Combined Heat and Power In the USA*

8% of Generating Capacity and 12% of MWh Generated and Growing

Presentation Today

• CHP technology evolution
• Why should utilities care?
• The CHP market in Florida
• Utility opportunities
  – New business models and rate designs
  – Compliance with the proposed Clean Power Plant rule

A Very Simple CHP Example

• Prime movers:
  – Reciprocating engines
  – Combustion turbines
  – Steam turbines

• CHP Makes:
  – Electricity
  – Cold water
    • Absorption or turbine chillers
  – Steam
  – Hot water

Exhaust – high temperature for steam
Jacket – close to boiling (absorption chiller)
Thermal manifold – blend to suit
CHP Can Be Much More Efficient Than Combined Cycle

CHP Used to Only Be Available As Custom Designed and Site Built

- System Integration
  - Prime over
  - Heat recovery
  - Parallel switchgear
  - Thermal manifold
  - Steam generator
  - Chillers
  - Diverters
  - Cooling
  - Monitoring
- On-site assembly
- Commissioning and testing
- Best suited for large industrial applications

Example: Gas CT to HRSG turbine to steam turbine centrifugal chiller
Evolution - Now Plug and Play!
Smaller Packages, Factory Tested and Less Expensive

Then: Industrial scale, custom design, lengthy onsite commissioning and testing

Now: Commercial, institutional scale and residential scale, skid mounted sound enclosures, absorption chillers down to 5 tons, water and air cooled
Why Should Utilities Care?

• Customers Like It
  – Reduces energy costs
  – Improves reliability
    • Keeps running during blackouts, hurricanes
  – Price stability

• Utility problems and opportunities
  – Lost revenue potential
  – Low cost additional generation capacity
  – T&D congestion relief
  – EPA Clean Power Plant rule compliance
    • Better than PV in several ways...
## 700% More CO2 Reduction Per Dollar And Less Intermittency Than Solar PV!

<table>
<thead>
<tr>
<th>Category</th>
<th>10 MW CHP</th>
<th>10 MW PV</th>
<th>10 MW Wind</th>
<th>Combined Cycle (10 MV Portion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Capacity Factor</td>
<td>85%</td>
<td>22%</td>
<td>34%</td>
<td>70%</td>
</tr>
<tr>
<td>Annual Electricity</td>
<td>74,446 MWh</td>
<td>19,272 MWh</td>
<td>29,784 MWh</td>
<td>61,320 MWh</td>
</tr>
<tr>
<td>Annual Useful Heat</td>
<td>103,417 MWh</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Footprint Required</td>
<td>6,000 sq ft</td>
<td>1,740,000 sq ft</td>
<td>76,000 sq ft</td>
<td>N/A</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>$20 million</td>
<td>$60.5 million</td>
<td>$24.4 million</td>
<td>$10 million</td>
</tr>
<tr>
<td>Annual Energy Savings</td>
<td>308,100 MMBtu</td>
<td>196,462 MMBtu</td>
<td>303,623 MMBtu</td>
<td>154,649 MMBtu</td>
</tr>
<tr>
<td>Annual CO2 Savings</td>
<td>42,751 Tons</td>
<td>17,887 Tons</td>
<td>27,644 Tons</td>
<td>28,172 Tons</td>
</tr>
<tr>
<td>Annual NOx Savings</td>
<td>59.4 Tons</td>
<td>16.2 Tons</td>
<td>24.9 Tons</td>
<td>39.3 Tons</td>
</tr>
</tbody>
</table>

Existing CHP Capacity in Florida
(Mid 2013)

<table>
<thead>
<tr>
<th>Prime Mover</th>
<th>Sites</th>
<th>Capacity (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiler/Steam Turbine</td>
<td>28</td>
<td>1,766,710</td>
</tr>
<tr>
<td>Combined Cycle</td>
<td>8</td>
<td>1,083,000</td>
</tr>
<tr>
<td>Combustion Turbine</td>
<td>13</td>
<td>291,445</td>
</tr>
<tr>
<td>Waste Heat to Power</td>
<td>5</td>
<td>183,206</td>
</tr>
<tr>
<td>Reciprocating Engine</td>
<td>15</td>
<td>55,205</td>
</tr>
<tr>
<td>Microturbine</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>Fuel Cell</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>70</strong></td>
<td><strong>3,379,626</strong></td>
</tr>
</tbody>
</table>

Florida’s CHP Technical Potential
7.6 Gigawatts!

• Industrial
  – 2,364 Sites
  – 933 MW
  – 78% of sites < 5 MW

• Commercial/Institutional
  – 22,248 Sites
  – 6,699 MW
  – 90% of sites< 5 MW

## Potential CHP Applications in Florida

<table>
<thead>
<tr>
<th>Applications</th>
<th>% of Capacity Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office Buildings</td>
<td>21.6%</td>
</tr>
<tr>
<td>Schools</td>
<td>15.2%</td>
</tr>
<tr>
<td>Hotels/Motels</td>
<td>15.0%</td>
</tr>
<tr>
<td>Nursing Homes</td>
<td>9.9%</td>
</tr>
<tr>
<td>Hospitals</td>
<td>9.7%</td>
</tr>
<tr>
<td>Golf Clubs</td>
<td>6.7%</td>
</tr>
<tr>
<td>Food Service</td>
<td>5.8%</td>
</tr>
<tr>
<td>Correctional Facilities</td>
<td>4.2%</td>
</tr>
<tr>
<td>Health Clubs/Spas</td>
<td>4.2%</td>
</tr>
<tr>
<td>Colleges and Universities</td>
<td>3.2%</td>
</tr>
<tr>
<td>Supermarkets</td>
<td>1.7%</td>
</tr>
<tr>
<td>Water/WW Treatment</td>
<td>1.1%</td>
</tr>
<tr>
<td>Commercial Laundries</td>
<td>0.6%</td>
</tr>
<tr>
<td>Refrigerated Warehouses</td>
<td>0.5%</td>
</tr>
<tr>
<td>Car Washes</td>
<td>0.3%</td>
</tr>
<tr>
<td>Museums</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

CHP Planning and Operating Characteristics

• Designed not to have net energy or excess thermal output
  – Often results in less than optimal sizing
• Usually operates in parallel with grid
• CHP prime mover has high capacity factor
  – Availability guarantee >90% not uncommon
• Maintenance in low demand periods
• Forced outages whenever.
1 kW solar  1,500 kWh/yr. lost revenue
1 kW CHP  7,000 kWh/yr. lost revenue
What Does CHP Do to Utility Revenue and Capacity Requirements?

• Lost revenue from:
  – Sales displaced by prime mover
  – Sales lost for cooling heating

• Load factors could worsen
  – 95% CHP capacity factor guarantees available
  – CHP maintenance and forced outages still occur
Utility CHP Management Strategies

• Standby or supplemental rates
  – Some Florida utilities already have

• Straight fixed-variable cost allocation (SFV)
  – Current practices recover fixed costs in energy charges

• Different business models
  – Dual Metering
    • Protects franchise fees, taxes, T&D requirements
    • Explicit value pricing mechanism
  – Facility participation
    • Distribute capacity additions
    • Get into steam, chilled water, heat business
    • Contributes to Clean Power Plan compliance
Standby Charges Will Not Cure Revenue Erosion But Participation Can!

EXAMPLE - RETROFIT FOR HOSPITAL WITH CHILLED WATER AND STEAM*

<table>
<thead>
<tr>
<th>Host/Utility Position</th>
<th>Utility Not Involved</th>
<th>Utility Owns CHP System** Retail Electric &amp; 50% Shared Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Standby Charges</td>
<td>With Standby Charges</td>
</tr>
<tr>
<td>IRR Tax-Exempt Host</td>
<td>17.6%</td>
<td>14.4%</td>
</tr>
<tr>
<td>IRR Taxable Host</td>
<td>23.9%</td>
<td>20.3%</td>
</tr>
<tr>
<td>Utility NPV Losses</td>
<td>($2,500,000)</td>
<td>($1,900,000)</td>
</tr>
<tr>
<td>IRR Utility***</td>
<td>na</td>
<td>na</td>
</tr>
</tbody>
</table>

*Recip. Engine, Net HR 7,921 Btu/kWh, 1200 kW Generator, 120 Ton Absorption Chiller, 50 HP Steam Generator, 5% Discount Rate, 20 years

** Utility rate bases prime mover, originates chiller and steam generator as DSM investment, host funds non-removable MEP facilities

*** Based on tax-exempt utility
Example: Co-Generation at Shands Hospital
(4 MW)

- Owned and operated by utility
- Hospital pays:
  - Retail rates on electric load
  - All natural gas consumption
  - Chilled water and steam
  - Facilities charge
- CHP sized to thermal needs
  - Excess electricity at times
- Generation a system resource
  - Contract heat rate
Utility Ownership Examples

<table>
<thead>
<tr>
<th>CHP Owner</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missouri Joint Municipal Electric Utility Commission</td>
<td>14.4</td>
</tr>
<tr>
<td>Austin Energy Distributed Chilled Water &amp; CHP</td>
<td>8.9</td>
</tr>
<tr>
<td>Gainesville Regional Utilities Chilled Water &amp; CHP</td>
<td>4.4</td>
</tr>
<tr>
<td>Ameren Energy CHP</td>
<td>44</td>
</tr>
<tr>
<td>Duke Energy at University of Florida</td>
<td>46</td>
</tr>
<tr>
<td>Alabama Power – Four CHP Sites</td>
<td>537</td>
</tr>
</tbody>
</table>

CHP Ownership Under EPA’s Proposed Clean Power Plan Rule

• EPA embraces CHP as a utility abatement strategy
  – EPA’s technical analysis employed 75% efficiency

• Utility ability to use as abatement will depend **entirely** on State Implementation Plan (SIP)
  – CHP prime mover heat rates not great
  – SIP DSM Provisions

• Carbon reduction credit accrues with:
  – Rebate?
  – Ownership?
  – Purchase of excess power?

• Utilities potentially need both CHP revenue and carbon credits
CHP Prime Mover Heat Rates Do Not $\text{CO}_2$/MWh (By Themselves)

Reciprocating Engine CHP Units
Gross Heat Rates On Natural Gas

![Graph showing Gross Heat Rate Btu/kW vs. Capacity kW](image.png)
Conclusions

• Conventional utility revenue recovery does not work well with CHP
• Rate designs that will be revenue neutral will require either:
  – SFV cost allocations
  – Demand ratchets
  – Or both.
• Customers likely to perceive as onerous
• Re-positioning utilities to be in the electric, heat and “coolth” business may be a win-win solution.
• Anti-trust regulations may be a significant obstacle
• Florida’s Clean Power Plan SIP policies on DSM will be critical to future utility involvement in CHP
Thank You For Your Time

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