

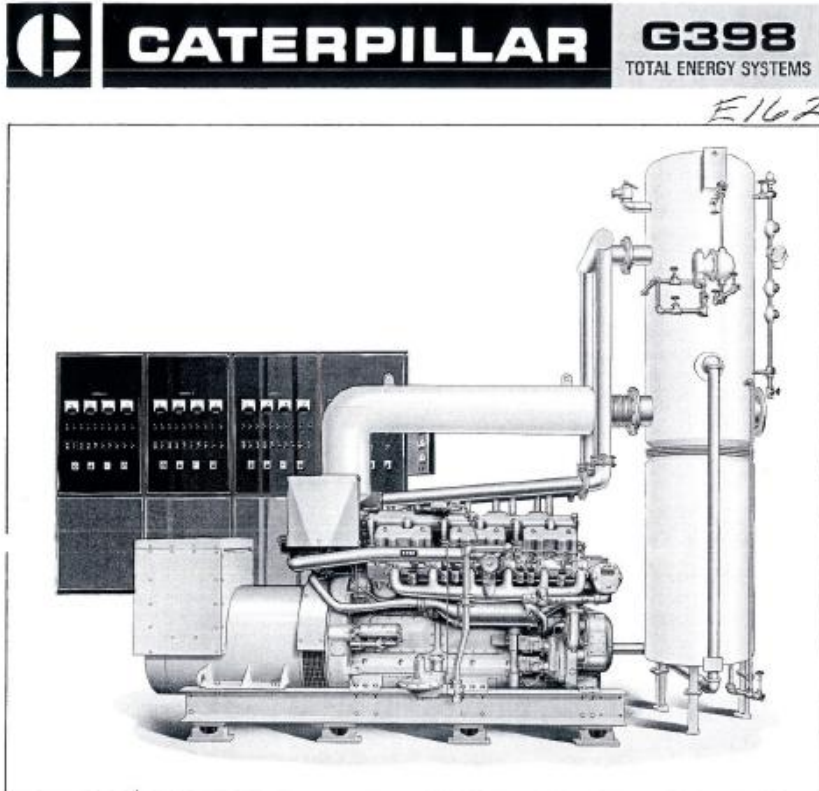


Combined Heat & Power (CHP)

CATERPILLAR®
TODAY'S WORK. TOMORROW'S WORLD.™



Prime Mover Technologies



STANDARD EQUIPMENT INCLUDES:

Factory designed and warranted, providing single source of responsibility for your total energy needs. Systems are factory engineered and tested, insuring compatibility, increasing plant reliability, decreasing initial investment.

- Caterpillar G398 TA Natural Gas Engines
- Caterpillar SRCR Generators
- Caterpillar Heat Recovery Systems
- Caterpillar Fully-Automatic System Controls

Note: Systems are available in three or four engine arrangements. All components of the standard systems are warranted by Caterpillar Tractor Co. See back page for provisions of Warranty.

Since 1960, Caterpillar and Cat dealers have provided combined heat & power solutions to our customers.

- CHP packages
- Power Modules
- Gas Engine Driven Chillers
- Attachments
- Ancillary equipment
- Switchgear

TEXAS COMBINED HEAT & POWER INITIATIVE

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Clean, Efficient, and Reliable Energy to Power Texas

Caterpillar Engine Generator Sets

DIESEL – from 8 kW to 16 MW



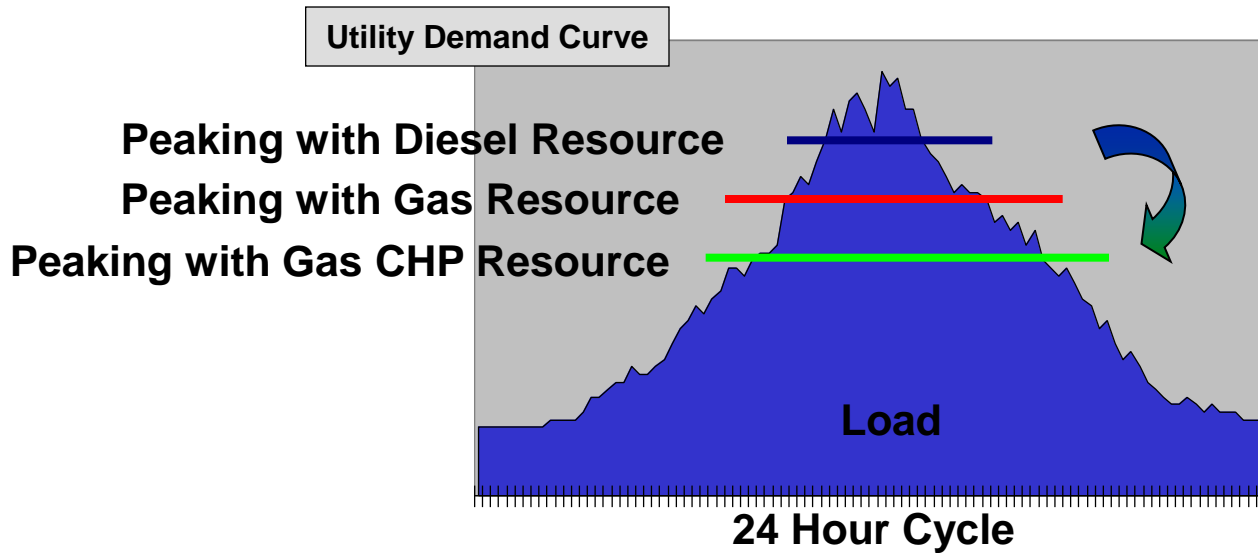
GAS – from 25 kW to 6 MW



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**Distributed Generation With Gas Resource
Improves Operating Cost/kw-hr
Allow Increased Time Online**

100 – 500 hrs/yr → 100 – 4000 hrs/yr

- Better resource efficiency
- Enhances local power quality
- Standby power source

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Gas Engine Generator Set Advantages

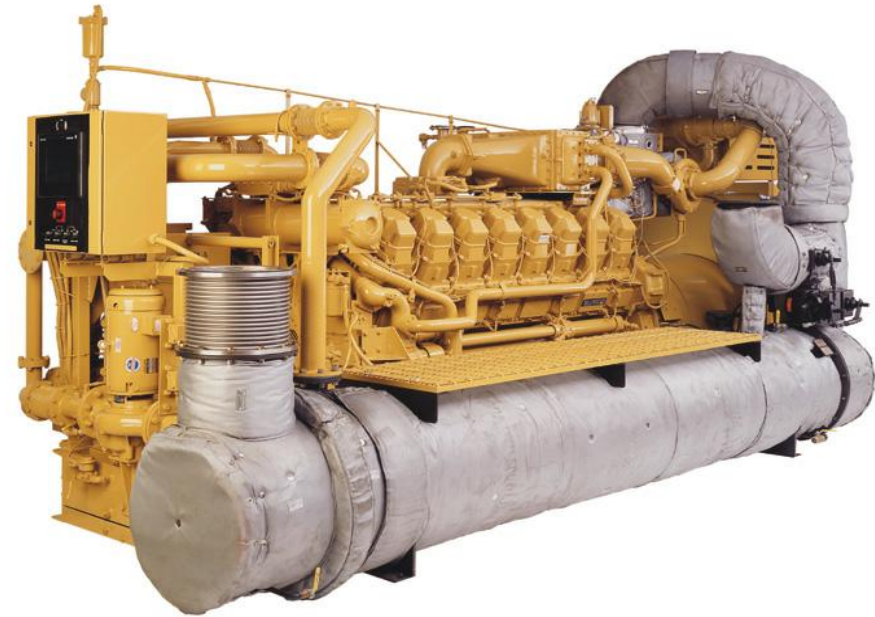
- ✓ Higher Fuel Efficiency
- ✓ Lower Initial costs for small schemes (<10 MWe)
- ✓ Better suited for Variable Load Applications
- ✓ More Tolerant to High Ambient Conditions and High Elevations (law of physics)
- ✓ Lower Fuel Pressure Requirement
- ✓ Accept low BTU fuels
- ✓ On line in less than 30 sec

CHP is an Economic Decision - decide which is most important: Electrical power or heat recovery

- Some electric power requirements are sized to meet **heat load** needs.
- Some system run times are determined by **electric load** needs.

Bottom Line

What is the \$ value of the heat recovered vs. the cost associated with retrieving and distributing the heat.



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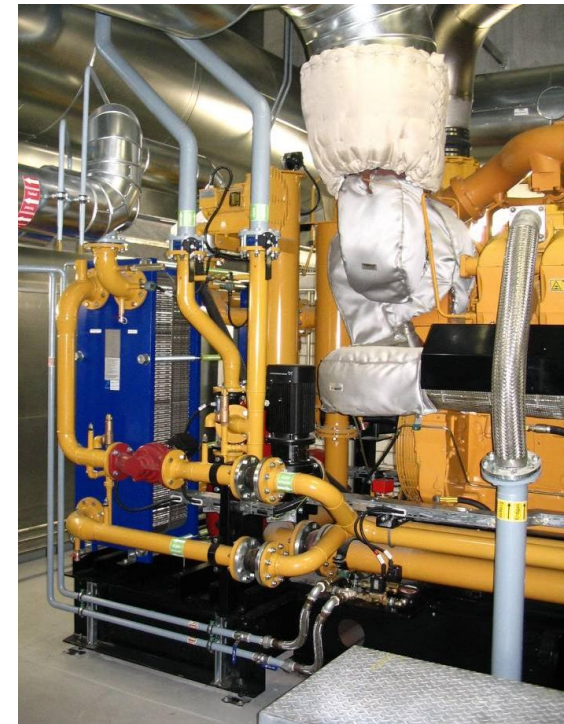
1250 kW CHP System

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- **Electric Intensive Applications**
 - Examples – Hospitals, Offices, Shopping Malls
 - Operates when electricity is required
 - Utilizes load balancing radiators - exhaust circuit bypass
- **Applications Requiring Heat & Power**
 - Examples - Cement Plants, Chemical Processes, Food Processing
 - More complex systems
 - Require radiators and thermal accumulators
- **Heat Intensive Applications**
 - Examples – Greenhouses, District Heating, Central Steam Plants
 - Operates when heat is required
 - Utilizes thermal accumulators - direct connection –
 - Can be hot water or steam circuits

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Gas Genset CHP Target Market Attributes

- Geographically
 - High electric costs
 - Relatively low fuel costs
 - Adequate grant/funding levels
- Site specific
 - High electric costs
 - Solid load factor
 - Coincident thermal and electric load profile
 - Available gas

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Separate Production of Electricity and Heat	
<p>Fuel 100 → Power Plant → Electricity 36</p> <p>Fuel 100 → Boiler → Heat 80</p>	Total efficiency: $\eta = \frac{36 + 80}{200} = 0.58$
Cogeneration	
<p>Fuel 100 → Cogeneration System → Electricity 30</p> <p>Heat 55</p>	Total efficiency: $\eta = \frac{30 + 55}{100} = 0.85$

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Typical gas engine heat balance:

<u>Recovered Energy</u>	<u>90%</u>
Shaft Output	42%
Aftercooler Water	11%
Jacket Water	12%
Oil Cooler	3%
Exhaust @ 120 C	22%
<u>Un-recovered Energy</u>	<u>10%</u>
Radiation	3%
Excess Exhaust	7%



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Financial Feasibility – High Level First Look

- Start with the obvious deal killers
 - Air quality permitting
 - Waste water discharge permitting
 - Adequate space
 - Adequate facility utilities
 - Electrical
 - Water
 - Fuel
 - Waste water

Financial Feasibility – High Level First Look

- Identify and stack \$/kWh pricing components (running costs)

Fuel: 8.8 (biggest cost)

Capital Recovery: 1.5

O & M: 1.5

Thermal Credits:(2.0)

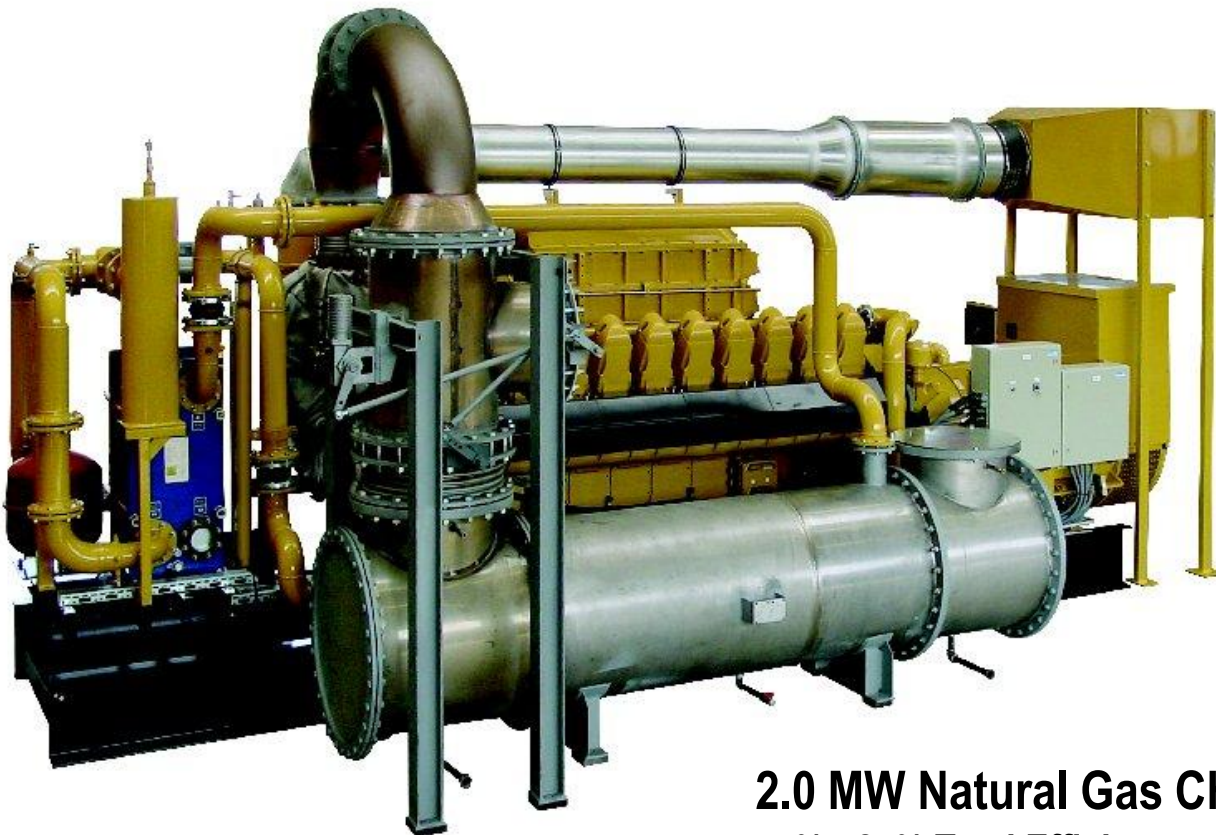
Total 9.8 cents/kWh

If this beats present retail purchase price, all in, including demand charges, investigate further. Potentially pull in engineer or developer. Commission a Feasibility study

WHO IS THE WINNER ?

- In fact in 95% of cases there's no contest
- If the NPV evaluation is made correctly, the choice is evident
- Low temp, low pressure gas, high altitude will go gas engine generator sets
- Large Heat / ekW ratio schemes, high pressure steam will go turbines
- Some hybrid systems are possible but not frequent. CAT & SOLAR are the two arms of a same family

Complete CHP Package From Caterpillar



2.0 MW Natural Gas CHP Generator Set
75% - 85% Total Efficiency

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