"Energy solutions with 'best in class' gas engine technology"
• Gas engine based CHP and other distributed generation systems
  – 30 – 200 kW with Capstone micro turbines
  – 60 – 500 kW with 2G optimized MAN gas engines
  – 500 – 4400 kW with 2G optimized Jenbacher gas engines

• Operation and Maintenance
  – Parts, Service, Plant operation
  – Cross Canada Service Network

• Emission control technology
  – HUG/Miratech/COdiNOx

• System management
  – Tenergy Services North America

• Balance of Plant Equipment

"Energy solutions with 'best in class' gas engine technology"
### 2012 Delivery Program - 60 Hz - Natural Gas

<table>
<thead>
<tr>
<th>Model</th>
<th>Electrical Output¹</th>
<th>Thermal Output²</th>
<th>Total Output kW</th>
<th>Electrical Efficiency (LHV) %</th>
<th>Thermal Efficiency %</th>
<th>System Efficiency %</th>
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<tbody>
<tr>
<td>2G-CHP-100NG⁴</td>
<td>100</td>
<td>143</td>
<td>243</td>
<td>34.8</td>
<td>49.8</td>
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<td>2G-CHP-160NG⁴</td>
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<td>242</td>
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<td>2G-agenitor 306⁴</td>
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<td>864</td>
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<td>2G-AVUS-500b⁵</td>
<td>633</td>
<td>814</td>
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<td>2G-AVUS-1000a⁵</td>
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<td>2G-AVUS-1000b⁵</td>
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<td>1265</td>
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<td>2G-AVUS-1500b⁵</td>
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<td>GE-JMS612⁶</td>
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<td>GE-JMS616⁶</td>
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<td>GE-JMS620⁶</td>
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<td>3067</td>
<td>6397</td>
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<td>41.7</td>
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<td>GE-JMS624⁶</td>
<td>4375</td>
<td>4515</td>
<td>8890</td>
<td>45.4</td>
<td>46.9</td>
<td>92.3</td>
</tr>
</tbody>
</table>

1) As measured at the generator terminals
2) Exhaust cooled to 120°C
3) Water cooled enclosure
4) Prime mover is MAN gas engine
5) Prime mover is Jenbacher gas engine
6) Greenhouse market only

---

"Energy solutions with 'best in class' gas engine technology"
• Capstone MicroTurbine base systems are available in 30, 65 and 200 kW versions.
Five C200 Power Modules in One Package

"Energy solutions with 'best in class' gas engine technology"
“Energy solutions with 'best in class' gas engine technology”

Agenda

• Introduction to CHP, CCHP and CHeP
• Financial Performance of CHP in today’s Environment
• Technology Options
• Project Examples
Introduction to CHP, CCHP and CHeP
"All Energy Ends Up As Heat"

Generating power and heat close to the thermal load while utilizing thermal storage technologies will maximise fuel efficiencies, minimise harmful emissions and optimise operational flexibility.
CHP systems utilize the waste heat incurred during engine operation to generate overall plant efficiencies of more than 90%.

HE 1: Mixture intercooler
HE 2: Oil heat exchanger
HE 3: Engine jacket water heat exchanger
HE 4: Exhaust gas heat exchanger

"Energy solutions with 'best in class' gas engine technology"
Energy solutions with 'best in class' gas engine technology

Primary energy savings: roughly 40%

\[
\text{Percentage savings} = \left(1 - \frac{2.5}{4.33}\right) \times 100 = 42\%
\]
Typical cogeneration schematic

"Energy solutions with 'best in class' gas engine technology"
Typical heat demand curve

"Energy solutions with 'best in class' gas engine technology"
"Energy solutions with 'best in class' gas engine technology"
Energy solutions with "best in class" gas engine technology

- Multi-engine concept for flexibility in operation
- Target >5,000 operating hours per unit to optimize economical results
- Increased operation time in connection with heat storage tank

"Energy solutions with 'best in class' gas engine technology"
Refrigeration is required for …
• air conditioning (e.g., hotels, conference centers, office buildings)
• industrial processes (e.g., food, chemical, computer industry)

Possibilities for refrigeration:
• Absorption chillers
• Compression-type refrigeration machines

Absorption chiller technology offers the most established and economic solution for reduced emission air conditioning systems.
• Approximately 150 to 170 kW of cold output is required per 1,000 m$^2$ of office space

• **Tons of refrigeration (TR)** is the unit for cold energy:
  - 1 TR(US) = 3.52 kWh
  - 1 TR(metric) = 3.86 kWh

• **Coefficient of performance (COP)** describes the efficiency of an absorption chiller:
  - Hot water chiller: COP between 0.6 and 0.8
  - Double-effect steam chiller: COP between 1.2 and 1.3
Working principle

- Two substances (e.g., water and lithium bromide salt) are separated through the addition of heat (desorption)
- They are then reunited through heat removal (absorption)
- Desorption and absorption at varying pressure conditions in a vacuum range:
  - Desorption: 80 mbar
  - Absorption: 8 mbar
- Water and lithium bromide salt generate chilled water in the temperature range from 6 to 12°C, ammonia and water are used for low temperature chilling down to -60°C
Water (refrigerant) evaporates at 4.5°C due to high vacuum (8 mbar abs.) thus cooling chilled water to 6°C.
Highly concentrated LiBr solution absorbs the evaporated water due to high hygroscopic affinity.
As the LiBr solution becomes diluted by absorption, it must be re-concentrated by means of an outside heat source.
The water vapor is brought back to the liquid phase in the condenser and is again available for the circuit.
Trigeneration: Gas engines in combination with absorption chiller

- Maximum total fuel efficiency
- Elimination of HCFC/CFC refrigerants
- Reduced overall air emissions

"Energy solutions with 'best in class' gas engine technology"
Trigeneration: Gas engines in combination with absorption chiller

"Energy solutions with 'best in class' gas engine technology"
"Energy solutions with 'best in class' gas engine technology"
Technology Options
"Energy solutions with 'best in class' gas engine technology"
The CHP Module

"Energy solutions with 'best in class' gas engine technology"
"Energy solutions with 'best in class' gas engine technology"
Energy solutions with 'best in class' gas engine technology
"Energy solutions with 'best in class' gas engine technology"
"Energy solutions with 'best in class' gas engine technology"
Reduction of:

- Nitrogen oxide (NOx)
- Carbon monoxide (CO)
- Volatile organic compounds (VOCs)
- Hazardous air pollutants (HAPs)
- Particulate Matter
- Sulfur Acids
Over $100M invested in product development

95 U.S. Technology Patents
- Air bearing technology
- One moving part
- No coolants, oils or grease

Flexible and economic technology
- Flexible configuration
- Lightweight & small footprint
- Multi-fuel capability
- Cost competitive positioning

Capstone value proposition
- Low total cost of ownership
- Ultra low emissions
- High reliability
- Minimal scheduled maintenance

"Energy solutions with 'best in class' gas engine technology"
• A low-emission, low maintenance power generation system
• Applications:
  – Paralleled with the grid
  – Stand Alone
  – Standby (not Emergency Standby!)
• Variety of fuel types: both gaseous and liquid

"Energy solutions with 'best in class' gas engine technology"
Key Components

"Energy solutions with 'best in class' gas engine technology"
• Superior annular recuperator design
  – Annular design increases life by reducing thermal stresses
  – Up to 80,000 hour design life
• Heat exchanger, preheats combustion air
• Increases fuel efficiency
  – By more than 50%
  – Highest electrical efficiency under 4.5 MW
Ultra Low Emissions

C200 Meets strict CARB Requirements
• Lean Premix + Passive Exhaust Catalyst
• Much Lower Than Traditional NG Reciprocating Engines

"Energy solutions with 'best in class' gas engine technology"
Minimal Maintenance Requirements

- One Moving Part
- No Lubricants, Antifreeze, Catalytic Converter (non-CARB)
- Air-Cooled System, & Electronics
- No Spark Plugs, Lifters, Admission Valves, Magneto parts, etc.

"Energy solutions with 'best in class' gas engine technology"
Microturbine CHP System

Traditional Approach

- 80% av. boiler efficiency
- 33% av. utility efficiency
- 54% average total efficiency
- 3.4 lb/MWh NOx & 2,320 lb/MWh CO2

Capstone ICHP

- 85% average total efficiency
- 0.15 lb/MWh NOx & 1,540 lb/MWh CO2

Source: EPA and DOE, see notes page for specific references

"Energy solutions with 'best in class' gas engine technology"
Financial Performance of CHP in today’s Environment
CHP Financial Performance - Recip

On-Site Cogeneration

2G Packaged CHP Systems

CHP System Performance

<table>
<thead>
<tr>
<th>Input</th>
<th>2G-KWK-100EG</th>
<th>agenitor 306</th>
<th>2G-KWK-400EG</th>
<th>2G-KWK-633EG</th>
<th>2G-KWK-850EG</th>
<th>2G-KWK-1135EG</th>
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<tr>
<td>Gas cost ($/GJ):</td>
<td>$5.00</td>
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<td></td>
<td></td>
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<tr>
<td>Electricity cost ($/kWh):</td>
<td>$0.12</td>
<td></td>
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<tr>
<td>Annual operating hours:</td>
<td>8,300</td>
<td></td>
<td></td>
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<td>Heat utilization factor:</td>
<td>90%</td>
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<tr>
<td>Boiler efficiency:</td>
<td>80%</td>
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<td>Installation cost factor:</td>
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<tr>
<td>Exchange rate (Euro/CAD):</td>
<td>1.32</td>
<td></td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>2G Gas Engine CHP</th>
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<th></th>
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<th></th>
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<tbody>
<tr>
<td>Power output (kW):</td>
<td>100</td>
<td>250</td>
<td>400</td>
<td>633</td>
<td>850</td>
<td>1135</td>
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<tr>
<td>Thermal output (kW):</td>
<td>151</td>
<td>294</td>
<td>556</td>
<td>814</td>
<td>980</td>
<td>1305</td>
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<tr>
<td>Fuel input - LHV (kW):</td>
<td>287</td>
<td>633</td>
<td>1,076</td>
<td>1,663</td>
<td>2,096</td>
<td>2,791</td>
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<td>Thermal output (btu/hr):</td>
<td>515,692</td>
<td>1,004,063</td>
<td>1,898,840</td>
<td>2,779,956</td>
<td>3,346,875</td>
<td>4,456,809</td>
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<td>Fuel input - HHV (GJ/hr):</td>
<td>1.14</td>
<td>2.51</td>
<td>4.26</td>
<td>6.59</td>
<td>8.30</td>
<td>11.05</td>
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<tr>
<td>Equipment cost (indoor/outdoor enclosure):</td>
<td>$188,571</td>
<td>$330,000</td>
<td>$400,714</td>
<td>$707,143</td>
<td>$952,286</td>
<td>$1,084,286</td>
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<td>Installation cost (est.):</td>
<td>$225,000</td>
<td>$525,000</td>
<td>$675,000</td>
<td>$825,000</td>
<td>$900,000</td>
<td>$975,000</td>
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<tr>
<td>Total project cost (est.):</td>
<td>$413,571</td>
<td>$855,000</td>
<td>$1,075,714</td>
<td>$1,532,143</td>
<td>$1,852,286</td>
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<tr>
<td>Fuel cost ($/hr):</td>
<td>$5.68</td>
<td>$12.53</td>
<td>$21.30</td>
<td>$32.93</td>
<td>$41.50</td>
<td>$55.26</td>
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<tr>
<td>Thermal benefit from heat recovery ($/hr):</td>
<td>$3.06</td>
<td>$5.95</td>
<td>$11.26</td>
<td>$16.48</td>
<td>$19.85</td>
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<td>Maintenance cost ($/hr):</td>
<td>$4.25</td>
<td>$5.49</td>
<td>$7.95</td>
<td>$9.26</td>
<td>$12.96</td>
<td>$16.09</td>
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<td>Net cost per hr:</td>
<td>$6.87</td>
<td>$12.07</td>
<td>$18.00</td>
<td>$25.70</td>
<td>$34.62</td>
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<tr>
<td>Net cost per kWh:</td>
<td><strong>$0.069</strong></td>
<td><strong>$0.048</strong></td>
<td><strong>$0.045</strong></td>
<td><strong>$0.041</strong></td>
<td><strong>$0.041</strong></td>
<td><strong>$0.040</strong></td>
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<td>Simple payback (yr):</td>
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<td>5.75</td>
<td>4.32</td>
<td>3.67</td>
<td>3.31</td>
<td>2.72</td>
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</table>

Notes:
- Equipment cost is subject to exchange rate adjustment
- Installation cost will vary, depending on site conditions and utility interconnection requirements
- Maintenance costs include preventive and corrective maintenance
- Maintenance costs can vary depending on site access and site specific requirements

"Energy solutions with 'best in class' gas engine technology"
Energy solutions with 'best in class' gas engine technology

CHP Financial Performance

Microturbine

On-Site Cogeneration

Capstone Microturbine

CHP System Performance

<table>
<thead>
<tr>
<th>Capstone Microturbine CHP</th>
<th>C65</th>
<th>C200</th>
<th>C400</th>
<th>C600</th>
<th>C800</th>
<th>C1000</th>
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<tbody>
<tr>
<td>Power output (kW):</td>
<td>65</td>
<td>200</td>
<td>400</td>
<td>600</td>
<td>800</td>
<td>1000</td>
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<tr>
<td>Thermal output (kW):</td>
<td>120</td>
<td>303</td>
<td>606</td>
<td>909</td>
<td>1212</td>
<td>1515</td>
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<tr>
<td>Fuel input - LHV (kW):</td>
<td>224</td>
<td>606</td>
<td>1212</td>
<td>1818</td>
<td>2424</td>
<td>3030</td>
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<tr>
<td>Thermal output (btu/hr):</td>
<td>409,821</td>
<td>1,034,799</td>
<td>2,069,598</td>
<td>3,104,398</td>
<td>4,139,197</td>
<td>5,173,996</td>
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<tr>
<td>Fuel input - HHV (GJ/hr):</td>
<td>0.89</td>
<td>2.40</td>
<td>4.80</td>
<td>7.20</td>
<td>9.60</td>
<td>12.00</td>
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<td>Equipment cost (indoor/outdoor enclosure):</td>
<td>$137,255</td>
<td>$392,157</td>
<td>$754,902</td>
<td>$1,009,804</td>
<td>$1,225,490</td>
<td>$1,450,980</td>
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<td>Installation cost (est.):</td>
<td>$150,000</td>
<td>$300,000</td>
<td>$450,000</td>
<td>$600,000</td>
<td>$600,000</td>
<td>$600,000</td>
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<tr>
<td>Total project cost (est.):</td>
<td>$287,255</td>
<td>$692,157</td>
<td>$1,204,902</td>
<td>$1,609,804</td>
<td>$1,825,490</td>
<td>$2,050,980</td>
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<tr>
<td>Fuel cost ($/hr):</td>
<td>$4.44</td>
<td>$12.00</td>
<td>$24.00</td>
<td>$36.00</td>
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<td>$59.99</td>
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<tr>
<td>Thermal benefit from heat recovery ($/hr):</td>
<td>$2.43</td>
<td>$6.14</td>
<td>$12.27</td>
<td>$18.41</td>
<td>$24.54</td>
<td>$30.68</td>
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<td>Maintenance cost ($/hr):</td>
<td>$0.96</td>
<td>$3.59</td>
<td>$7.01</td>
<td>$10.29</td>
<td>$13.53</td>
<td>$16.67</td>
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<td>Net cost per hr:</td>
<td>$2.97</td>
<td>$9.45</td>
<td>$18.74</td>
<td>$27.88</td>
<td>$36.98</td>
<td>$45.98</td>
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<tr>
<td><strong>Net cost per kWh:</strong></td>
<td><strong>$0.046</strong></td>
<td><strong>$0.047</strong></td>
<td><strong>$0.047</strong></td>
<td><strong>$0.046</strong></td>
<td><strong>$0.046</strong></td>
<td><strong>$0.046</strong></td>
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<tr>
<td>Simple payback (yr):</td>
<td>6.99</td>
<td>5.60</td>
<td>4.84</td>
<td>4.29</td>
<td>3.64</td>
<td>3.26</td>
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</tbody>
</table>

Notes:
- Equipment cost is subject to exchange rate adjustment
- Installation cost will vary, depending on site conditions and utility interconnection requirements
- Maintenance costs include preventive and corrective maintenance
- Maintenance costs can vary depending on site access and site specific requirements

"Energy solutions with 'best in class' gas engine technology"
"Energy solutions with 'best in class' gas engine technology"
Project Examples

"Energy solutions with 'best in class' gas engine technology"
A PureComfort® solution featuring four C60 Capstone microturbines provide cooling, heating, and power for this supermarket in New York state.
A PureComfort® 240M solution featuring four C60 Capstone microturbines provide cooling, heating, and onsite power to East Hartford High School in Connecticut.

"Energy solutions with 'best in class' gas engine technology"
Ten C65 Capstone microturbines provide electricity and heating to a 44,520 m² apartment complex in South Korea.

"Energy solutions with 'best in class' gas engine technology"
Sixteen Capstone C60 microturbines running on natural gas provide electricity for the Air Force One Pavillion at the Ronald Reagan Presidential Library in Simi Valley, California.

"Energy solutions with 'best in class' gas engine technology"
Four C60 Capstone microturbines provide cooling, heating, and power to the prestigious Ritz-Carlton hotel in San Francisco, California.

"Energy solutions with 'best in class' gas engine technology"
Twelve roof-top mounted Capstone microturbines provide electricity and heating for the 35-story office tower at Avenue of the Americas in Manhattan, New York.
Sobeys Distribution Centre in Vaughan - 2400 kW

Project Details:
• Natural gas fuelled generator that provides emergency power as well as peak shaving.
• Project was possible due to change of CSA282 – the code that governs Emergency Power
• Primary Fuel: Natural Gas (No diesel fuel on site!)
• Electrical Output: 2400 kW
• System Efficiency: 42%
• In Service Date: 2008
• Owner: Sobeys
• Location: Vaughan, Ontario

"Energy solutions with 'best in class' gas engine technology"
Queensway Carleton Hospital - 1000 kW CHP Project

Project Details:
- CHP system provides power and heating (hot water & steam).
- Project met investment criteria for energy efficiency improvements.
- Primary Fuel: Natural Gas
- Back-up Fuel: Propane
- Electrical Output: 1000 kW
- Thermal Output: 4.2 Mbtu
- System Efficiency: 88%
- In Service Date: 2004
- Owner: Queensway Carleton Hospital
- Location: Ottawa

"Energy solutions with 'best in class' gas engine technology"
Project Details:

- CHP system provides power, heating and emergency standby power (no diesel on site!)
- Made possible by changes to CSA282 and capital cost contribution by NRCan
- Fuel: Natural Gas
- Electrical Output: 335 kW
- Thermal Output: 1.4 Mbtu
- System Efficiency: 83%
- In Service Date: 2007
- Owner: Villa Charities
- Location: Vaughan

"Energy solutions with 'best in class' gas engine technology"
Project Details:

- CHP system provides power, heating and emergency standby power (no diesel on site!)
- Made possible by changes to CSA282 and capital cost contribution by NRCan
- Fuel: Natural Gas
- Electrical Output: 335 kW
- Thermal Output: 1.4 Mbtu
- System Efficiency: 83%
- In Service Date: 2009
- Owner: Toronto Community Housing Corporation
- Location: Toronto
Ontario Police College - 848 kW Tri-Generation Project

Project Details:

- CHP system provides power heating and cooling and includes SCR system for ultra low emissions
- ORC mandate to meet efficiency improvement standards
- Fuel: Natural Gas
- Electrical Output: 848 kW
- Thermal Output: 3.7 Mbtu
- System Efficiency: 87%
- In Service Date: 2007
- Owner: Ontario Realty Corporation
- Location: Aylmer
Soave Hydroponics – 12 MW CHP Project with CO2 Fertilization

Project Details:

- CHP system provides power, heating power and CO2
- Was offered in response to CHP RFP
- Electrical Output: 12 MW
- Thermal Output: 49.2 Mbtu
- System Efficiency: 93%
- In Service Date: 2008
- Owner: Soave Hydroponics
- Location: Kingsville

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