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Industrial Assessment Center **(SFSU)**

ENERGY CONSERVATION & WASTE MANAGEMENT
ASSISTANCE FOR INDUSTRY
A U.S. DEPARTMENT OF ENERGY SPONSORED PROGRAM

Overview of Combined Heat and Power (CHP) Systems

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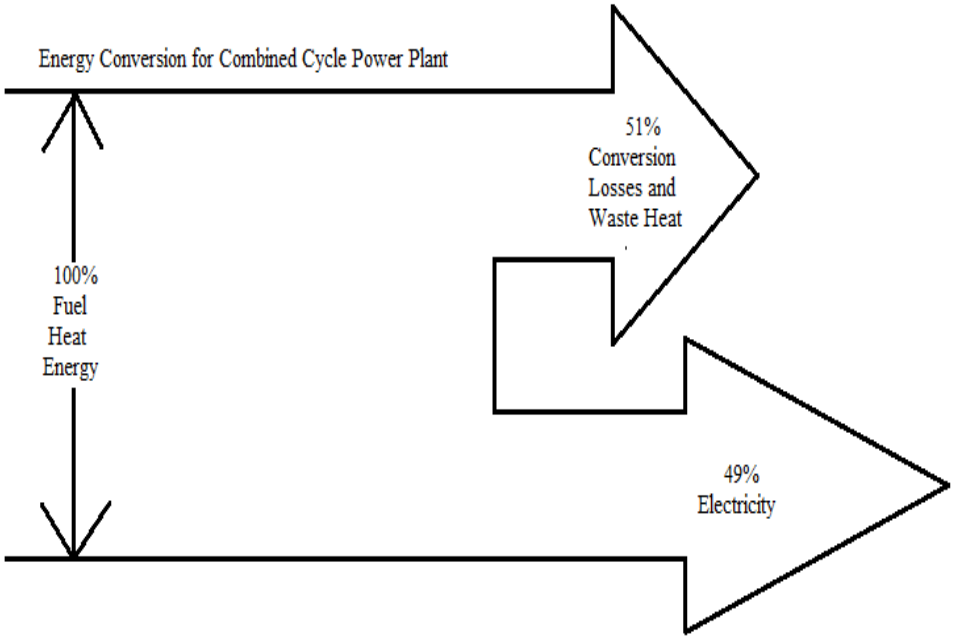
October 11, 2011

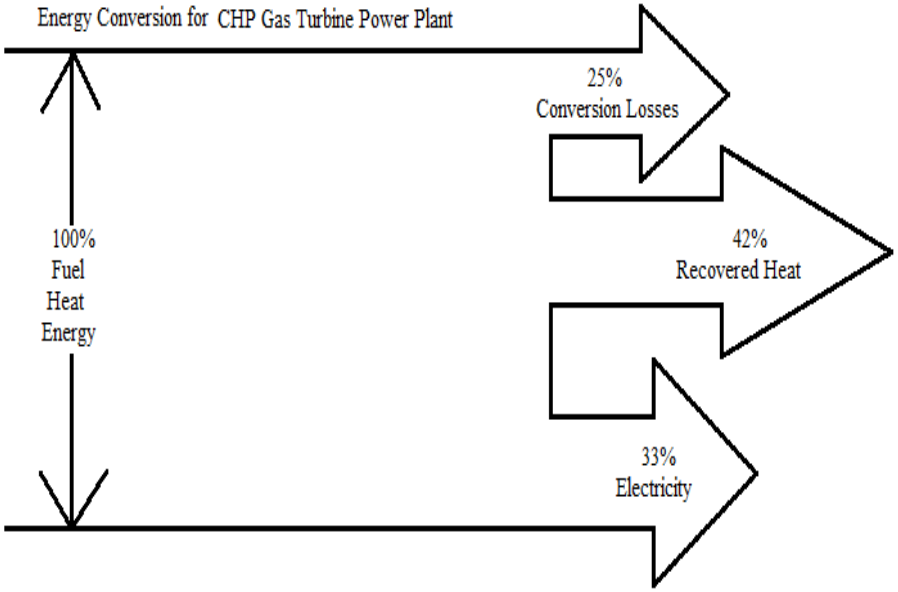
Presentation Outline

- Definition of Combined Heat and Power
- Types of Facilities that Benefit from CHP
- Common CHP Prime Movers
- Examples of Savings

Definition of Combined Heat and Power

- Simultaneous Generation of Electrical or Mechanical Power and Useful Heat from a Single Fuel Source

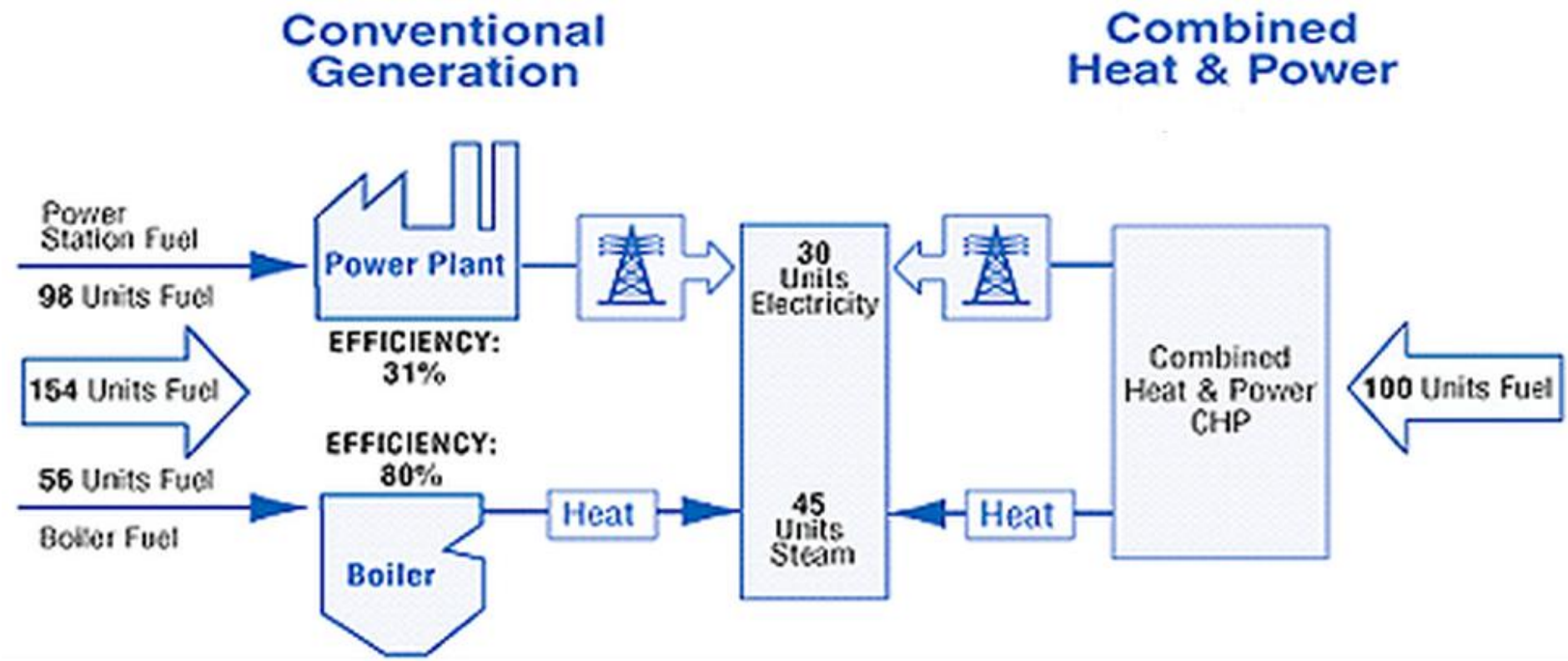




Adapted From NREL Life Cycle Assessment of a Natural Gas Combined-Cycle Power Generation System

Adapted From http://www.nrel.gov/dtet/about.html

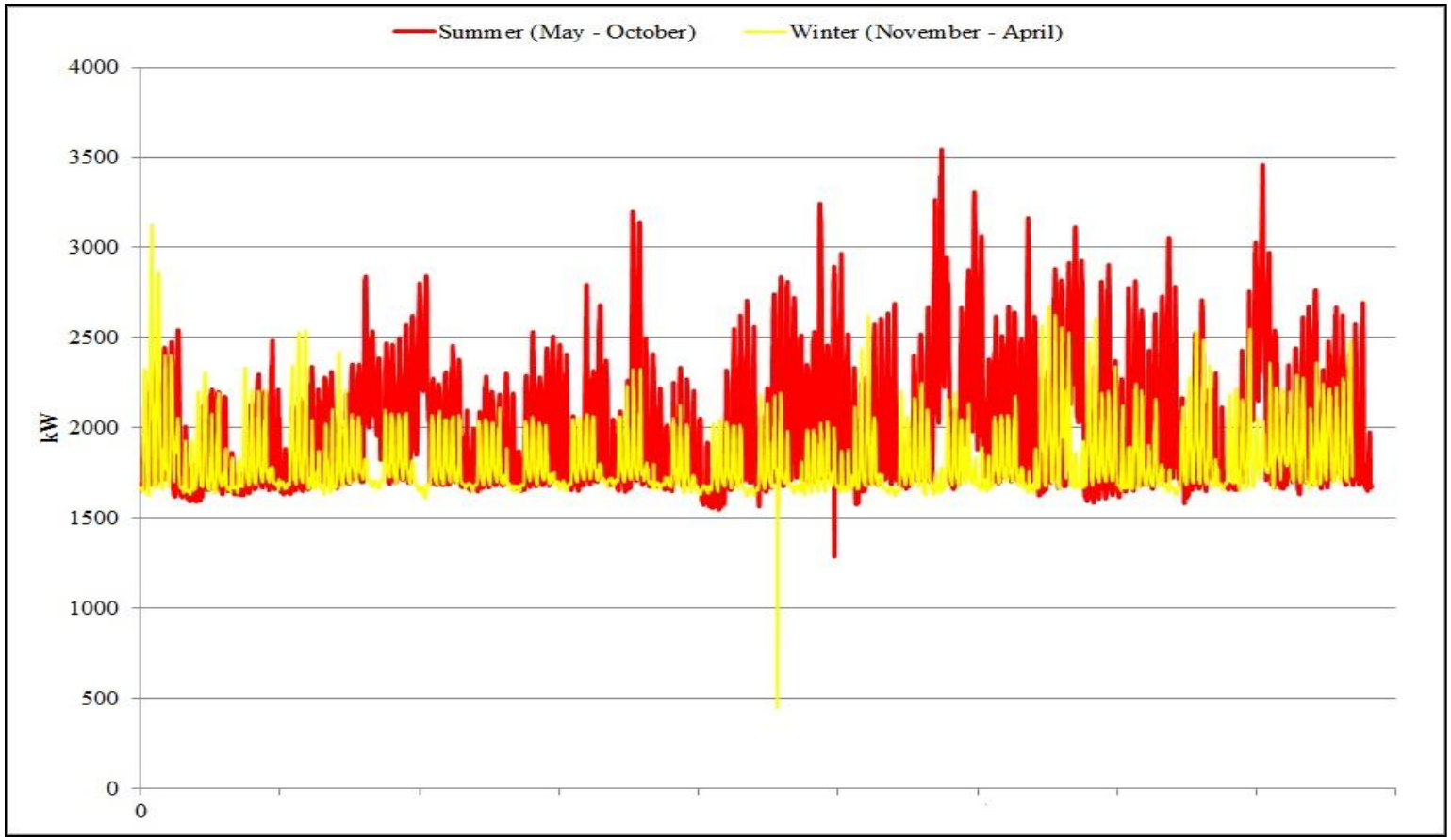
Definition of Combined Heat and Power



Source: EPA Combined Heat and Power Partnership: Methods for Calculating Efficiency

Types of Facilities that Benefit From CHP

- Plants that have a significant electrical base load and heating or cooling loads throughout the year that can be satisfied with waste heat.



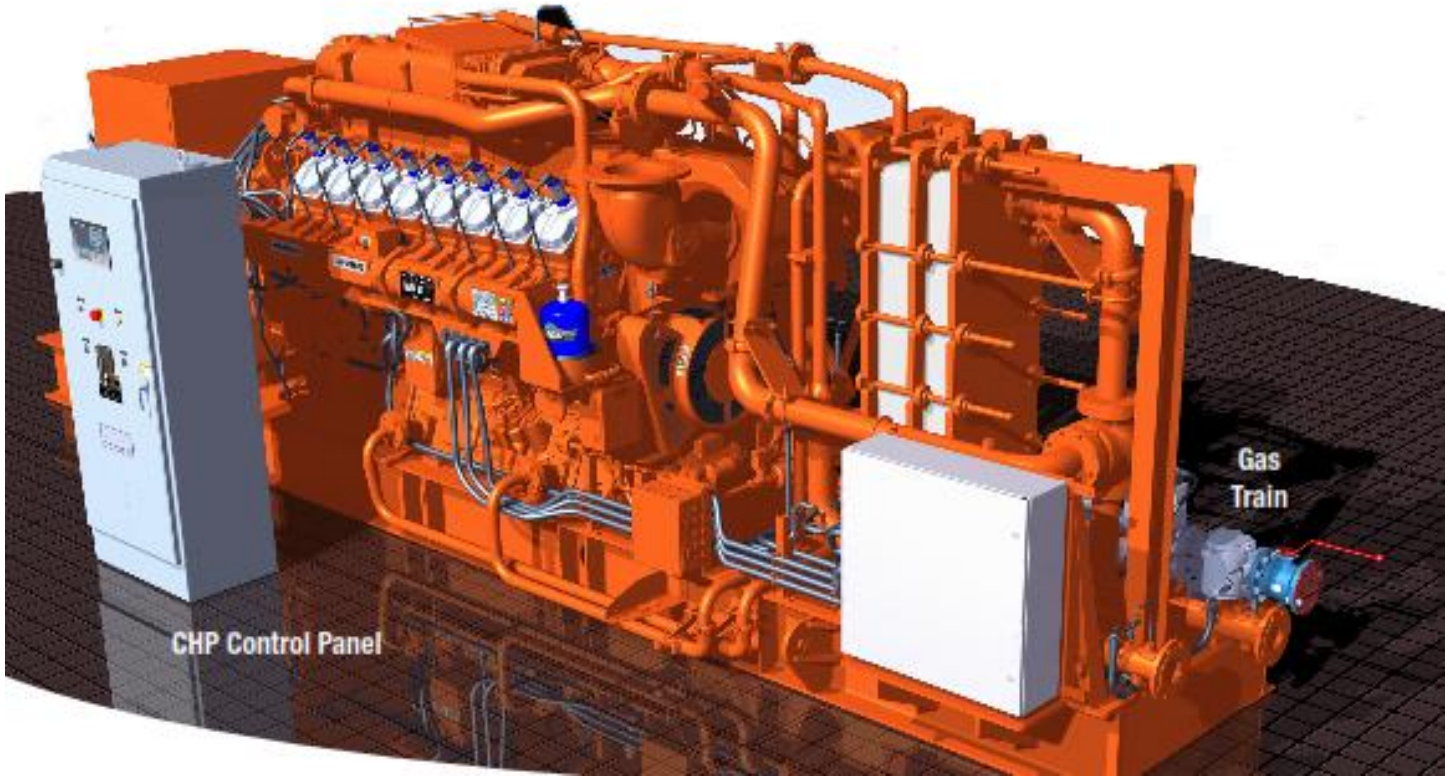
Types of Facilities that Benefit From CHP

- Industrial Manufacturers
  - Food Processing, Ethanol, Glass Manufacturing
- Institutions
  - Universities, Hospitals, Military Bases
- Commercial Buildings
  - Hotels, Airports, Large Office Buildings
- Municipal
  - Wastewater Treatment, Municipal Energy Systems

Common CHP Power Generators

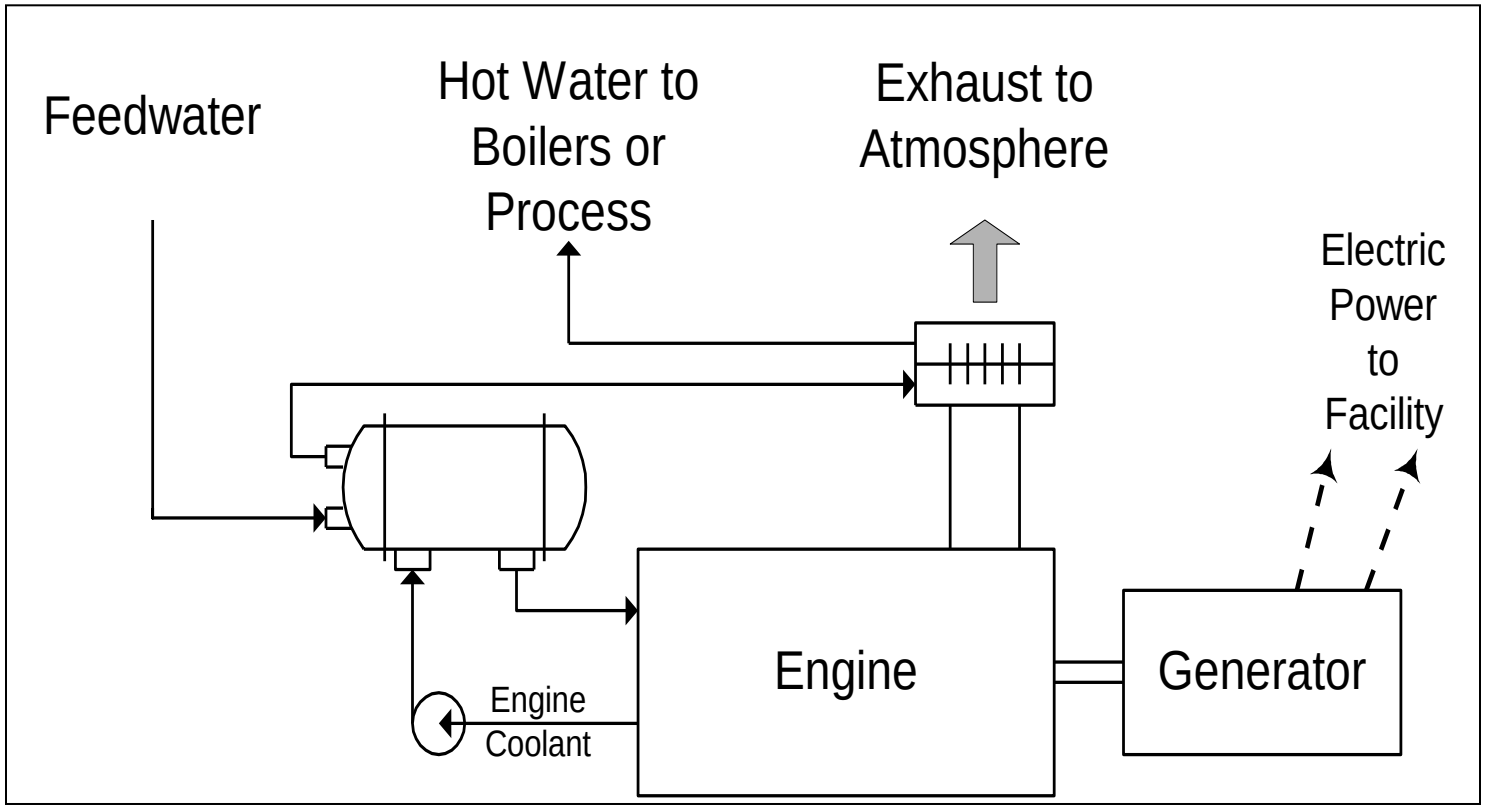
- Reciprocating Engines
- Gas Turbines
- Fuel Cells
- Others Include Microturbines and Steam Turbines

Reciprocating Engines



Source: Dresser Waukesha APG1000 Technical Specifications

Reciprocating Engines

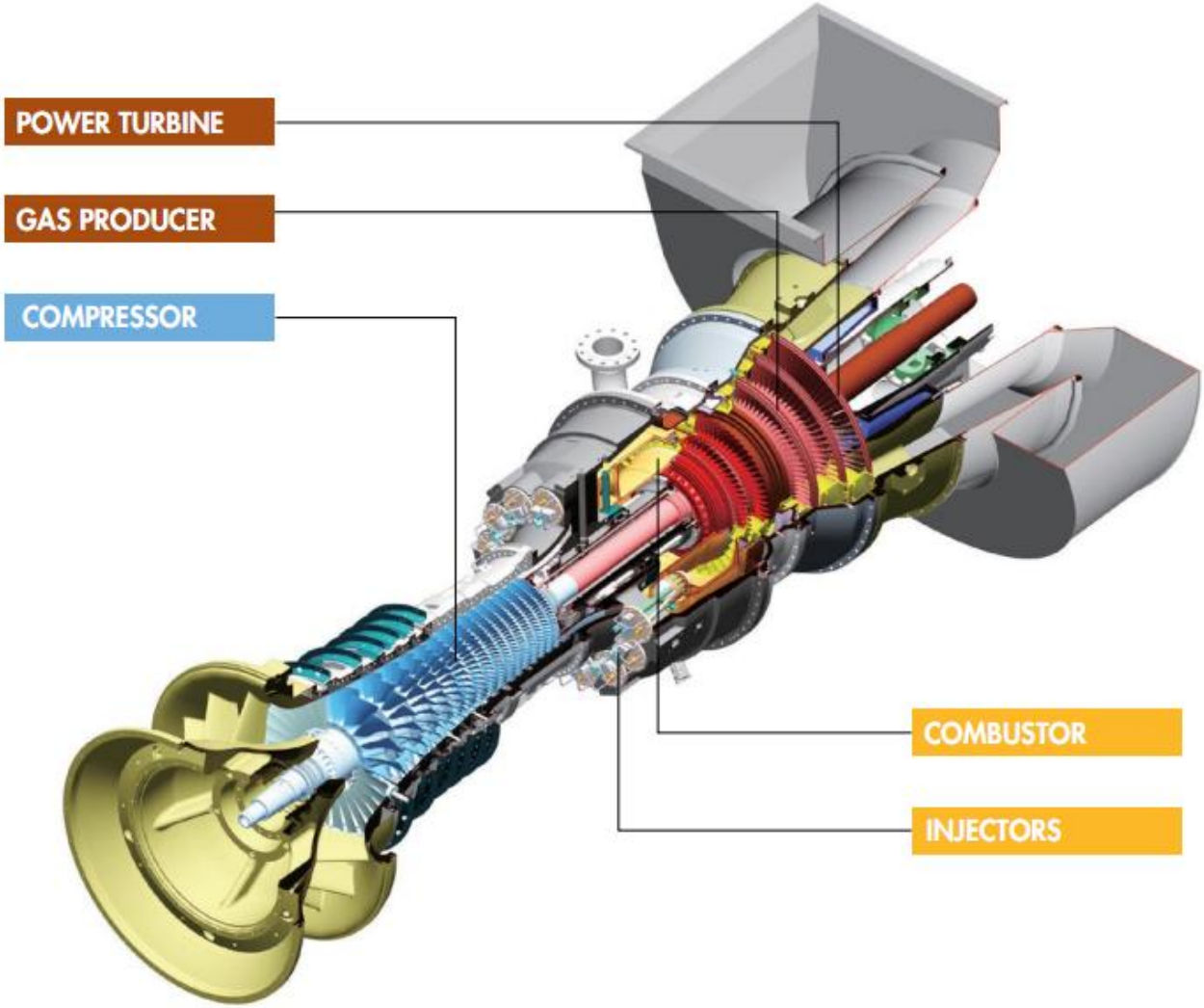


Reciprocating Engines

- Power Range: 5 kW – 7 MW[1]
- Fuel Types: Natural Gas, Gasoline, Diesel, Oil Fuel[1]
- Installed Cost: 450-1,800 [$/kW][1]
- Electrical Efficiency: 25-45% (LHV)[1]
- Total Efficiency with Heat Recovery: 70-80% (LHV)[1]
- O&M Costs: 0.005 – 0.01 [$/kWh] [1]
- Major U.S. Manufacturers
  - Caterpillar, Cummins, Waukesha

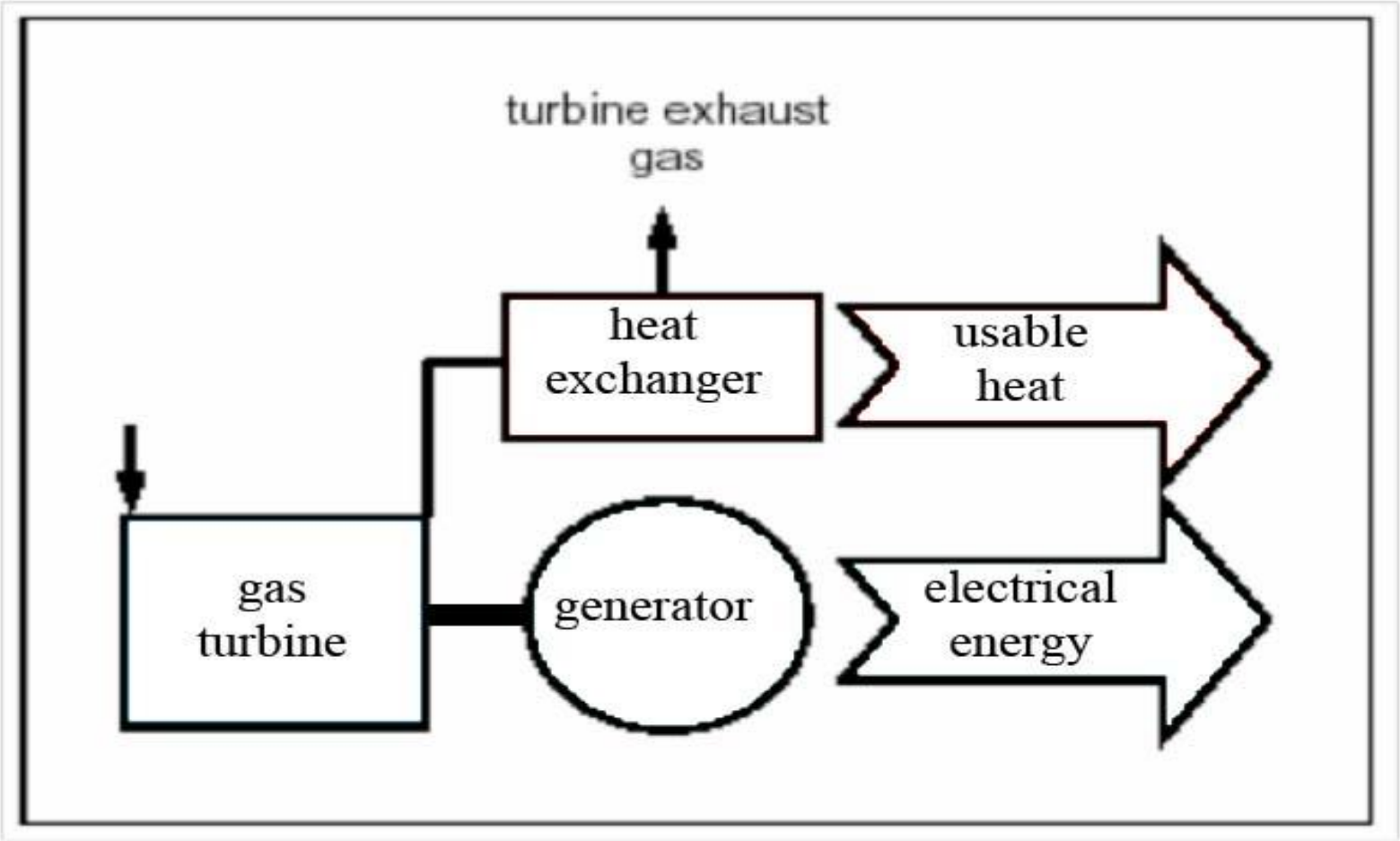
[1] EPRI: Technical and Economic Assessment of Combined Heat and Power Technologies For Commercial Customer Applications, Mar. 2003

Gas Turbines



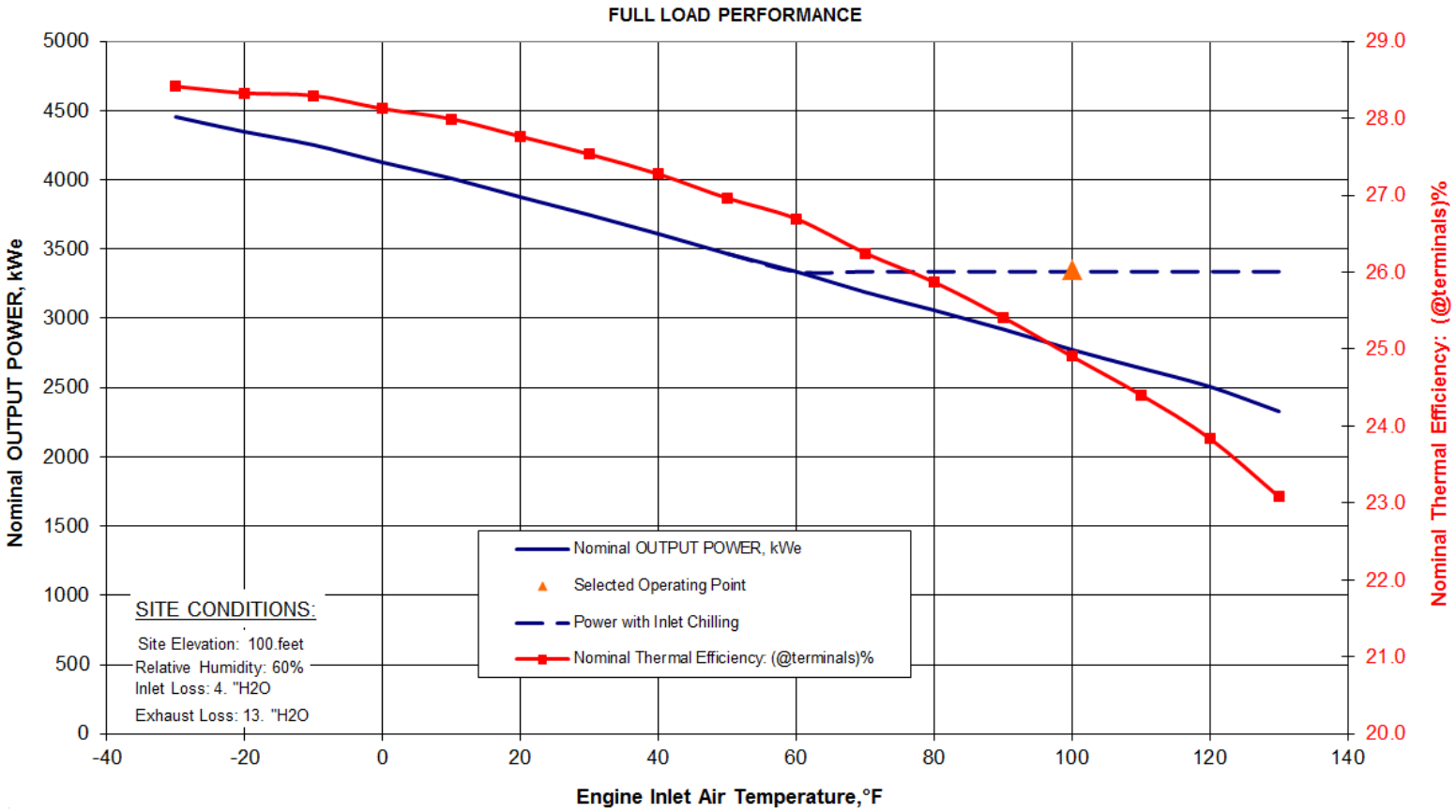
Source: Solar Turbines Titan 250 Gas Turbine System Brochure

Gas Turbines



Adapted from Cogen3 Cogen Technologies and Applications, November 2004

Gas Turbines



Adapted from Cogen3 Cogen Technologies and Applications, November 2004

Gas Turbines

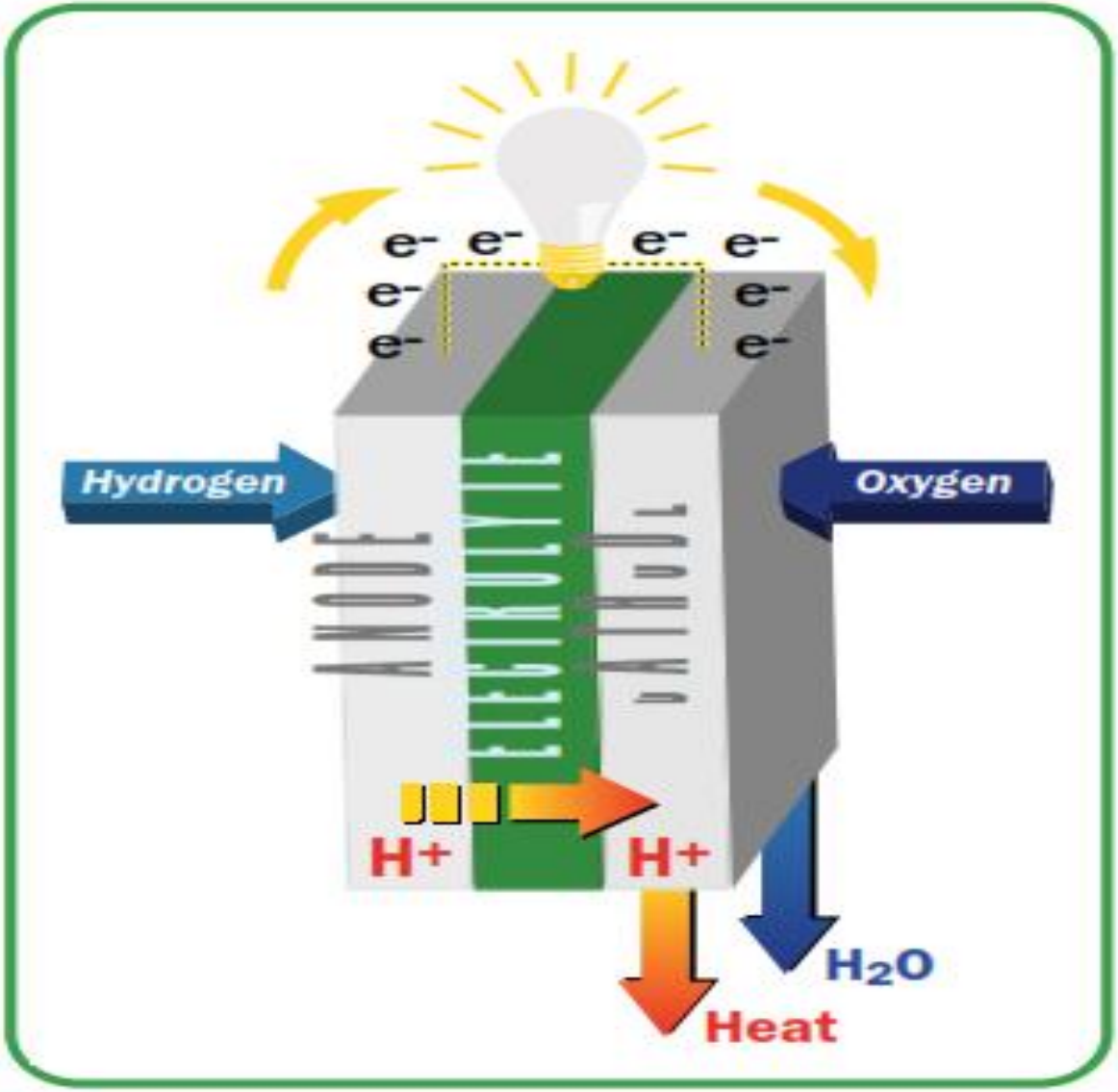
- Power Range: 500 kW – 30 MW[1]
- Fuel Types: Natural Gas, Liquid Fuels[1]
- Installed Cost: 700-1,100 [$/kW][1]
- Electrical Efficiency: 20-45% (LHV)[1]
- Total Efficiency with Heat Recovery: 70-78% (LHV)[1]
- O&M Costs: 0.01 – 0.02 [$/kWh]
- Major U.S. Manufacturers
  - Solar Turbines, Siemens, General Electric Power Systems

[1] EPRI: Technical and Economic Assessment of Combined Heat and Power Technologies For Commercial Customer Applications, Mar. 2003

Fuel Cells

Source: UTC Power Knowledge Library

Fuel Cells



Adapted from UTC Model 400 Purecell System Manufacturer Data Sheet

Fuel Cells

- Power Range: 100 kW – 10 MW[1]
- Fuel Types: Natural Gas, Methanol, Gasoline, Fuel Oil, Hydrogen[1]
- Installed Cost: 4,000 – 5,500 [$/kW][1]
- Electrical Efficiency: 30-50% (LHV)[1]
- Total Efficiency with Heat Recovery: 65-75% (LHV)[1]
- O&M Costs: 0.02 – 0.05 [$/kWh] [1]
- Major Manufacturers
  - UTC, Fuel Cell Energy, General Electric Power Systems

[1] EPRI: Technical and Economic Assessment of Combined Heat and Power Technologies For Commercial Customer Applications, Mar. 2003

Examples of Savings

- Commercial/Retail Building in Downtown San Francisco, CA
- Waste Water Treament Plant in Tracy, CA

555 California St.

Recommended to Install a Reciprocating Engine To Cover the Electrical Base Load of The Facility And Produce 120 psig Steam to be Used in the Facility or Injected into the City's Steam Loop

Estimated Electrical Energy Savings	15,391,539 kWh/yr M
Demand Savings	1,850 kW
Estimated Steam Production	36,655,922 lb/yr
Net Gas Usage Increase	135,827 MMBtu/yr
Total Cost Savings	$1,137,090/yr
Implementation Cost	$3,450,000
Simple Payback	3.0 years

Waste Water Treatment Plant

Recommended to Install a 298 kW Reciprocating Engine to Utilize Digester Biogas, Supplement the Electrical Base Load and Provide Heating for the Digester

Estimated Electrical Energy Savings	2,479,956 kWh/yr
Demand Savings	298 kW
Estimated Usable Heat Production	13,590 MMBtu/yr
Net Gas Usage Increase	8,089 MMBtu/yr
Total Cost Savings	$186,673/yr
Implementation Cost	$750,000
Simple Payback	4.0 years

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