Combined Heat and Power

A Bird's Eye View

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Agenda:

- What is CHP?
- How Does CHP Work?
- Why Install CHP?
- Who Should Consider CHP?

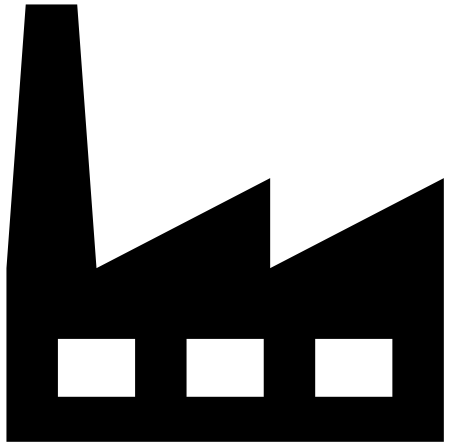
What is CHP?

Conventional Energy Source

FUEL

Boiler / Furnace

HEAT & STEAM



Facility Process Loads

FUEL

Turbine or RICE Generator

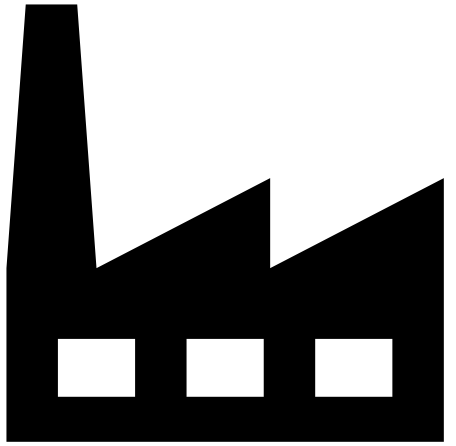
ELECTRICITY

Combined Heat and Power

FUEL

HEAT & STEAM

ELECTRICITY



Facility Process Loads

COMBINED HEAT & POWER

How Does CHP Work?

System of Parts

PRIME MOVER

- Reciprocating Engine
- Gas Turbine
- Boiler/Steam Turbine
- Microturbine
- Fuel Cell

GENERATION

- Generator and Controls / Excitation
- Interconnection to Electrical Distribution

HEAT RECOVERY

- Heat Recovery Steam Generator (HRSG)
- Heat Exchanger for Hot Water
- Heat Exchanger for Hot Air

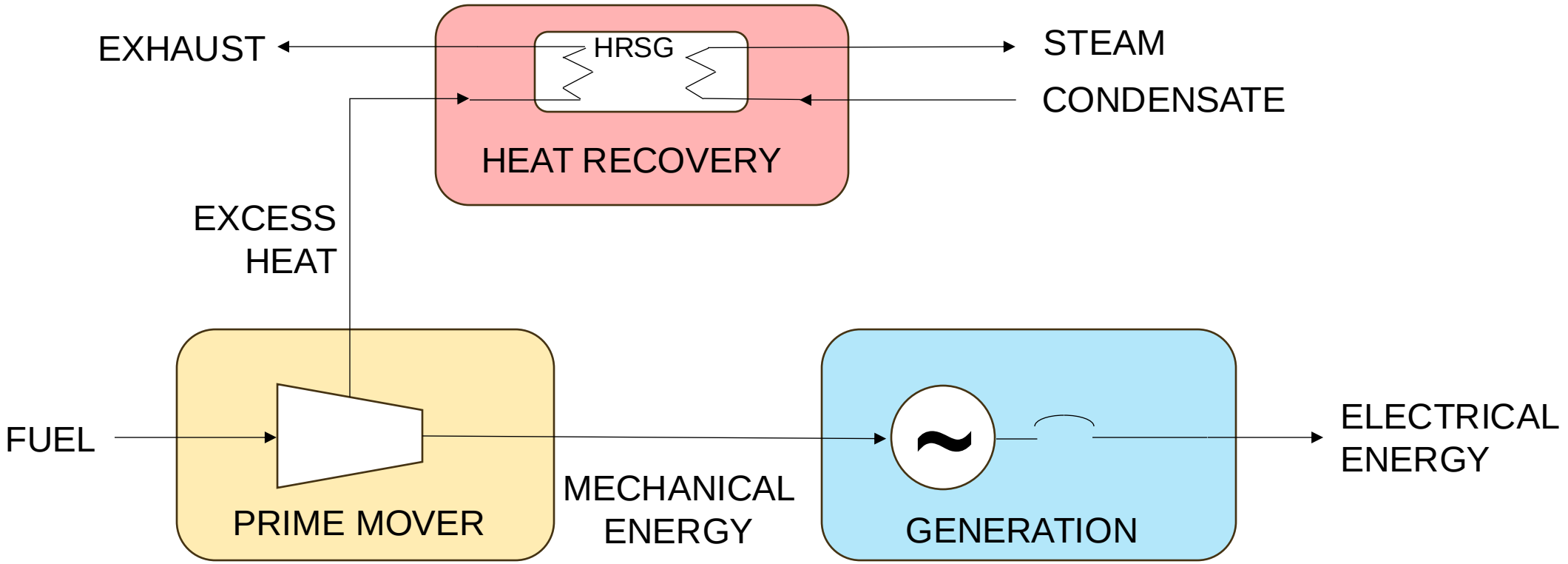
Table 1-1. U.S. Installed CHP Sites and Capacity by Prime Mover

Prime Mover	Sites	Share of Sites	Capacity (MW)	Share of Capacity
Reciprocating Engine	2,194	51.9%	2,288	2.7%
Gas Turbine*	667	15.8%	53,320	64.0%
Boiler/Steam Turbine	734	17.4%	26,741	32.1%
Microturbine	355	8.4%	78	0.1%
Fuel Cell	155	3.7%	84	0.1%
Other	121	2.9%	806	1.0%
Total	**4,226**	**100.0%**	**83,317**	**100.0%**

* includes gas turbine/steam turbine combined cycle

Table taken from EPA 2015 CHP Report

Typical CHP Flow Diagram



Common Fuels

Reciprocating Engine/Combustion Turbine	Gasoline Diesel Natural Gas / Biogas
Steam Turbine	Natural Gas / Biogas Coal Biosolids Nuclear

Common Types of CHP

CHP Type	Advantages	Disadvantages	System Sizes
Reciprocating Engine (Spark or Compression)	• Quick start-up (full load in 2 minutes or less) • Low capital cost • Can follow variable loads	• High maintenance costs • Relatively high air emissions • High noise emissions	1 kW to 10 MW
Gas Turbine	• Highly Reliable • Low Emissions • No cooling needed • Large amount of heat generation • Relatively fast start-up (full load in 20 minutes)	• Requires high pressure gas source • Reduced efficiency at low loading • Output is dependent on the ambient temperature	500 kW to 300 MW
Steam Turbine	• Long working life and high reliability • Boilers can be fired by many fuel sources	• Requires steam source (boiler) • Slow start up (hours)	50 kW and up large scale MW

Other Types of CHP

CHP Type	Advantages	Disadvantages	System Sizes
Micro Turbine	• Limited amount of moving parts • Compact and light weight • Low emissions • No cooling needed	• High capital cost • Relatively low mechanical efficiency • Limited to lower temperature and power applications	30 kW to 250 kW
Fuel Cells	• Low emissions • Quiet operation • Modular design	• High capital cost • Sensitive to fuel impurities • Fuel is more complicated to procure • Relatively low power density	5 kW to 2 MW

Why Install CHP?

Increase Efficiency

Conventional heat and electrical generation is typically 50-55% efficient

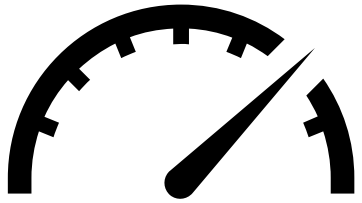
By combining the heat and electrical generation, CHP can typically achieve efficiencies of 65-85%

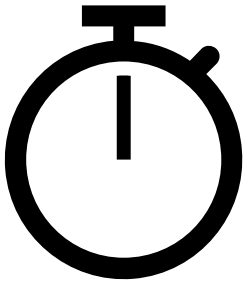
Electrical Independence

- Aging Electrical Infrastructure
- Reduced Accredited Generation
- Increasing Electrical Loads
- Storms

CHP Keeps Your Lights On

Economic





Reduce Energy Cost

Reduce Down Time

Reduce Demand Charges
&
Peak Shaving

Who Should Consider CHP?

Common Applications

- Industrial Facilities

  - Ethanol Plants
  - Beet Sugar Processing
  - Soybean Crush and Refining
  - Many Others…

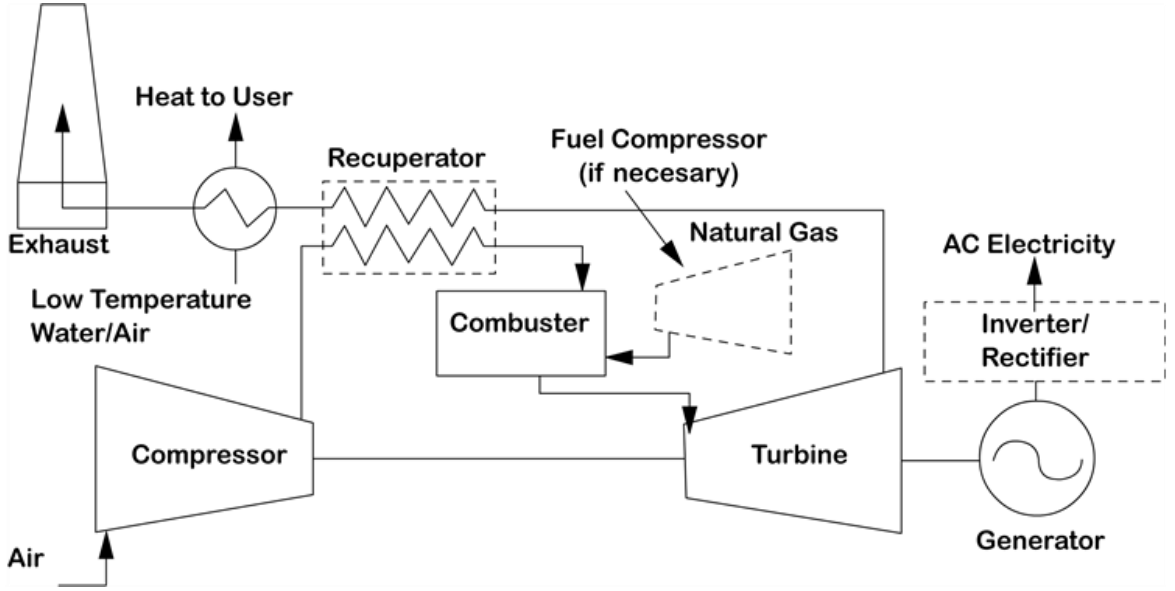
- Commercial Buildings
  - Municipal Heating Districts
  - Multi-building Campus
  - Many Others…

- Residential

  - Domestic Hot Water
  - Space Heating

Microturbines CHP

- Small Combustion Turbines
  - Modular Units: 30-250 kW
  - Can run on multiple types of fuel including some “waste gas”
- Electrical production plus domestic water or space heating
- Current capital costs are relatively high



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Thank You

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