Cat® Electric Power

CHP Technology

BUILT FOR IT.

Agenda

- Cogeneration of Heat and Power
- Cogeneration with Hot Water Production
- Cogeneration with Steam Production
- Cogeneration with Chilled Water Production
- Greenhouse application
- Modular Building

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Cogeneration of Heat and Power

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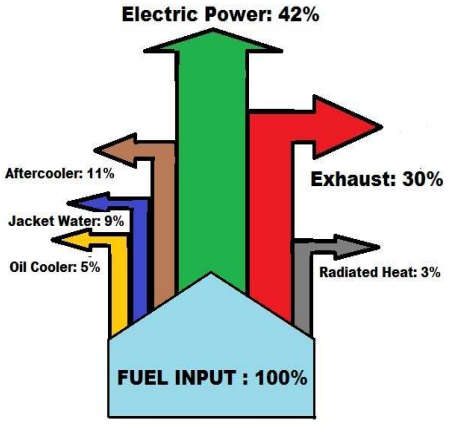
Combined Heat & Power

- The simultaneous and sequential use of power and heat from the same fuel source.
- Utilize the heat that otherwise would have been wasted.
  - Heat
  - Hot Water
  - Steam



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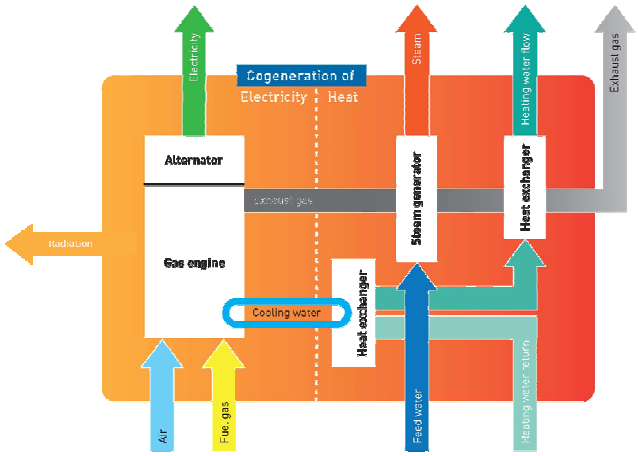
Combined Heat and Power Plants (CHP)



source: www.mwm.net

Cogeneration of Heat and Power

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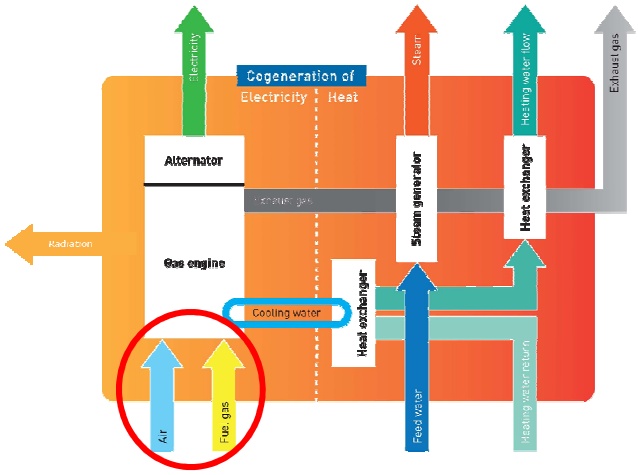
Combined Heat and Power Plants (CHP)



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Cogeneration of Heat and Power

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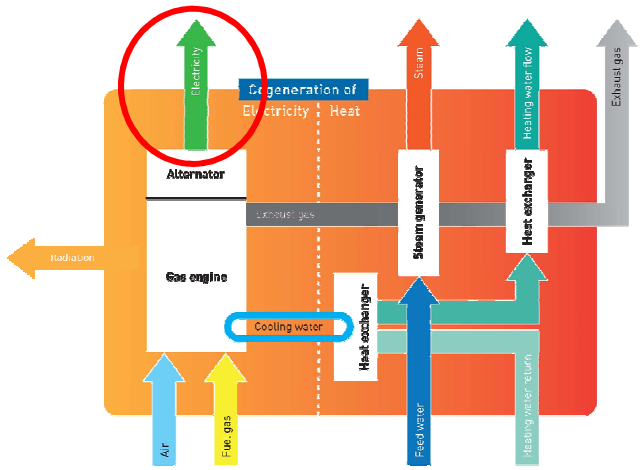
Combined Heat and Power Plants (CHP)



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Cogeneration of Heat and Power

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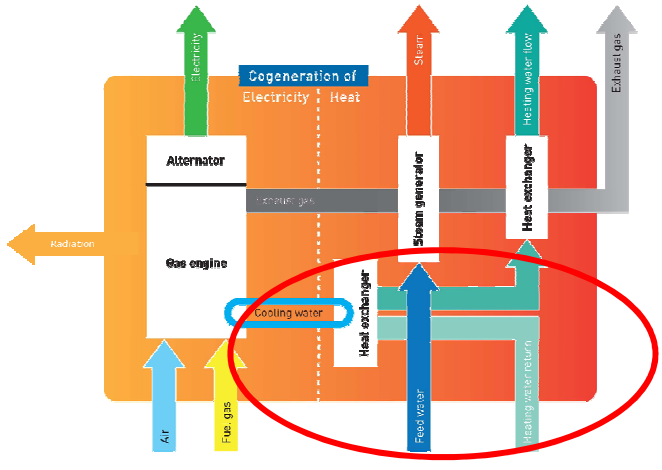
Combined Heat and Power Plants (CHP)



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Cogeneration of Heat and Power

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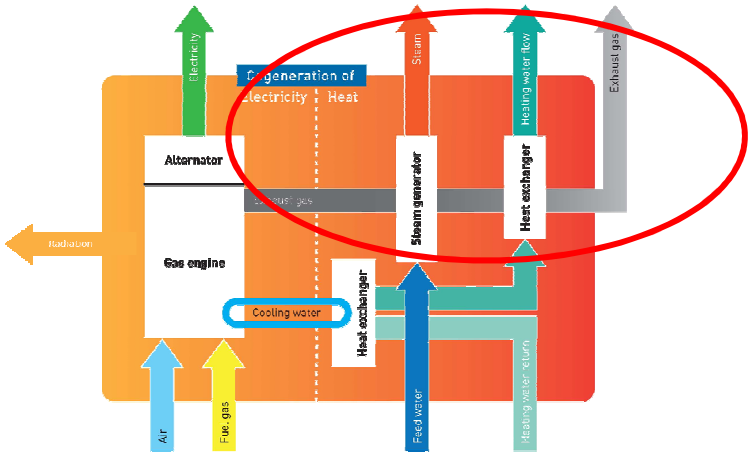
Combined Heat and Power Plants (CHP)



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Cogeneration of Heat and Power

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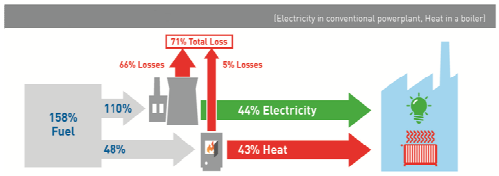
Cogeneration of Heat and Power



- **Traditional energy production – production of energy for own use**
  - **Energy** is produced where it is needed
  - **Heat** from the production of electric energy **is wasted**
  - Total **efficiency is limited** to generator set electrical efficiency
  - **Independency** from outages or grid problems

source: www.mwm.net

Cogeneration of Heat and Power

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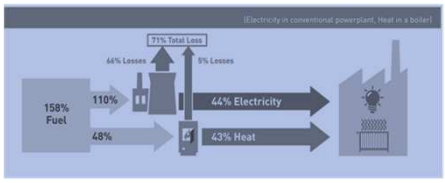
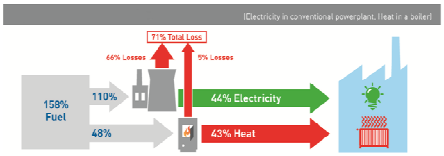
Cogeneration of Heat and Power





- **Decentralized energy production – production of energy for own use**
  - **Energy** is produced where it is needed (heat led or power led)
  - Use of **waste heat** for heating, cooling, steam or heat recovery for power generation
  - Total **efficiency** up to **90%**
  - **Independency** from outages or grid problems

source: www.mwm.net

Cogeneration of Heat and Power

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How to Use the Heat?

Applications

Gas Fuel

Electric Power

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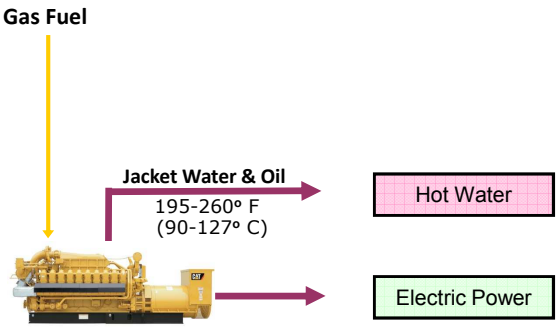
How to Use the Heat?

Applications



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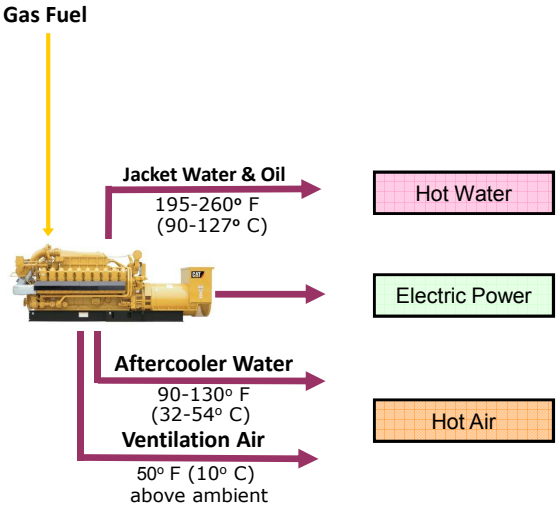
How to Use the Heat?

Applications



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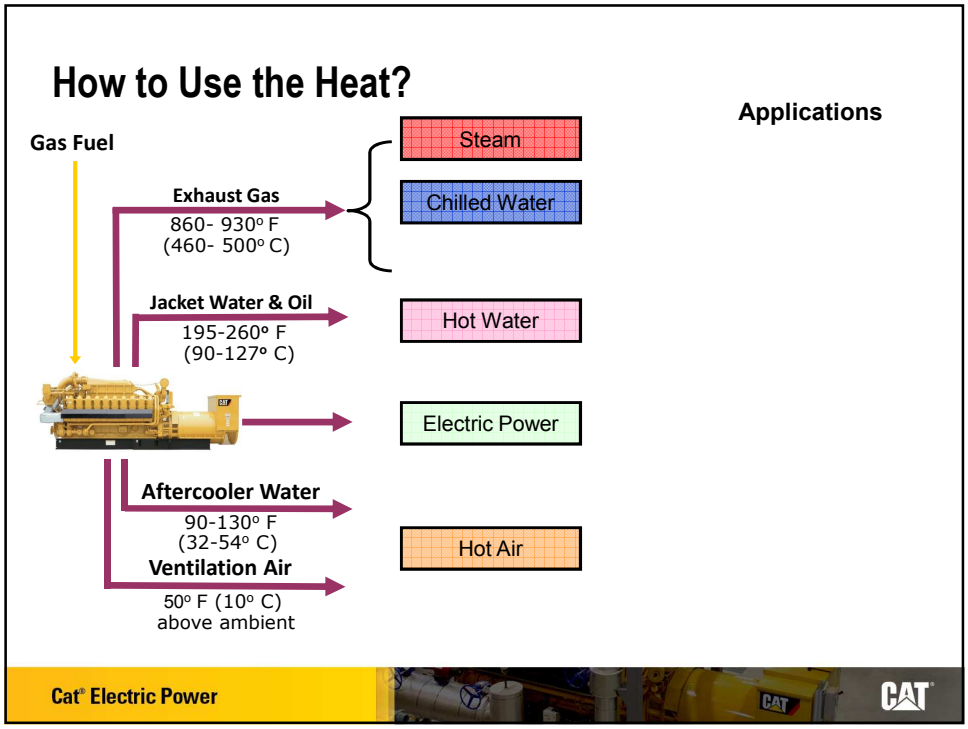
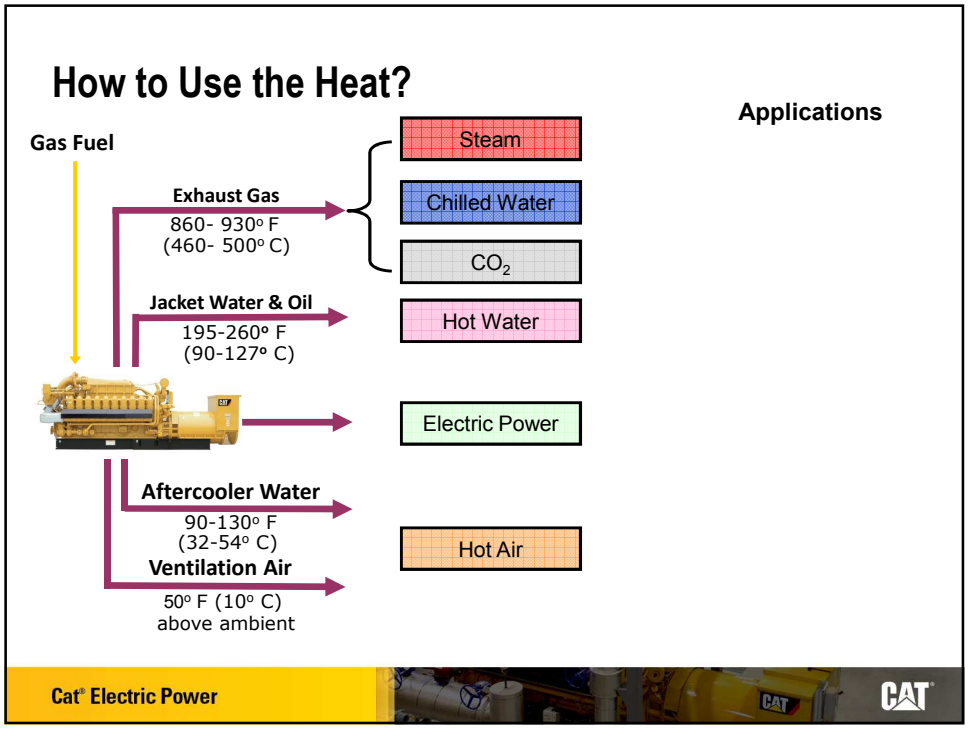

How to Use the Heat?
Applications
Gas Fuel
Exhaust Gas
860- 930° F
(460- 500° C)
Steam
Chilled Water
Jacket Water & Oil
195-260° F
(90-127° C)
Hot Water
Electric Power
Aftercooler Water
90-130° F
(32-54° C)
Ventilation Air
50° F (10° C)
above ambient
Hot Air
Cat® Electric Power
CAT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Cat® Electric Power
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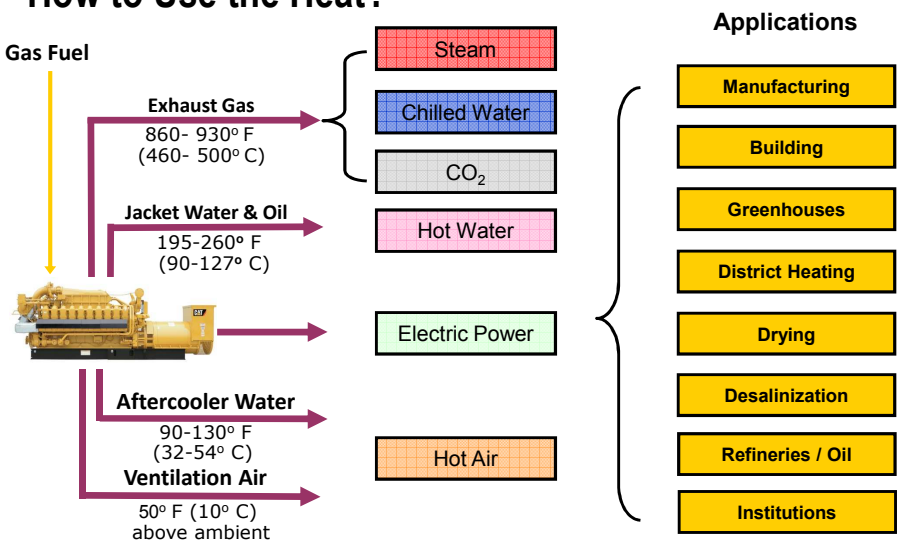
How to Use the Heat?



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Waste Heat Applications

- **High Pressure Steam >15 bar (150 psi)**
  - Dearator
  - BFW Heating
  - Air Preheat
- **Int. Pressure Steam <15 bar (150 psi)**
  - Pasteurization
  - Sterilization
  - Distillation
  - Process Temp Control
  - Evaporation
  - District Heating
  - Viscosity Reduction
  - Solvent Stripping
  - Chilling
  - Drying
- **Low Pressure Steam < 1 bar (15 psi)**
  - Deaeration
  - Space Heating
  - Humidification
  - Tank Heating
  - Steam Tracing
  - Viscosity Control
  - Slurry Preheat
  - Distillation
  - Evaporation
  - Degreasing
  - Electroplating
  - Chilling

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Waste Heat Applications

- Hot Water
  - HVAC
  - Laundry
  - Food Processing
  - Degreasing (Bath)
  - Electroplating
  - Immersion Coating
  - Printing
  - Digester Temp
  - Paint Drying
- Warm Water
  - Space Heating
  - Air Heating
    - pulverizers, kilns, dryers
- Air Heating
  - Boilers
  - Pulverizers
  - Kilns (lime, cement, ceramics)
  - Dryers (gypsum, grain, lumber)
  - Synthetic Fiber
- Chilling (Absorption)
  - HVAC (Hospitals, hotels, offices, factories, casinos)
  - Process Control
    - Semiconductors
    - Pharmaceuticals
    - Plastic Injection Molding
    - Plastics Recycling
    - Extrusion

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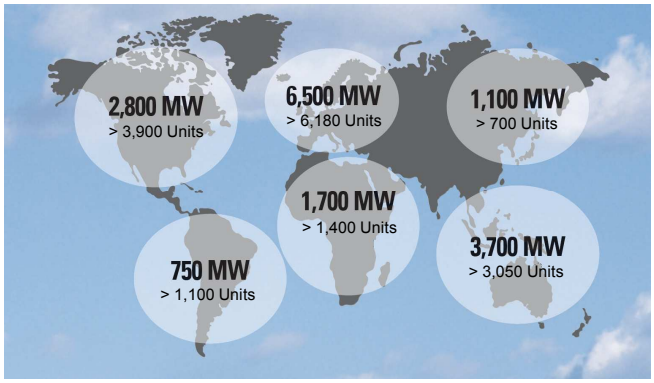
Caterpillar Gas Generator Experience



- **EXPERIENCE** Cat & MWM Gas Installed Capacity (1995-2010)
  - Caterpillar Shipped >24,500,000+ Gas HP in Last Decade
  - More than 47,500 stationary gas engines shipped
  - 4.736 billion estimated operating hours

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Caterpillar CHP Generator Experience

High Pressure Steam >15 bar (150 psi) > 700MW Greenhouses (Holland)

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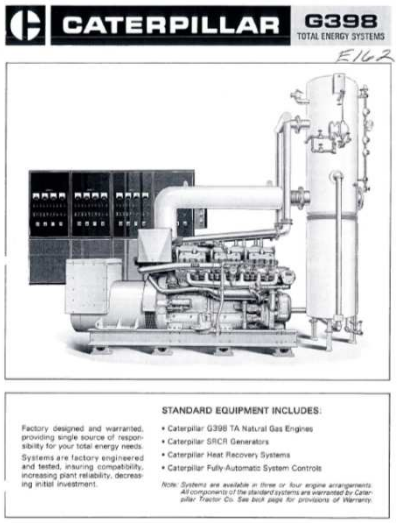
Decades of Experience in CHP



Since 1960, Caterpillar and its dealers have provided CHP solutions to our customers.

CHP packages
Power Modules
Gas Engine Driven Chillers
Ancillary equipment
Switchgear & Controls
Product Support (P&S)

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When Does CHP Makes Sense?

- High electric and/or thermal demands
- Possible effect of carbon and electricity
- Extended operating hours
- Need for emergency/backup systems
- Ability to export power to the grid
- Need reliable, high quality power
- Operate with reduced emissions
- Standards for energy efficiency

ECONOMIC DECISION

If >50% of available thermal energy can be used on an annual basis, CHP makes good economic sense

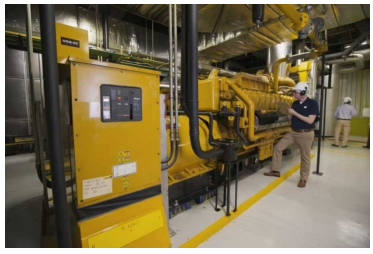
CHP is an Economic Decision Based Upon:

- **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.

What is the cost associated with retrieving and distributing the heat?



Can you Depend on the Grid?

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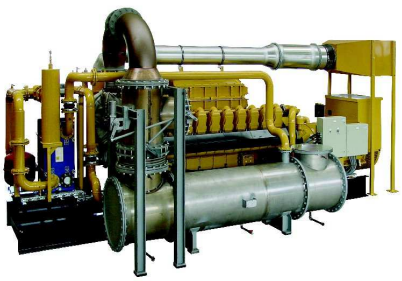
CHP Key Benefits

- Reduces Energy Costs
- Less GHG emissions
- Increase efficiency
- Power quality
- Backup to your installation



2.0 MWe
85% 95+% Total Efficiency
~$600 - $800 / kWe Installed

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Cogeneration with Hot Water Production

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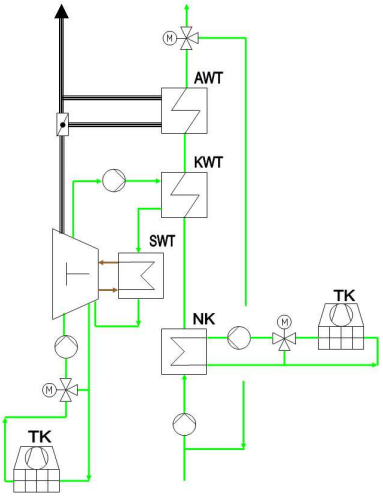
Variant Power Heat Max - Evaluation



- **Pro:**
  - **Small dump fan cooler** needed due to existence of exhaust bypass
  - **Utilization** of lube oil heat within Jacket Water Circuit
  - Less expensive lube oil heat exchanger
- **Contra:**
  - Max. forward temperature 85° C incase exhaust is bypassed

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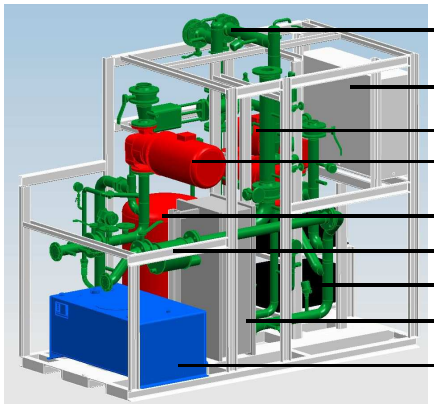
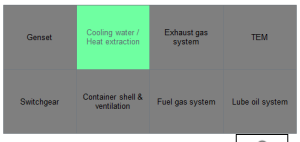
Cooling Water/Heat Extraction

Power Heat – Module



Modular Concept



Cooling water/Heat extraction

Compact construction for enough moving space

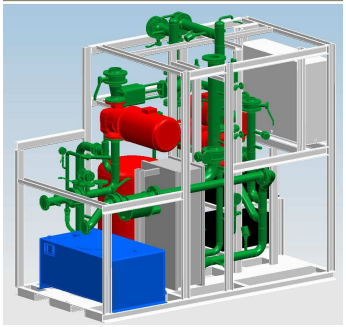
Better quality due to industrial production on quasi mass-production level

Covers heat circuit temperature range of up to 70-95° C

Power

Power Heat Basic

Power Heat Max Container



Further P&ID for up to 70-100° C available

High operation safety due to selection of high qualiy, durable and reliably components

Comprehensive safety instruments for genset and plant protection

CG170-20 References: Novotel Mangga Dua, Indonesia

Novotel Mangga Dua is located in the business district Mangga Dua in northern Jakarta. It is part of a large and modern shopping, entertainment, exhibition, wholesale as well as a retail complex. With eight gensets of the type CG 170-20 a total electric output of 14.7 MW_{el} is generated and used by Novotel.

Genset/Engine
8 x CG170-20

Segment/Gas type
Cogeneration/Natural gas

Customer
Novotel Mangga Dua, Indonesia

Total output
14.7 MW_{el}

Commissioning
2005

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Cogeneration with Steam Production

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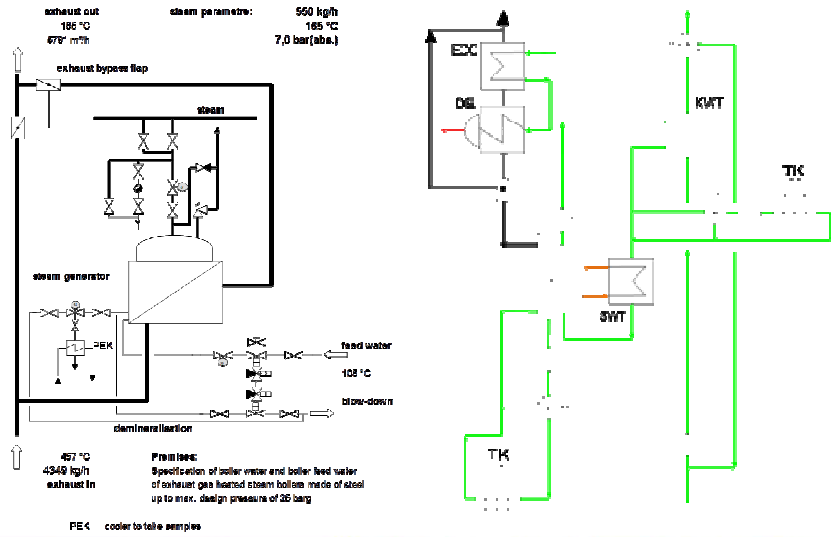
Variant Power Heat Steam



CG260-16 References: Lanhua Daning Coal Mine, China

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Genset/Engine
8 x CG260-16

Segment/Gas type
Cogeneration/Coal mine gas

Customer
LDCMMPG, Shanxi, China

Total output
32.0 MW_{el}

Commissioning
2010

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Cogeneration with Chilled Water Production

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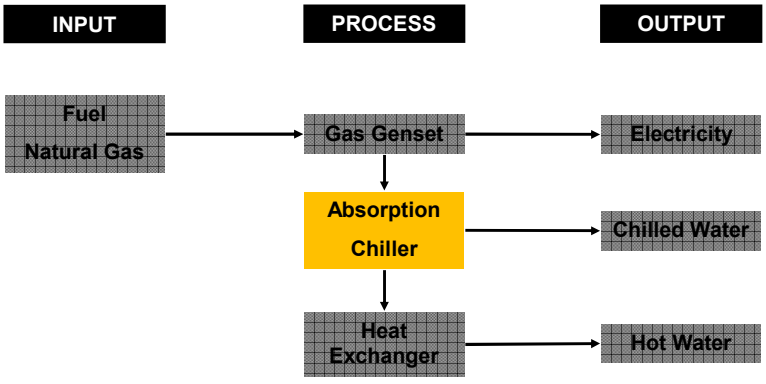
Tri-Generation

Simultaneous production of electricity heat and cooling from one source.



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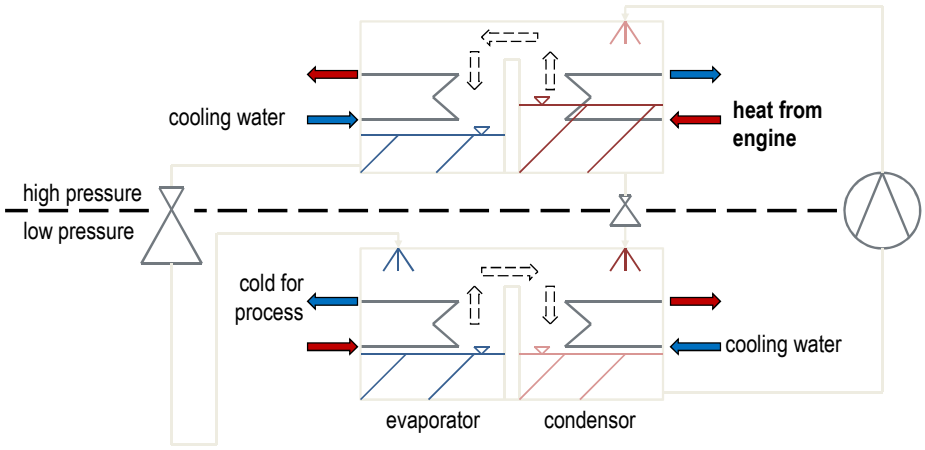
Variant Power Heat Steam



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Applications for Chilled Water

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CG170-20 References:
Shopping Center Novo America Rio de Janeiro, Brazil

For the modernization of the existing shopping center Novo America in Rio de Janeiro, Sotreq awarded the contract for the renovation of the power supply. The tri-generation plant supplies electricity to the grid with two CG 170-20 units. Throughout the year, the generated heat is converted into a two-stage absorption chiller to produce cold water for the air conditioning of the shopping center.

Genset/Engine
2 x CG170-20

Segment/Gas type
Trigeneration/Natural gas

Customer
Grupo SERVTEC Sao Paulo, Brazil

Total output
4 MW_{el}

Commissioning
2013

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CG260-16 References:
AMD, Germany

Since 2006, AMD's cutting-edge "Fab 36" fabrication unit is producing a new generation of microprocessors. The electricity required at the "Fab 36" is produced by nine CG 260-16 natural gas gensets. Without interruptions, Energy Supply Center II is able to deliver 35 MW power, 38 MW heat and cooling for the semiconductor "Fab 36".

Genset/Engine
9 x CG260-16

Segment/Gas type
Trigeneration/Natural gas

Customer
AMD plant in Dresden, Germany

Total output
35.0 MW_{el}

Commissioning
2005 & 2007

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Greenhouse application

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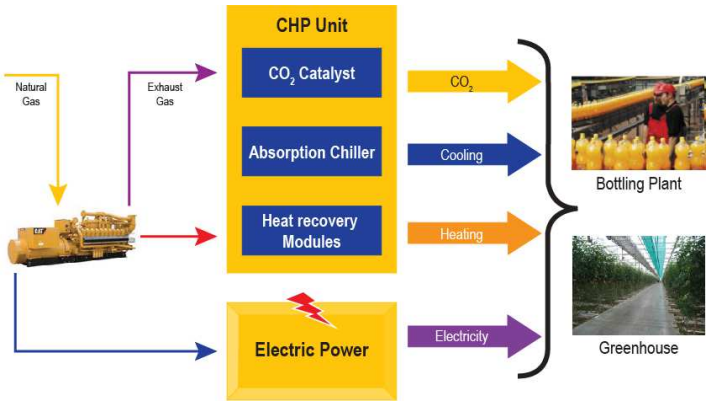
Quad Generation

Power + Hot & Chilled Water + CO_2
for Soda Bottling/ Greenhouses Applications



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Greenhouse Application

- Application:
  - Providing **power**, **illumination**, **heat** and **CO_2-fertilizer** for greenhouses

Plant Layouts
Greenhouse Application

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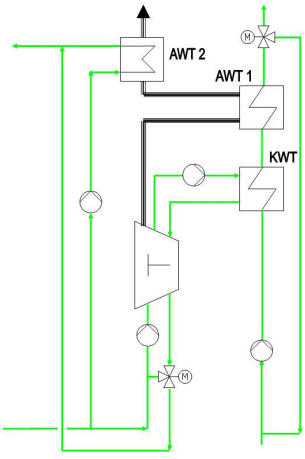
Variant Power Heat Steam



- Use of generated energy to power **lamps** for **assimilation light** and **heat** for plants
- Use of **CO_2** in exhaust gas for **fertilizing** plants
- **30% Production improvement** of greenhouse due to CO_2 fertilizing
- Use of residual **heat in exhaust gas** for **climate control** in greenhouse (besides heating circuit)
- Use of **NT heat** for additional climate control in greenhouses

Plant Layouts
Greenhouse Application

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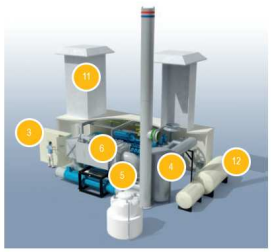
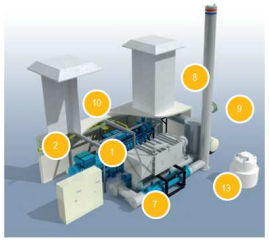
Variant Power Heat Greenhouse – Design Notes

- **Selective catalytic reduction** (SCR) converter needed
- **Size of CHP plant** for fertilizing process:
  - Sweet peppers
    100 Nm³ gas/h/hectare (burned in engine)
  - Tomatoes
    150 Nm³ gas/h/hectare (burned in engine)
- **Size of heat storage** (not displayed in PID):
  - Depending on crop
  - Depending on region
  - Depending on gas and electricity prices
  - Average size: 200 - 400 m³/hectare
- No dump cooling circuit

Plant Layouts
Greenhouse Application

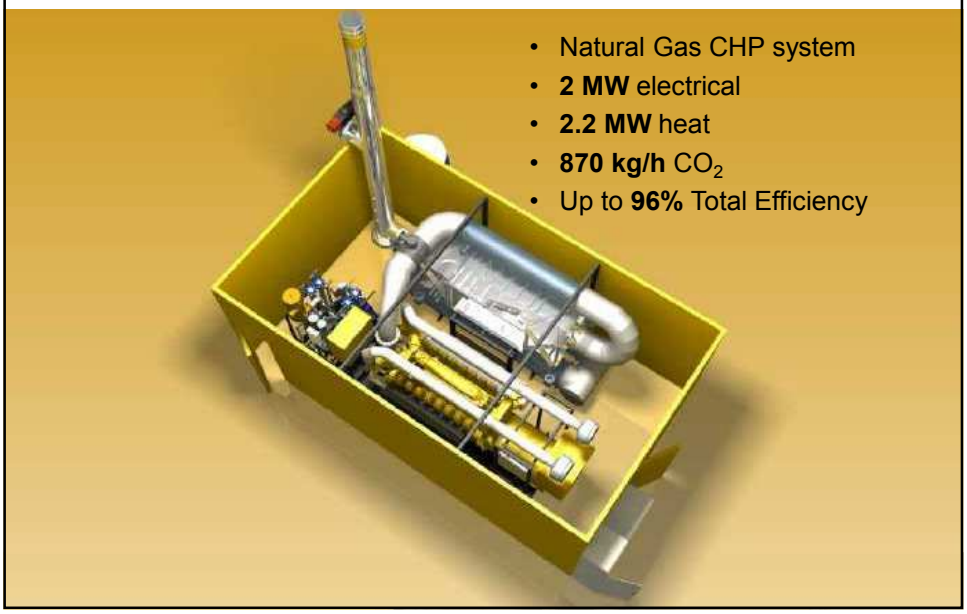
Greenhouse Application





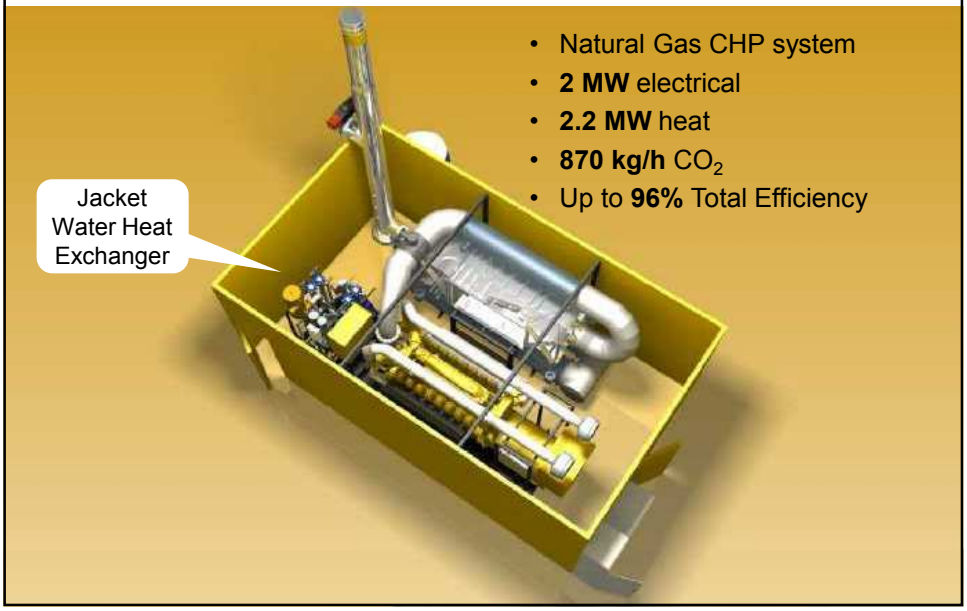
1. Engine
2. Gas train
3. Control panel
4. Silencer
5. Urea injection
6. Exhaust gas purifier
7. Exhaust gas cooler
8. Chimney
9. CO_2 connection
10. Acoustic enclosure
11. Ventilation shaft
12. Oil tanks
13. Urea tanks

Heat Recovery Package From Caterpillar



- Natural Gas CHP system
- **2 MW** electrical
- **2.2 MW** heat
- **870 kg/h** CO_2
- Up to **96%** Total Efficiency

Heat Recovery Package From Caterpillar



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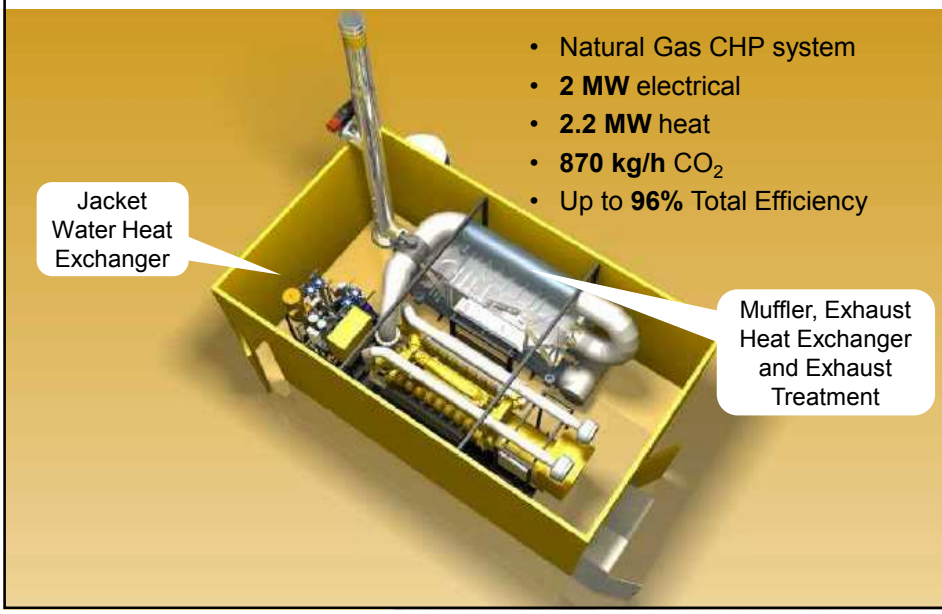
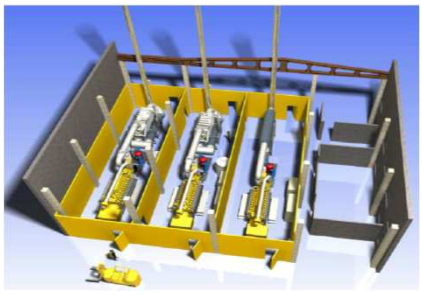
Heat Recovery Package From Caterpillar



- Natural Gas CHP system
- **2 MW** electrical
- **2.2 MW** heat
- **870 kg/h** CO_2
- Up to **96%** Total Efficiency

Heat Recovery In Series

- Using natural gas for heating and lighting 6MW CHP Power plant with CHP + boiler in industrial green houses.



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CG170-12 References:
Ronald Bunnik Bromelia´s, The Netherlands

The greenhouse is powered by 2 units of type CG 170-12 with electricity. The special challenge of this project has been the flexibility of the power. Fluctuating lighting conditions require it to supply the greenhouse with different amounts of electricity.

Genset/Engine
2 x CG170-12

Segment/Gas type
Trigeneration/Natural gas

Customer
Ronald Bunnik Bromelia's, The Netherlands

Total output
2.4 MW_{el}

Commissioning
2009

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Modular Building

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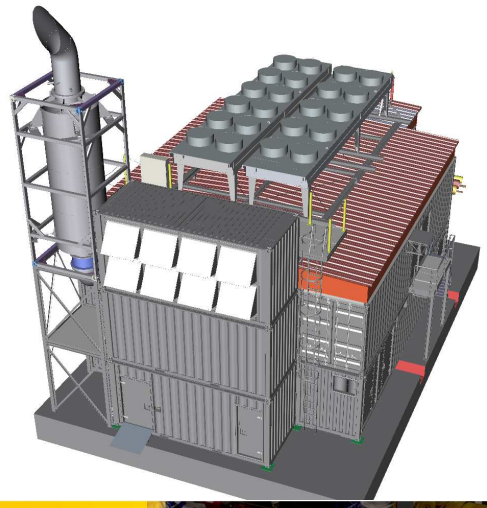
Current Project Status



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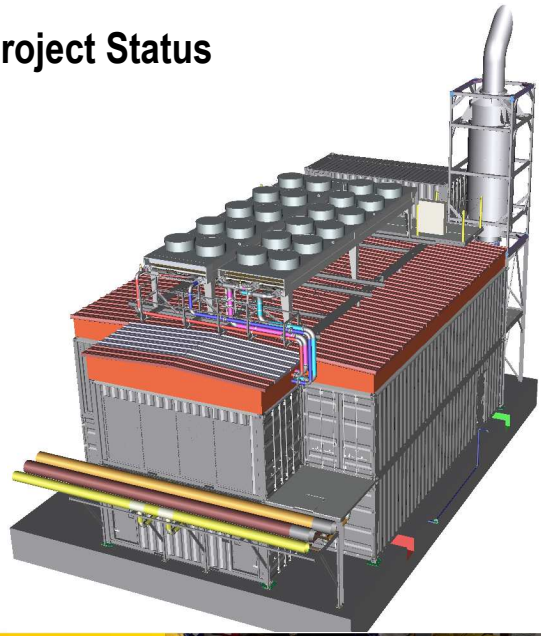
Current Project Status



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Current Project Status

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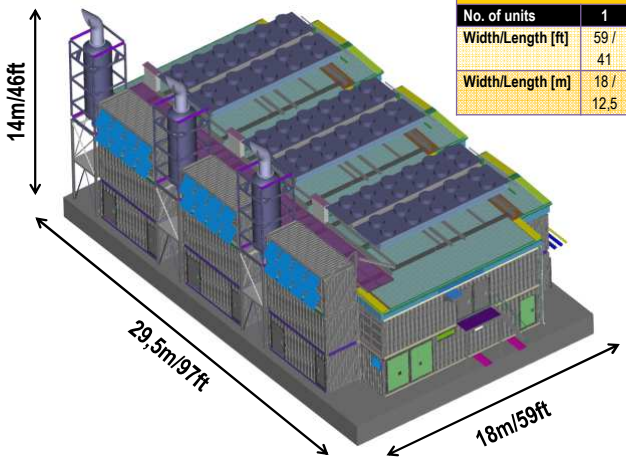
Footprint



Size of foundation						
No. of units	1	2	3	4	5	6
Width/Length [ft]	59 / 41	59 / 69	59 / 97	59 / 125	59 / 153	59 /181
Width/Length [m]	18 / 12,5	18 / 21	18 / 29,5	18 / 38	18 / 46,5	18 / 55

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Final Remarks

- Many ways of doing CHP…
  - CHP can be simple or complex
- Technical & economic feasibility
  - Reduces energy costs
  - Increase efficiency
- Sustainable facilities
  - Reduced GHG emissions
  - LEEDs certification
- Can be a great investment!
  - Backup to your existing installation
  - Improved power quality

Choose to work with a CHP **EXPERT**
with **PROVEN** References **GLOBALLY**

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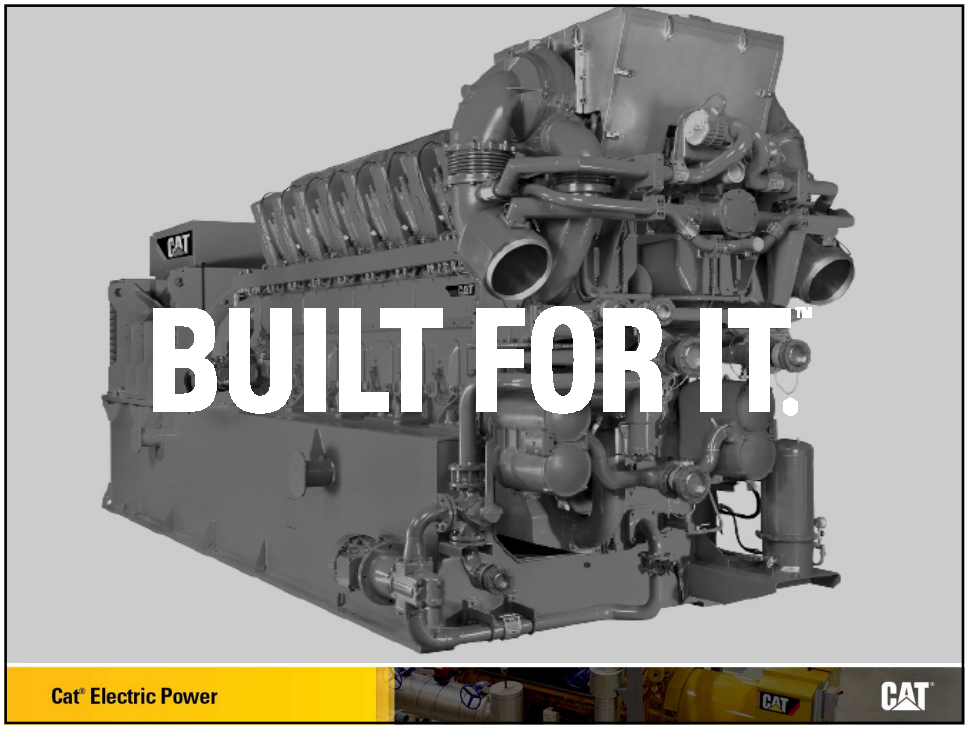

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Questions?

BUILT FOR IT.

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