E-9. Utilize a Combined Heat and Power System

GHG Mitigation Potential

Potentially small reduction in GHG emissions from CHP energy generation

Co-Benefits (icon key on pg. 34)

Climate Resilience

CHP systems reduce sensitivity to fuel price shocks or scarcity and can contribute to generation capacity, reducing energy costs and the risk of outages. These systems can also provide backup energy to a building if the main grid fails during an extreme weather event.

Health and Equity Considerations

Reduction of natural gas combustion would help improve indoor air quality. However, CHP systems still involve natural gas usage, and thus localized effects of emissions on communities should be reviewed closely.

Measure Description

This measure involves using combined heat and power (CHP) systems in place of separate heat and power (SHP) systems. For the same level of power output, CHP systems use less input energy than traditional SHP generation, resulting in lower CO_2 emissions. In traditional SHP systems, heat created as a by-product is wasted as it is released into the surrounding environment. CHP systems harvest the thermal energy and use it to heat onsite uses or for processes in proximity, which reduces the amount of natural gas or other fuel that would otherwise be combusted for heating or for use in those processes. CHP systems also result in a reduced demand for electricity from the grid, which displaces the CO_2 emissions from the production of electricity from the grid.

Subsector

Energy Efficiency Improvements

Scale of Application

Project/Site

Implementation Requirements

It is possible that certain CHP systems may not be appropriate for certain locations, where the carbon intensity of the electricity provider is relatively low. In these instances, the emissions reduction will be negative, which indicates an emissions increase.

Cost Considerations

CHP systems are more efficient than systems where heat and power are produced separately. As long as the system is located near to where the power and heat are being used, CHP systems are quick and relatively inexpensive to install. Coupled with the improved efficiency, CHP systems represent a long-term potential cost savings.

Expanded Mitigation Options

Non-applicable.

GHG Reduction Formula

This section describes how to estimate emissions reductions from utilizing a CHP system to supply energy demands that would otherwise have been provided by separate heat and power systems (e.g., electricity from the grid for uses requiring electricity and boilers for thermal demand). The user should quantify emissions reductions using the U.S. EPA's (2020) CHP Energy and Emission Calculator (CHP Tool), which allows users to estimate the energy savings from displaced electricity and thermal production from 10 CHP technologies: reciprocating engine (rich burn, lean burn, and diesel) microturbine, fuel cell, combustion turbine, boiler/steam turbine, other prime mover, and waste-heat-to-power (power only, and power and thermal).

The user has the option to input project-specific data, such as fuels types, duct burner operation, cooling demand, and boiler efficiencies. The CHP Tool has the capabilities to calculate GHG emissions reduction directly from the use of CHP systems, and the user can choose to use the calculator for that purpose. To ensure consistency with the methods and factors used for other measures in this document, the user can also use the calculator to determine the energy savings and calculate the GHG reductions separately, using the methodology provided in this section.

$$A1 = [(B \times C \times D) + (E \times F) - (G \times F)] \times H$$

$$A2 = \frac{(D + G) - B}{(D + G)}$$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A1	Reduction in GHG emissions from use of CHP System	[ ]	MT CO_2e	calculated by user or in CHP Tool
A2	Percent reduction in GHG emissions from use of CHP System	[ ]	%	calculated by user or in CHP Tool
User Inputs				
	None			
Constants, Assumptions, and Available Defaults				
G	Fuel consumption of CHP system	[ ]	MMBtu per year	calculated in CHP Tool
F	Carbon intensity of commercial natural gas	119	lb CO_2e per MMBtu	U.S. EPA 2020
B	Displaced electricity production from CHP use	[ ]	MMBtu per year	calculated in CHP Tool
C	Conversion from MMBtu to kWh	0.2931	MWh per MMBtu	conversion

ID	Variable	Value	Unit	Source
D	Carbon intensity of local electricity provider	Tables E-4.3 and E-4.4	lb CO_2e per MWh	CA Utilities 2021
E	Displaced thermal production from CHP use	[ ]	MMBtu per year	calculated in CHP Tool
H	Conversion from lb to MT	0.000454	MT per lb	conversion

Further explanation of key variables:

- (A1) – The methodology shown for (A1) involves the use of the fuel consumption results provided by the CHP Tool (Table 1 of the Results tab in the CHP Tool). However, the user can also use the CHP Tool to calculate GHG reductions directly (Table 2 of the Results tab in the CHP Tool). The CHP Tool allows the user to choose an electricity emissions factor (the "displaced electricity generation profile") from a pre-determined list, or it allows the user to enter a custom emission factor. If calculating GHG emissions directly in the CHP Tool, the user should enter a custom emission factor that corresponds to the applicable electricity provider for only CO_2 emissions. The CHP Tool does not allow the user to enter a CO_2e factor.
- (B, D, G) – Standard assumptions to calculate these energy quantities are from EPA's CHP Tool, which can be inputted by the user, are included below. The user should enter project-specific values if available.
  - Operation of 8,760 hours per year.
  - Provides heat only (no cooling).
  - Combusts natural gas fuel (1,028 Btu/ft^3 heat content).
  - No supplementary duct burner.
  - Assumes 4.8 percent transmission loss for displaced electricity (based on Western Interconnect assumptions from the CHP Tool).
  - Assumes thermal demand for a boiler with 80 percent efficiency.

GHG Calculation Caps or Maximums

- All caps and maximums are indicated in the EPA's CHP Tool.
- Because the electric power sector is progressively becoming a zero-carbon source, this measure may not achieve GHG reductions for some combinations of CHP system types, sizes, and other variables inputted into the CHP Tool. In those cases, the CHP Tool will return negative energy savings or emissions reductions, meaning that using a CHP system would result in an increase in energy consumption and emissions relative to using SHP generation. If considering a CHP system to reduce GHG emissions and save energy, the user should ensure that the CHP set-up actually results in reductions.

Example GHG Reduction Quantification

The user's project includes a single unit 600 kW microturbine CHP system fueled by natural gas and used for heating-only with no duct burners. The CHP system is assumed to operate for 8,760 hours per year and is displacing a new gas boiler. Parameters for both the microturbine CHP system and the displaced new gas boiler are assumed from the CHP

Tool. The electricity that is displaced by the CHP system is derived entirely from a natural gas-based powerplant. The electricity provider for the project area is Imperial Irrigation District and the analysis year is 2025. The carbon intensity of electricity is, therefore, 225 lb CO_2e per megawatt-hour (D). The energy quantities calculated from the CHP Tool are displaced electricity production (40,252 MMBtu), displaced thermal production (25,258 MMBtu), and a CHP system consumption of (59,831MMBtu). The example scenario results in a 662 MT CO_2e reduction.

$$A1 = [\left(40{,}252 \text{ MMBtu} \times 0.2931 \frac{\text{MWh}}{\text{MMBtu}} \times 225 \frac{\text{lb } CO_2e}{\text{MWh}}\right) + \left(25{,}258 \text{ MMBtu} \times 119 \frac{\text{lb } CO_2e}{\text{MMBtu}}\right) - (59{,}831 \text{ MMBtu} \times 119 \frac{\text{lb } CO_2e}{\text{MMBtu}})] \times 0.000454 \frac{\text{MT}}{\text{lb}} = -662 \text{ MT } CO_2e$$

$$A2 = \frac{(40{,}252 \text{ MMBtu} + 25{,}258 \text{ MMBtu}) - 59{,}831 \text{ MMBtu}}{(40{,}252 \text{ MMBtu} + 25{,}258 \text{ MMBtu})} = 9\%$$

Quantified Co-Benefits

Improved Air Quality

The CHP Tool can calculate reductions in two criteria air pollutants (NO_x and SO_2). To quantify this co-benefit, the user should use the CHP Tool.

Energy and Fuel Savings

To calculate the energy savings for this measure (H), the user should add the displaced electricity production (D) and displaced thermal production (G) from the CHP Tool and then subtract the CHP system energy consumption (B) from the CHP Tool.

Energy Savings Formula

$$H = (D + G) - B$$

Sources

- California Utilities. 2021. Excel database of GHG emission factors for delivered electricity, provided to the Sacramento Metropolitan Air Quality Management District and ICF. January through March 2021.
- U.S. Environmental Protection Agency (U.S. EPA). 2020. *Combined Heat and Power Energy and Emissions Savings Calculator*. Available: https://www.epa.gov/chp/chp-energy-and-emissions-savings-calculator. Accessed: January 2021.