP and WHP to decarbonize.

Conventional electric generation is very inefficient, with roughly two-thirds of fuel inputs lost as wasted heat from the process. Additional energy is lost during transmission from the central power plant to the end user. By generating both heat and electricity from a single fuel source at the point of use, CHP lowers emissions and increases overall fuel efficiency—allowing utilities and companies to effectively "get more with less." CHP can make effective use of more than 70 percent of fuel inputs. As a consequence, natural gas-fired CHP can produce electricity with about one-quarter of the GHG emissions of an existing coal power plant. WHP, which uses waste heat from industrial processes to generate electricity with no additional fuel and no incremental emissions, reduces emisisons and offsets costs associated with purchased power.

Fig. 1: CO_2 Emissions – 5 MW CHP Versus 5 MW of Separate Heat and Power Production[4]



Source: U.S. EPA, 2015, https://bit.ly/2E2IByK.

Reducing Emissions Through Improved Efficiency

- Because they combust less fuel to provide the same energy services, CHP systems reduce all types of emissions, including greenhouse gases, criteria pollutants, and hazardous air pollutants.
- Natural gas-fired CHP can produce half the CO_2 emissions of conventional fossil fuel generation, while providing the same amount of energy services (Fig. 1).
- WHP systems capture waste heat, a byproduct of industrial processes, and use it to generate electricity; no additional fuel is used and no emissions are generated.

- According to an analysis by the Alliance, by deploying economically viable CHP and WHP, states can:
  - Cut CO_2 emissions by 32.6 million short tons in 2030 (equivalent to the GHG emissions avoided by 6,267 wind turbines running for one year);
  - Save businesses more than $140 billion in cumulative costs (2016-2030) from avoided electricity purchases; and
  - Save nearly 184-million megawatt-hours of electricity in 2030 (Fig. 2).[5]

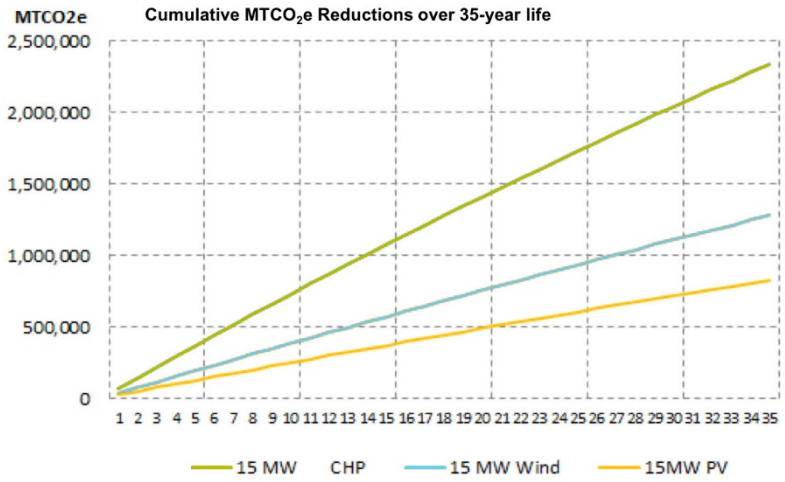
Fig. 2: Potential CO_2, Energy, and Bill Savings from CHP and WHP

Metric	CHP/WHP
Annual CO_2 savings (short tons)	32,625,000
Annual energy savings (MWh)	183,855,000
Cumulative utility bill savings through 2030 (2011$)	$140,590,000

The CHP Difference: High Capacity Factor

- A unit's **capacity factor** (CF) is the ratio of the electricity produced for a set period of time to the electricity it *would have* produced if running continuously at full capacity.
- Well-applied CHP systems can have a much higher capacity factor than other sources of electricity: 95% compared to 54% for coal-fired generation, 51% for natural gas-fired combined cycle systems, 34% for wind, and 22% for solar.[6]
- Because of CHP's low emission rate and high capacity factor, it would take 15-megawatt solar plant 35 years to achieve the same reductions that a 15-megawatt CHP plant can acheive in only 11 years of operation (Fig. 3), even though CHP is not a zero-carbon technology.

Fig. 3: Cumulative Emissions Reductions over 35 year Life: CHP, Wind, Solar PV[7]



Note: Calculated using EPA eGRID data for a hypothetical unit at a university in the Southeast, from 2020 to 2035, demonstrating specific unit emissions displaced by year.

Source: Sterling Energy Group, LLC, 2018

Renewable-Fueled CHP & WHP

- CHP systems can run on renewable fuels, such as biomass (e.g., forest and crop residues, wood waste, food-processing residue) or biogas (e.g., manure biogas, wastewater treatment biogas, landfill gas), which can lower GHG emissions even further.
- Renewable natural gas (RNG), or biomethane, is a pipeline-quality gas that is fully interchangeable with natural gas and compatible with U.S. pipeline infrastructure and can be used to fuel CHP systems.
- Over time, CHP systems can evolve and use different types of fuel. A system using natural gas today may run on RNG in the future.
- About 20 states include waste heat as an eligible energy resource in ther renewable portfolio standard or similar program.

CHP Enables Microgrids

- Many state and federal policymakers are beginning to encourage investments in microgrids. A microgrid is a local energy grid that can disconnect from the traditional grid and operate on its own during grid outages.[8]
- CHP provides 39% of the energy in existing microgrids.[9]
- Microgrids offer the opportunity to deploy more zero-emission electricity sources, such as wind and solar, thereby reducing GHG emissions. They also improve reliability and resiliency in the event of a grid disruption.
- To function independently, a microgrid either requires battery storage, which can be expensive, or a form of distributed generation, such as CHP or WHP. Such systems can island and black start, enabling a microgrid's independence. They often serve as the backbone of a microgrid by delivering consistent, reliable, dispatchable baseload power.

---

[1] U.S. Environmental Protection Agency, "Sources of Greenhouse Gas Emissions" (https://bit.ly/2ecDrVc).
[2] Rhodium Group, Jan. 8, 2019, "Preliminary US Emissions Estimates for 2018" (https://bit.ly/2sfsSbY).
[3] *Id.*
[4] U.S. Environmental Protection Agency, Feb. 2015, "Fuel and Carbon Dioxide Emissions Savings Calculation Methodology for Combined Heat and Power Systems" (https://bit.ly/2E2IByK). Note: Conventional power plant delivered efficiency of 33% (higher heating value [HHV]) is based on eGRID2012 and reflects the national average all fossil generating efficiency of 36.1% and 8.33% transmission and distribution losses. Note that the CO_2 benefits would vary somewhat around the country, depending on the fossil generation mix in the region that would be expected to be displaced by the CHP generation.
[5] Alliance for Industrial Efficiency, Sep. 15, 2016, "State Ranking of Potential Carbon Dioxide Emissions Reductions through Industrial Energy Efficiency" (https://bit.ly/2yjAJJL).
[6] CHP capacity factor based on actual data from utility-owned CHP. Wind and solar capacity factors from EIA 2018 (https://bit.ly/2GSsIgE). Coal-fired generation and natural gas fired combined cycle capacity factors from EIA 2018 (https://bit.ly/2xpLYNc).
[7] Sterling Energy Group, LLC, 2018, "The Power of Collaboration on CHP" PowerPoint presentation.
[8] U.S. Department of Energy, Jun. 17, 2014, "How Microgrids Work" (https://bit.ly/2nFsiSP).
[9] Greentech Media, Jun. 1, 2016, "US Microgrid Growth Beats Estimates: 2020 Capacity Forecast Now Exceeds 3.7 Gigawatts" (https://bit.ly/2MyGybr).