

GLOBACON 05

HVAC Systems for Cogen

Track 2, Session 2B
Advanced HVAC and Building Systems
Date: March 24th, 2005

Gearoid Foley
President
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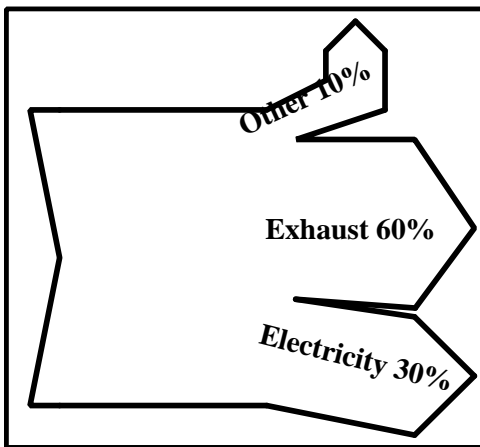
Integrated CHP Systems Corp.



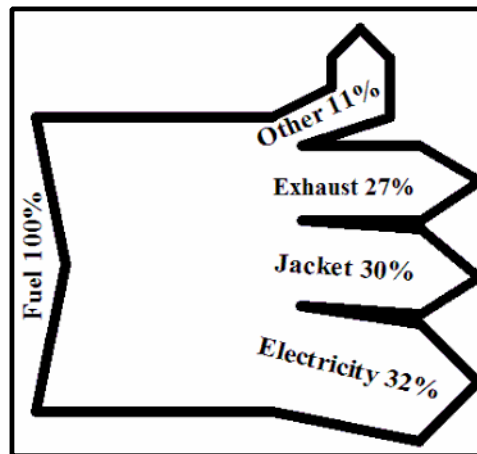
Sankey Diagram

- Generators typically are under 30% electrically efficient (HHV) with 60% of the input being converted to Thermal energy. 10% is losses and parasitics.

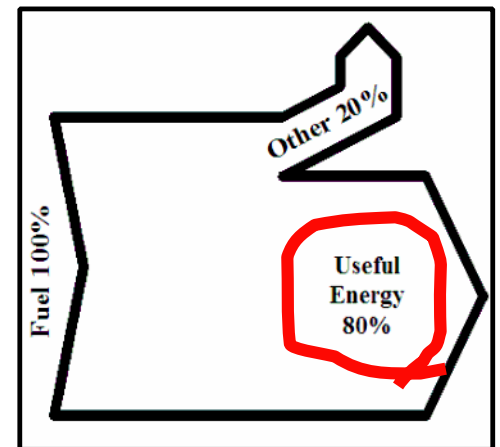
CT Sankey Diagram



ICE Sankey Diagram

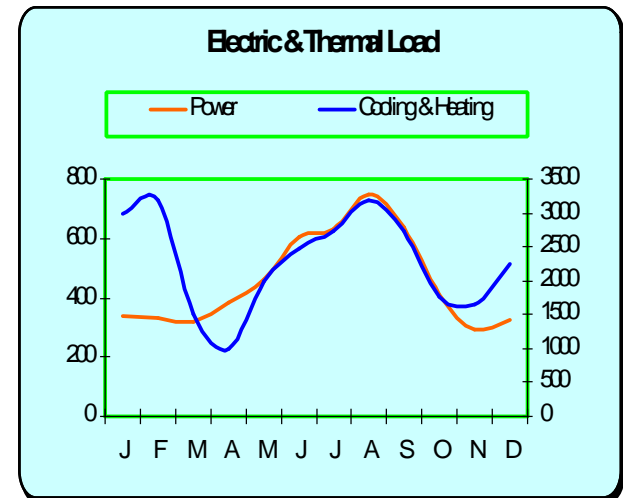


CHP Sankey Diagram



Building Energy Types

- Electrical:
 - 60 Hz, A/C Electricity
- Thermal:
 - Chilled Water
 - Low-Temp Solution
 - Hot Water 140 F to 200 F
 - Low Pressure Steam
 - High Pressure Steam
 - Dehumidification
 - Combination of Types





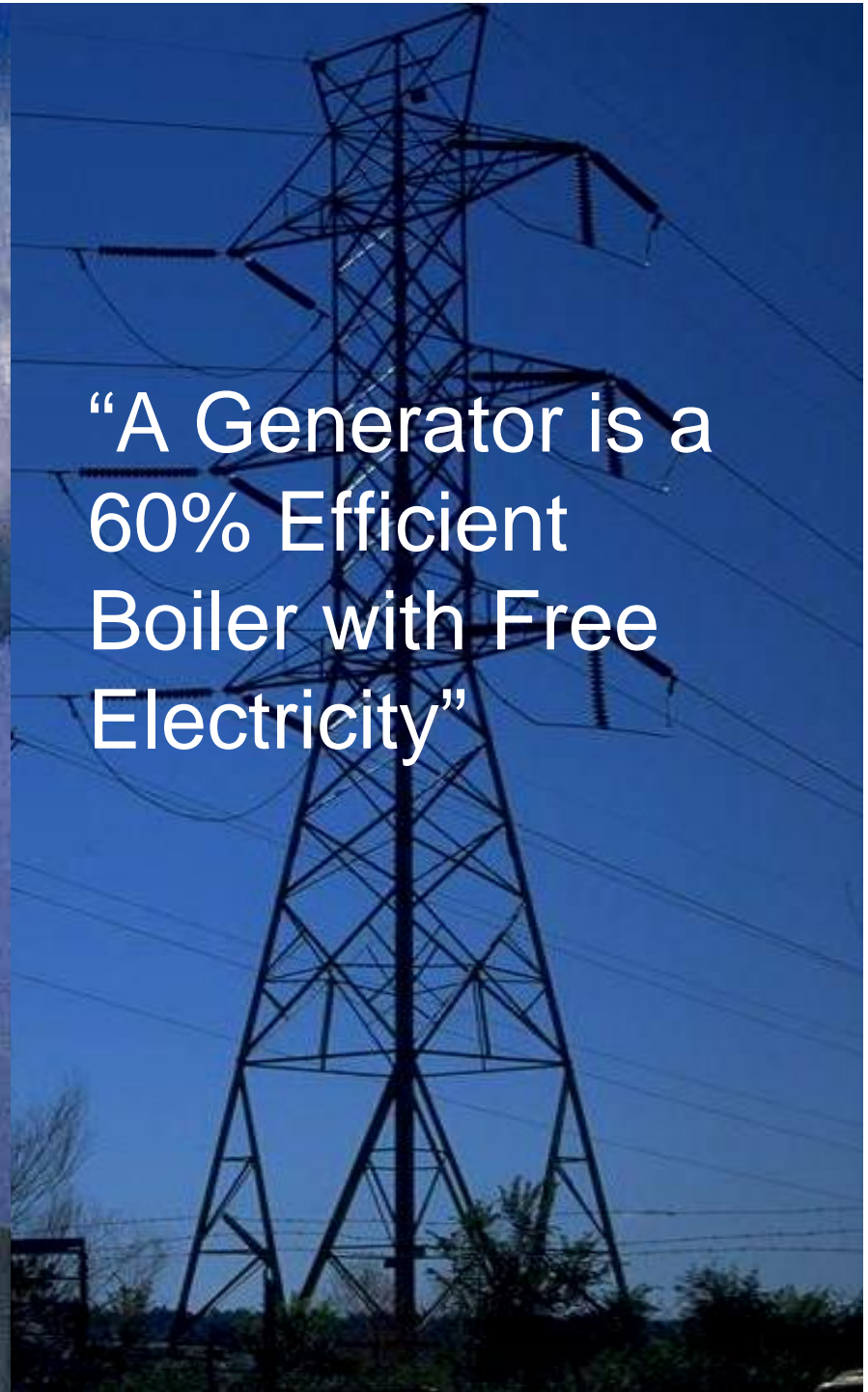
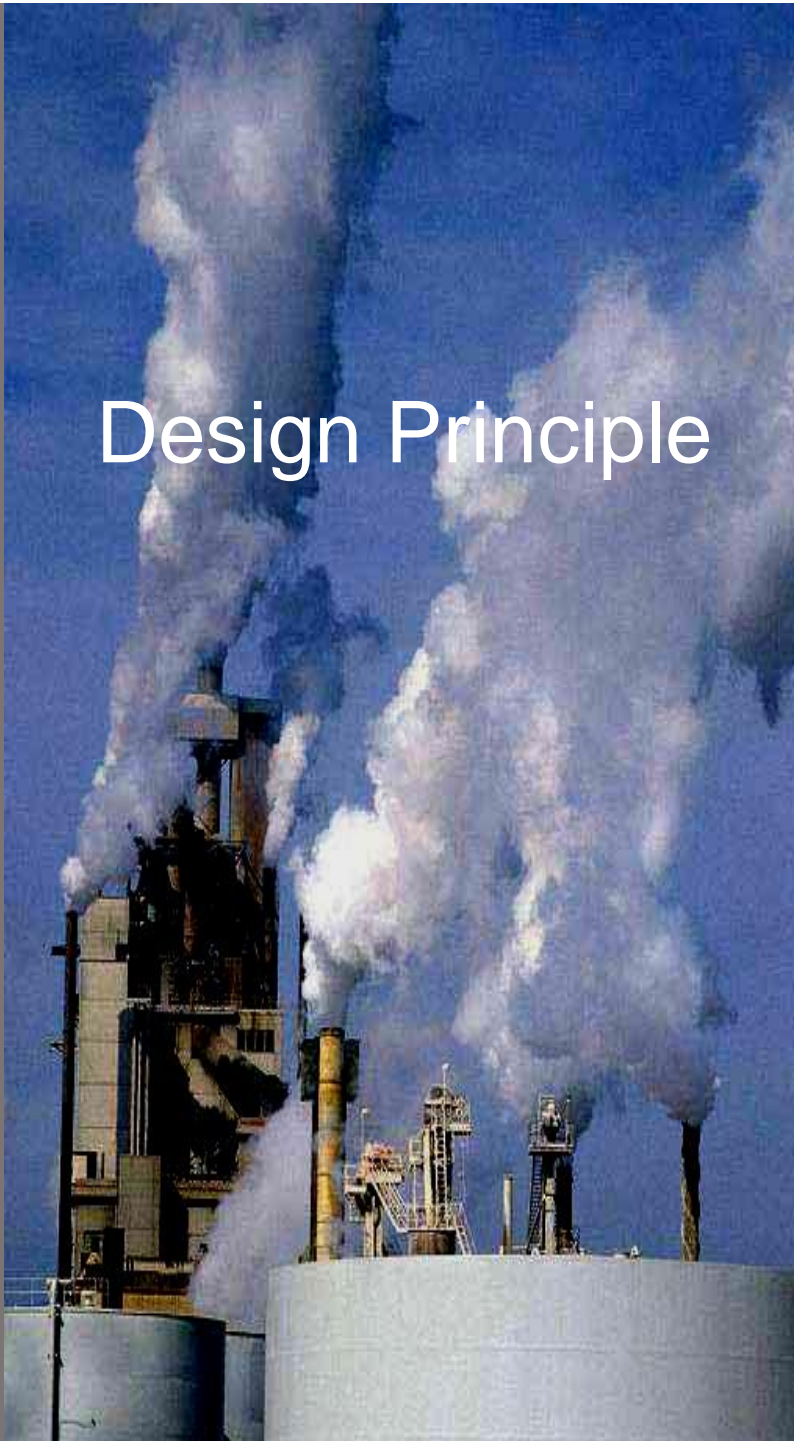
Reverse Engineering

- Thermal Form Varies – Electric Form is Constant
- Conventional Wisdom:
 - Select Generator on Electric Load Basis
 - Select Thermal Technology on Generator Basis
 - Fit Thermal Output to Building
- CHP Wisdom:
 - Select Thermal Technology on Thermal Load Basis
 - Select Generator on Thermal Basis
 - Fit Electric Output to Building



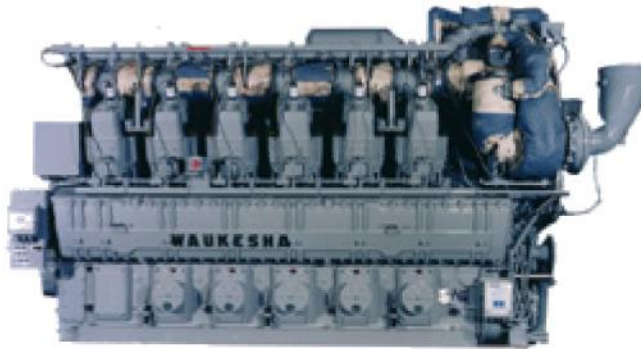
Design Principle

“A Generator is a
60% Efficient
Boiler with Free
Electricity”

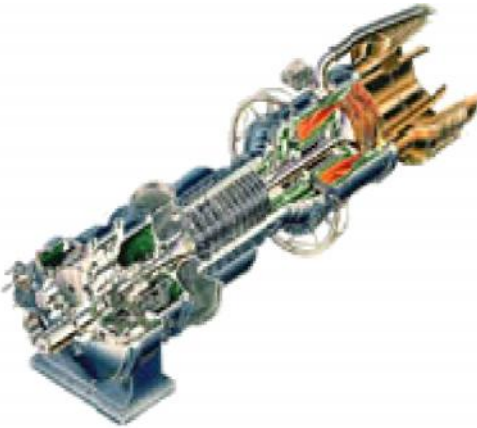




CHP Prime Movers



- Combustion Turbines 0.5 – 5 MW
 - Microturbines 30 – 200 kW
 - IC Engines 30 kW – 3 MW
 - Fuel Cells 200 kW – 1 MW
-
- 75% - 60% HEAT
 - 25% - 40% Electricity





Generator Thermal Output

- Simple Cycle Combustion Turbine:
 - High Volume, High Temp Exhaust (900 – 1000 F)
- Recuperated Microturbine:
 - High Volume, Medium Temp Exhaust (500 – 600 F)
- IC Engine:
 - Low Volume, High Temp Exhaust (900 – 1000)
 - + Hot Water (200 – 220 F)
- Fuel Cell (SOFC):
 - Low Volume, Medium Temp Exhaust (600 – 700 F)



Thermally Activated Technologies

- Technologies:

- Hot Water HEX
- Boilers/Steam Generators
- Absorbers
- Steam Turbines
- Desiccants
- Adsorbers



- Applications:

- Process Heat
- Space Conditioning Heat
- Pool Heat
- Domestic Hot Water
- Cooling
- Freezing
- Dehumidification





Absorption

- **Single Effect:**
 - Low Temperature Activation, 200 F
 - Cost Effective
 - Simple
 - Good Efficiency – 0.65 COP
- **Double Effect:**
 - High Temperature Activation, 350 F
 - Expensive
 - High Efficiency – 1.2 COP



Wide range of models from <100 tons to >1,000 tons

Activated by Steam (15 psi - 125 psi), Hot Water or Exhaust

4 to 5 GPM Condenser Water, Large & Heavy, Slower Response

Steam Turbine Chillers

- High Temperature Activation
- Expensive
- High Pressure Steam System
- High Efficiency



700 to 5,000 Tons

Steam Pressure 90 to 200 psi

Same compressor operation as electric chiller

High FL Efficiency – 1.2 COP, 10 lbs/ton, compact footprint

High PL Efficiency – 1.8 COP

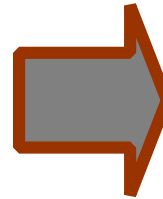
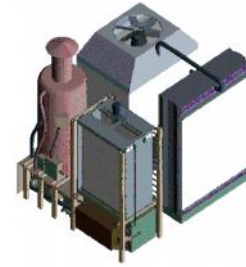
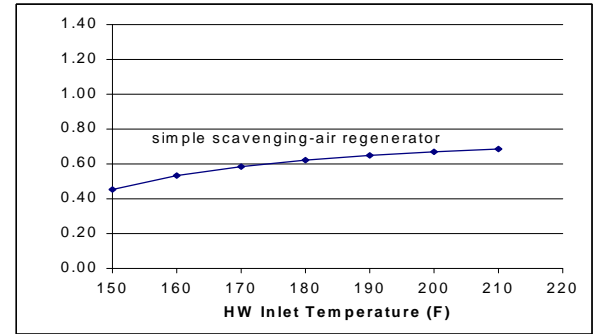
Condenser Water 3 to 4.5 GPM

Steam Condenser Included



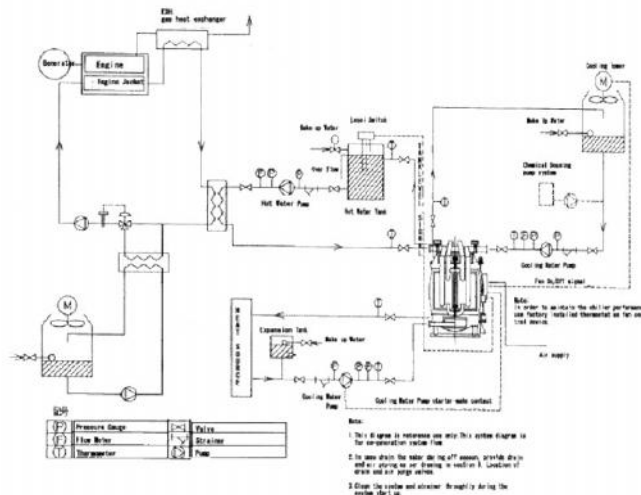
Desiccants

- Low Temperature Activation
 - 1,800 to 2,300 Btu per lb moisture removed
- Liquid Desiccant
 - Compact Size
 - 0.54 COP at 160 F
 - Requires Cooling Tower
- Solid Desiccants
 - Less Expensive
 - 0.5 COP
 - Increases sensible heat



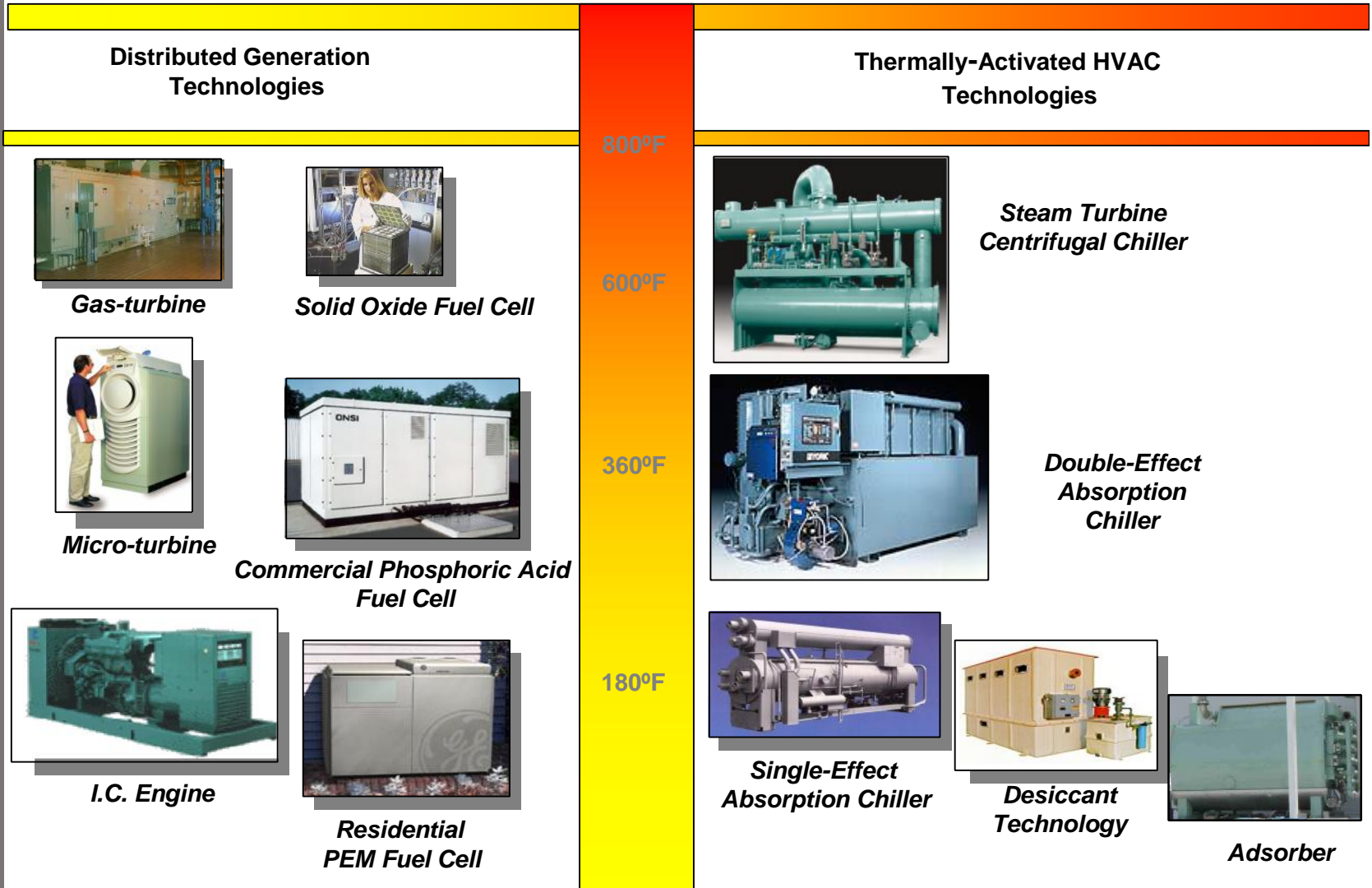
Adsorption

- Low Temperature Activation
- Low Efficiency – 0.5 COP
- Refrigeration
- Large & Very Expensive
- Requires Surge Tanks & Cooling Tower





Thermally-Activated Technologies are Key to Improving Overall Efficiency of DG





CHP Choices & Issues

| Generator | Range | Cooling TAT | Av. Ton/kW |
|---------------------|--------------------|-----------------------------------|-------------------|
| Gas Turbine | > 1 MW | Steam Turbine Absorber | 0.5 - 0.6 |
| Microturbine | < .4 MW | Absorber Desiccant | 0.4 - 0.5 |
| IC Engine | .1 to 3 MW | Absorber Desiccant | 0.3 - 0.4 |
| Fuel Cell | > .25 MW | Absorber | 0.1 - 0.2 |

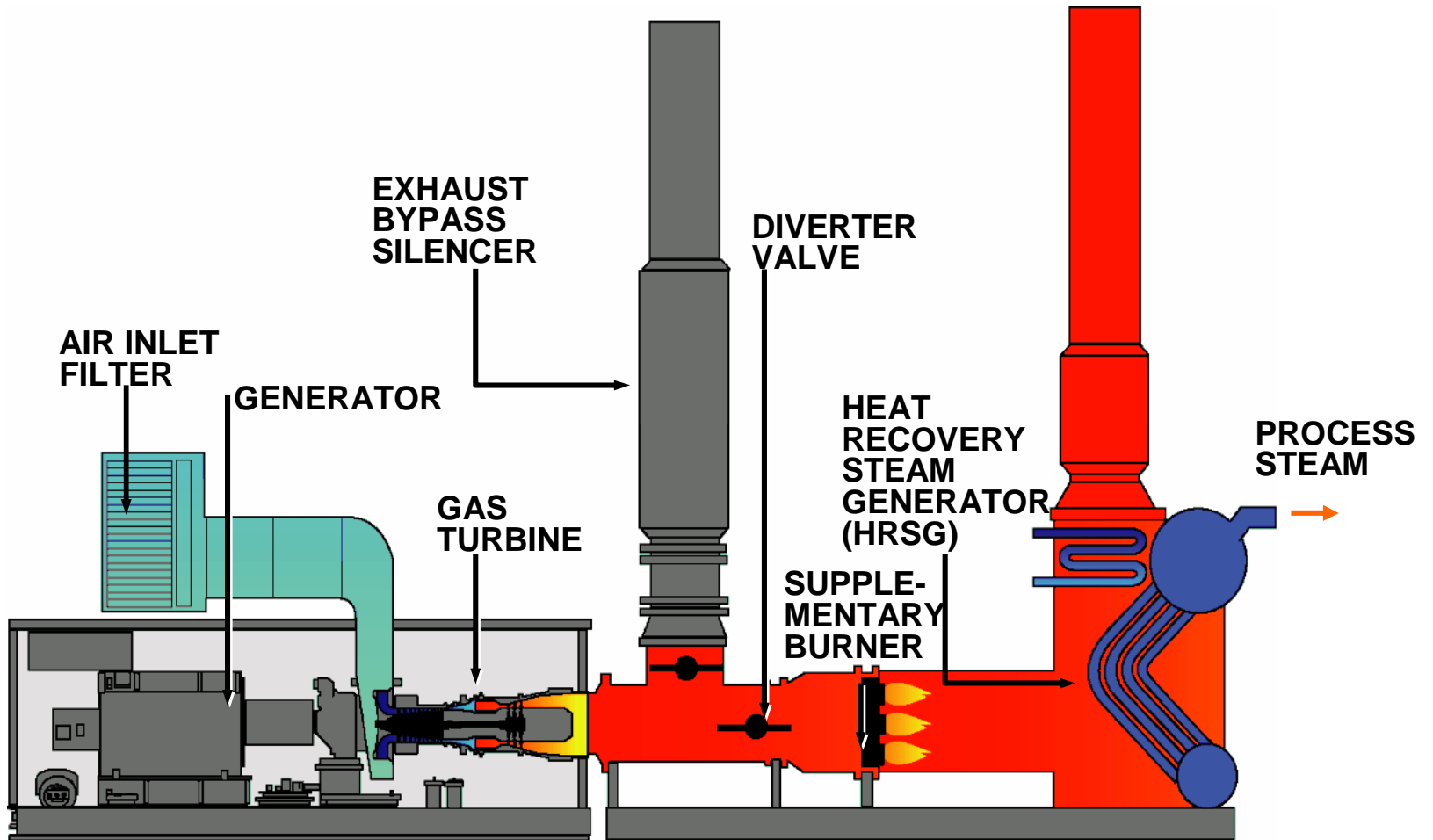


Simple Cycle Combustion Turbine CHP

- High temperature/High volume Flue Gas
- Heat Recovery Steam Generators
- High Pressure Steam
- Co-Firing
- Steam Turbine Chillers
- Steam Fired Absorbers
- Exhaust Fired Absorbers
- Heating & Cooling



CT CHP System



Source: Solar Turbines





CT CHP System

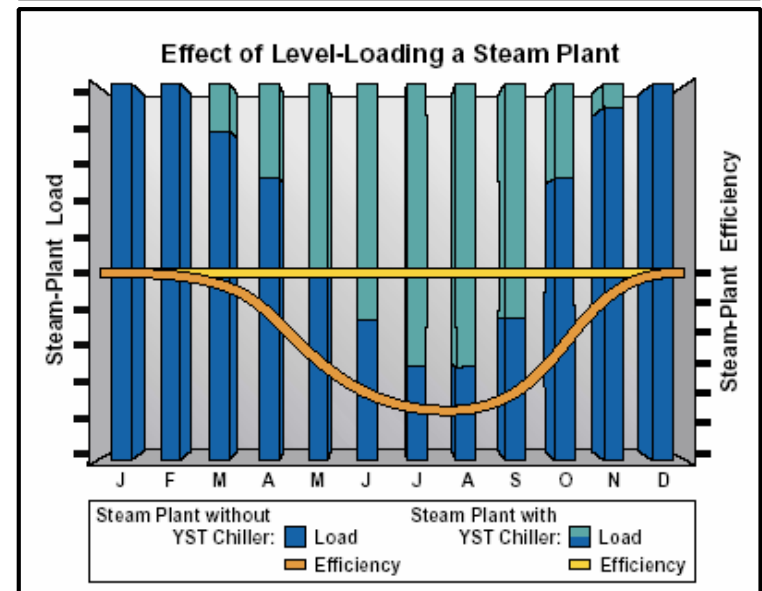
Heat Recovery Steam Generator (HRSG)

- HRSG provides high pressure steam to chillers or heating distribution system.
- Duct firing or co-firing increases thermal capacity and CHP efficiency.
- HRSG with Duct Burner provides variable thermal output.
- Additional cost for additional thermal capacity is minimal.

| | |
|---|---------------|
| Gas Turbine: | |
| KW Gross Output @ 59 F Inlet Air, 500 Ft Ele, 60% RH: | 5,203 KW |
| Total Auxiliary Power Consumption incl Compressor: | 64 KW |
| Net Turbine Power Production: | 5,139 KW |
| HRSG: | |
| Process Steam Pressure: | 150.0 psig |
| Process Steam Temperature: | 366 °F |
| Steam Contributed by Gas Turbine: | 29,367 lb/hr |
| Steam Contributed by Ductburners: | 36,379 lb/hr |
| Deaerator Steam Consumption: | 4,551 lb/hr |
| Boiler Steam Flow: | 65,747 lb/hr |
| Steam Flow to Process: | 61,196 lb/hr |
| Chillers: | |
| Steam Flow to Chiller System: | 61,196 lb/hr |
| Tons of Refrigeration Produced @ 1.2 COP: | 6,120 Tons |
| Cycle Performance (lower heating value basis): | |
| Net Turbine Heat Rate: | 11,670 BTU/KW |
| Gross Plant Heat Rate: | 3,970 BTU/KW |
| Average Cycle Efficiency: | 86.0 % |

CT CHP System

- Steam Driven Centrifugal Chiller
- Level steam production 12 months – cooling in summer and heating in winter.
- High chiller efficiencies at part load with low temp condenser water. IPLV COP = 1.8



Source: YORK International

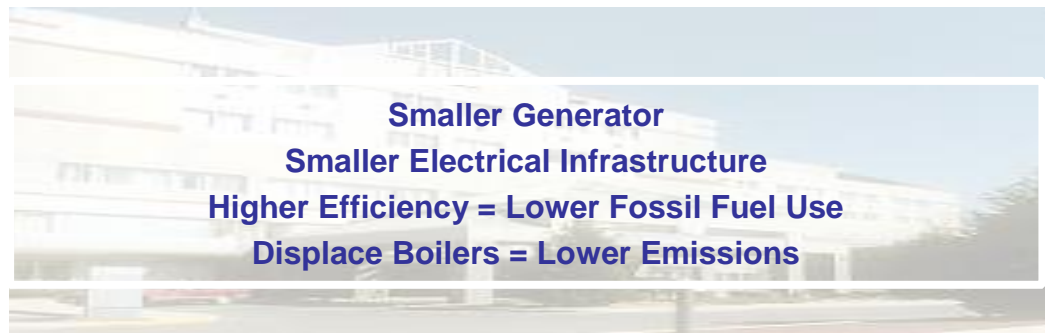




CT CHP System Typical Application

1.25M sq ft Commercial Complex

- Electric based Design
 - -Electric Demand w/ Electric Chillers = 6.2 MW
 - Electric Chiller Load = 25% / 1.55 MW / 2,583 Tons
 - Net Demand w/o Electric Chiller = 5.25 MW
- CHP Design
 - CT Generator Electric Output = 5.25 MW
 - Steam Driven Chiller Output = 2,803 Tons
 - Total Effective Output = 6.2 MW



Microturbine CHP

- Waste Heat Fired eliminates HEX and increases capacity and efficiency
- Capacity and Efficiency vary directly with Waste Heat Temperature
- Co-firing mixes exhaust with gas to supplement unlimited tonnage
- Heating can be provided as well as cooling



Capacity

100%

70%

Single Stage Waste Heat Fired

COP

.7

.6

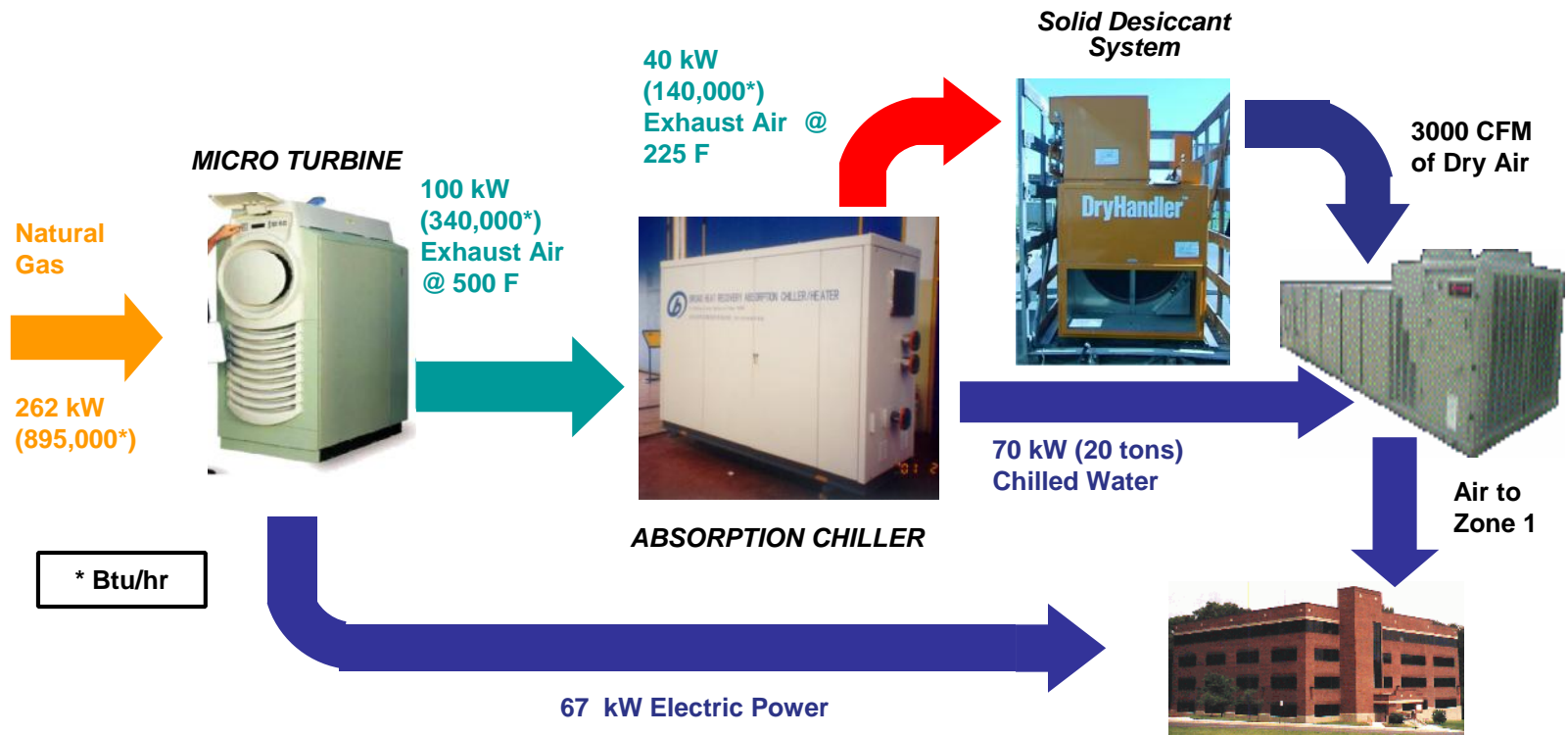
500 F

600F

700 F



UMD CHP System Microturbine/Absorber/Desiccant



Efficiency:

25% generator only

64% with chiller

79% with desiccant

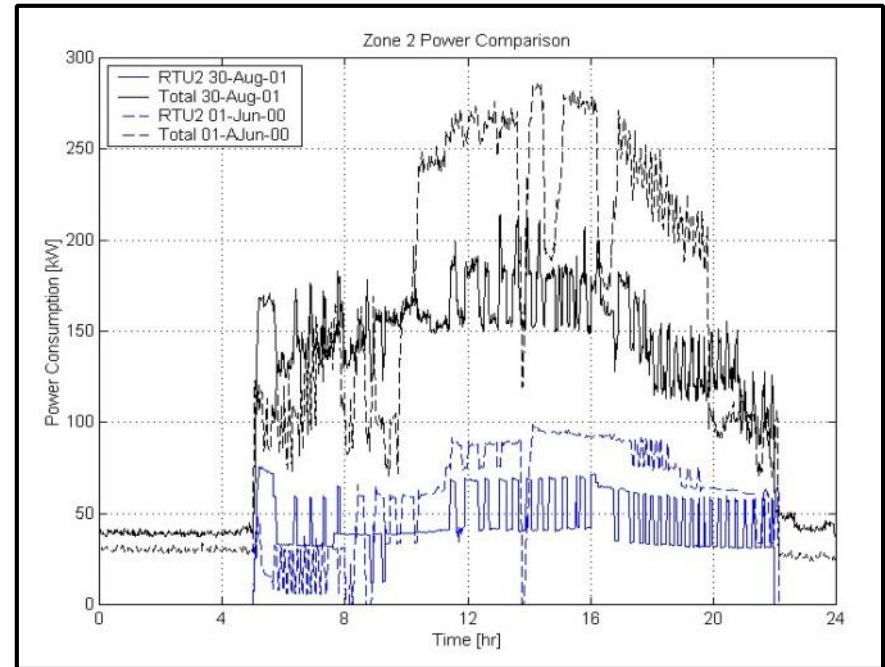




Comparative Effects

Thermal Technologies
Only

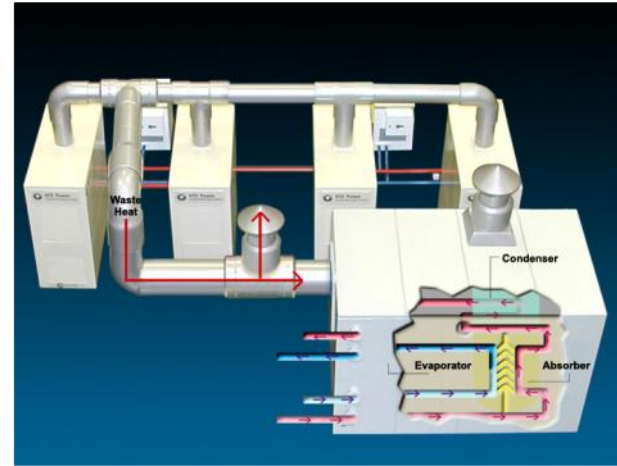
30% Demand Reduction





Microturbine CHP

- **UTC Power/Carrier PureComfort 240'**
 - 240 kW Power @ ISO
 - and 110 tons Cooling
 - Or 900 MBH Heating



Two Stage Exhaust Fired CHP Package



Microturbine CHP

- **Desiccants**
This dehumidification system uses “recovered” thermal energy from a micro-turbine power generator. The combined thermal efficiency is in the high 70’s.



Source: SG America

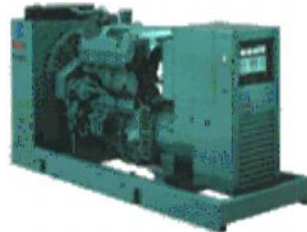


IC Engine CHP

32% Electrical Output,
45% Thermal (jacket & exhaust) HR
18% Exhaust
5% Other

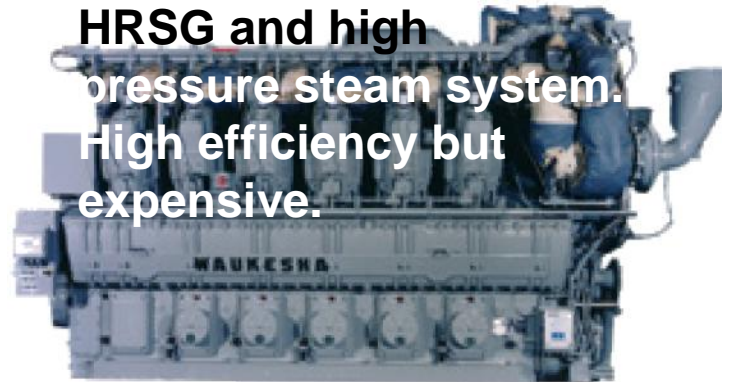
- **< 1 MW IC Engine CHP Design**

- Blend Exhaust Energy into Jacket Loop with HEX
- Single Stage HW Absorber – Simple & Cost Effective



- **> 1 MW IC Engine CHP Design**

- Exhaust Energy provides Medium Pressure Steam (125 psig)
- Jacket Loop provides Hot Water
- Two Stage Steam Absorber – Requires HRSG and high pressure steam system. High efficiency but expensive.



| Output | Low Temp 205/180 F | High Temp 217/192 F |
|---------------------|----------------------------|----------------------------|
| 500 kW IC Engine | 125 Tons (.25 Tons /kW) | 225 Tons (.35 Tons /kW) |



IC Engine CHP

- Engines optimized for cogeneration:
 - Natural Gas Continuous Prime Power
 - High Temperature Coolant System (Return >185 F)
 - Jacket Water HR Included
 - Exhaust HR Included
 - Dump Radiator/HEX
 - Control Connection with Thermal Plant



Source: BluePoint Energy



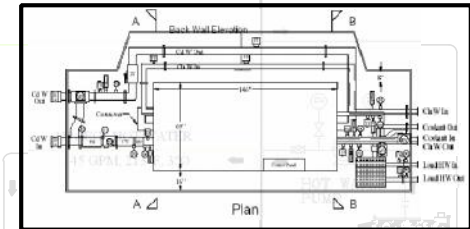
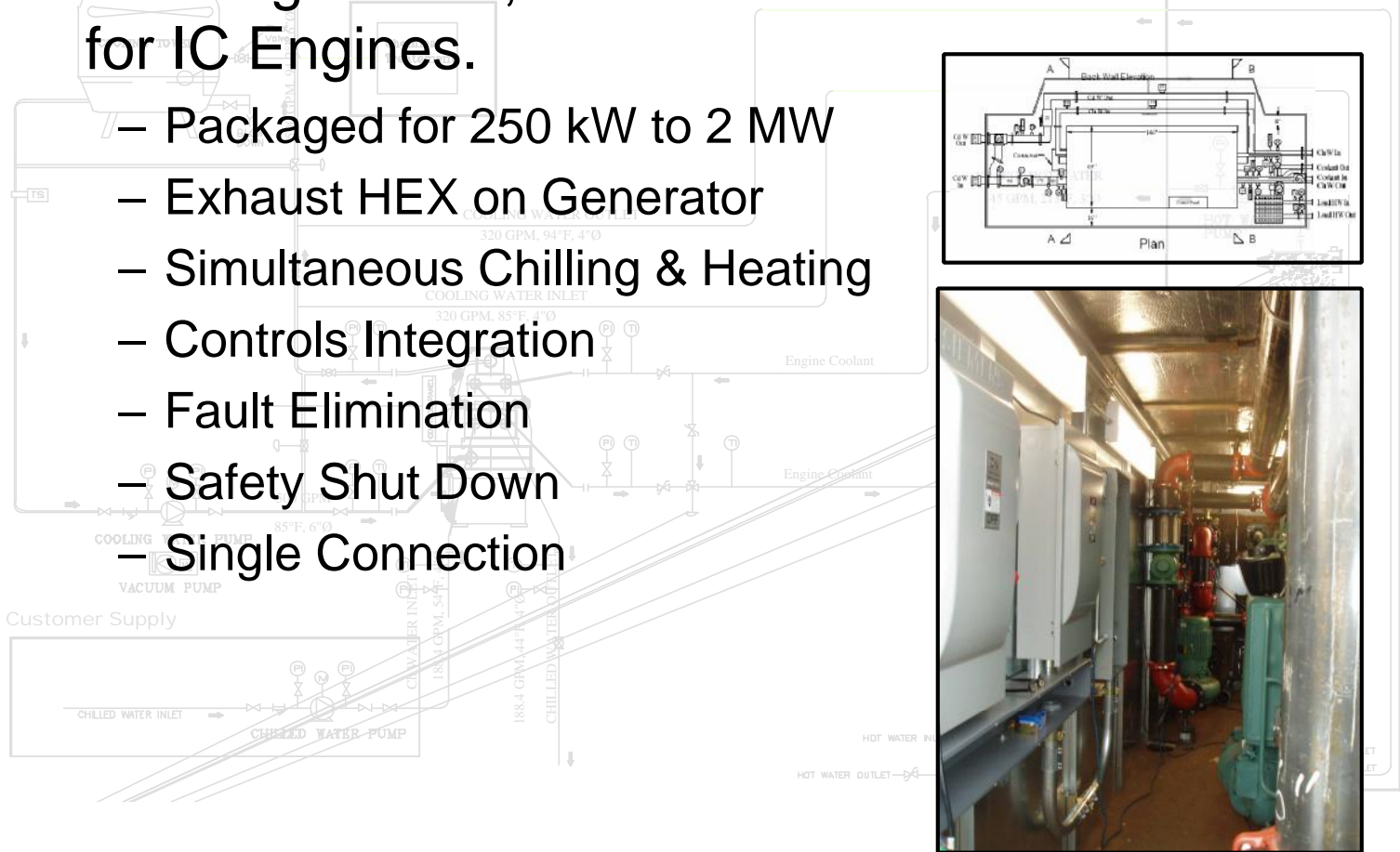
Source: Stewart & Stevenson



IC Engine CHP

- Pre-Engineered, Prefabricated Thermal Plants for IC Engines.

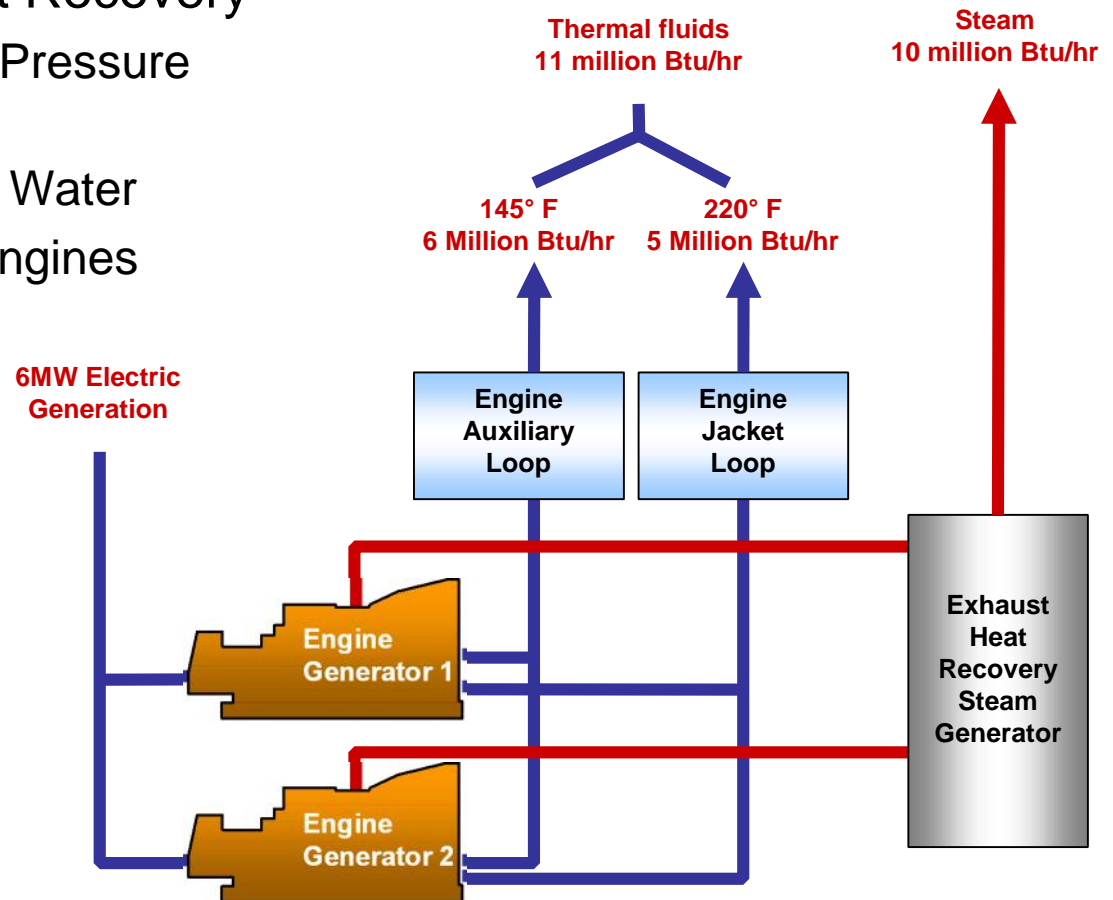
- Packaged for 250 kW to 2 MW
- Exhaust HEX on Generator
- Simultaneous Chilling & Heating
- Controls Integration
- Fault Elimination
- Safety Shut Down
- Single Connection





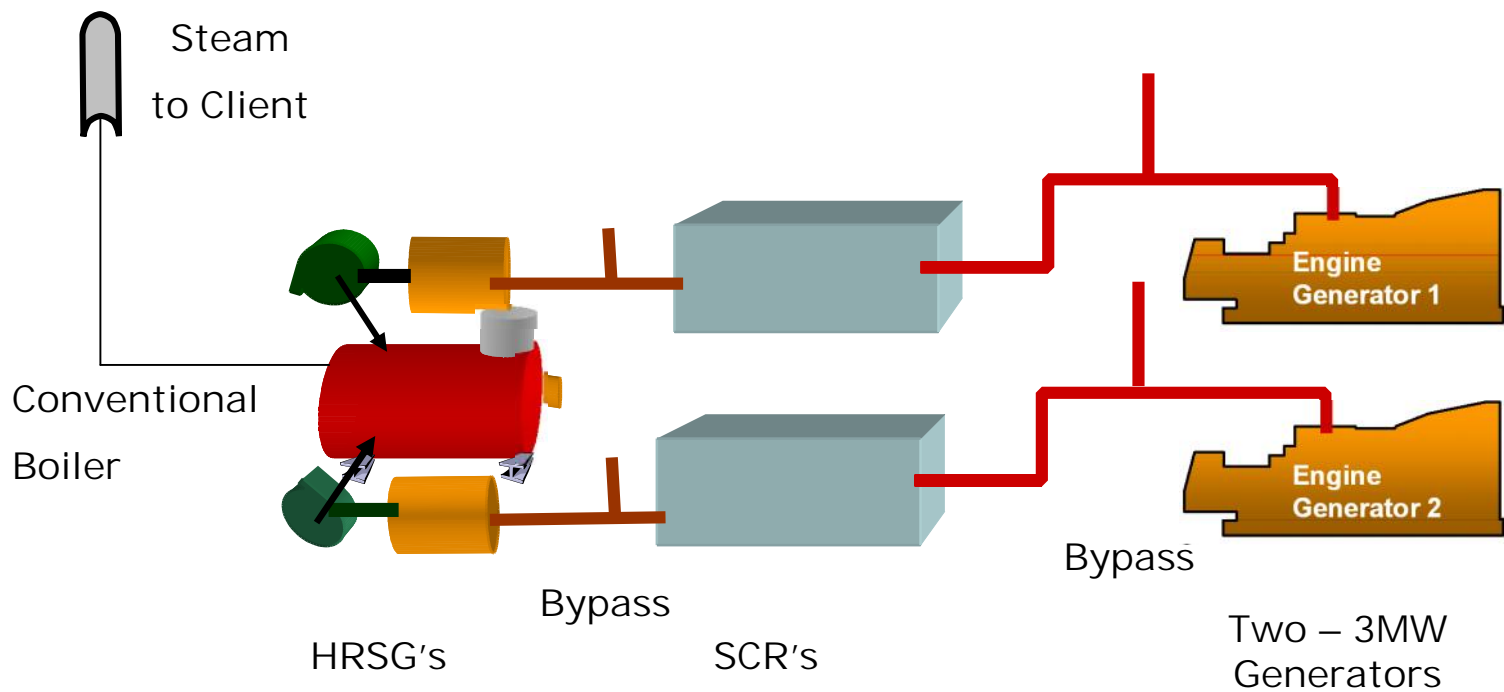
IC Engine CHP

- Separate Jacket and Exhaust Heat Recovery
 - Low/High Pressure Steam
 - 220 F Hot Water
 - 1 + MW Engines



IC Engine CHP

- Exhaust Heat Recovery after SCR.
- With Back-up/Peaking Boiler



GLOBACON 05 HVAC Systems for Cogen

Q & A

Gearoid Foley
President
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