Expanding Combined Heat and Power in Iowa

DOE State Energy Program
Central Iowa BOMA Meeting

Iowa Energy Office
Iowa Economic Development Authority
Presentation Team

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CHP: An Iowa Example
CHP: An Iowa Example

Heat Recovery Equipment

- Radiators
- Exhaust Heat
- Engine Heat

- Natural Gas: 10.5 MMBtu/hr
- Electric Power: 4.1 MMBtu/hr
- Hot Water: 5 MMBtu/hr

Engine Generator
CHP: An Iowa Example

University of Iowa/Oakdale Research Park Campus Utilities

Legend:
- Green: Electrical
- Orange: Steam
- Blue: Chilled Water
- Magenta: Hot Water
- Light Blue: Synthesis Gas
Commercial sector: 2\textsuperscript{nd} largest for potential CHP projects in Iowa (behind industrial)

Late 2015, CHP Resource Guide available at IEDA website:
- Vendors, engineers/consultants, financing contacts, permit guidance
Combined Heat and Power (CHP)

- Concepts and Benefits
- Emerging Drivers
- Opportunities in the Commercial Market Sector
Energy Resources Center (ERC)

- Based out of the College of Engineering at the University of Illinois at Chicago (UIC)
- Founded in 1973 as a “fast response” team capable of extending technical expertise, advice, and professional assistance to various organizations related to energy efficiency and the environment
- Expertise areas include energy efficiency, distributed generation, utilities billing management, and biofuels and bioenergy.
- [www.erc.uic.edu](http://www.erc.uic.edu)
Market Opportunity Analysis
Supporting analyses of CHP market opportunities in diverse markets including industrial, federal, institutional, and commercial sectors.

Education and Outreach
Providing information on the energy and non-energy benefits and applications of CHP to state and local policy makers, regulators, end users, trade associations, and others.

Technical Assistance
Providing technical assistance to end-users and stakeholders to help them consider CHP, waste heat to power, and/or district energy with CHP in their facility and to help them through the development process from initial CHP screening to installation.

http://www.energy.gov/chp
Fuel Utilization by U.S. Utility Sector

More than two-thirds of the fuel used to generate power in the U.S. is lost as heat.

**CHP: A Key Part of Our Energy Future**

- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification

CHP provides efficient, clean, reliable, affordable energy – today and for the future.

Benefits of CHP

- CHP is *more efficient* than separate generation of electricity and heat
- Higher efficiency translates to *lower operating cost*, (but requires capital investment)
- Higher efficiency *reduces emissions of all pollutants*
- CHP can also *increase energy reliability and enhance power quality*
- On-site electric generation *reduces grid congestion and avoids distribution costs*
Emerging CHP Drivers

- Benefits of CHP recognized by policymakers
  - 2012 Executive Order to accelerate investments in industrial EE and CHP set national goal of 40 GW of new CHP installations by 2020
  - Midwest SEOs exploring CHP opportunities
  - Policy Makers being educated on impacts of State Portfolio Standards (RPS, EEPS, APS), tax incentives, grants, standby rates, net metering, etc.

- Favorable outlook for natural gas supply and price in North America

- Utilities exploring and engaging in CHP opportunities
  - Utilities owning and partnering on CHP projects
  - CHP being explored and implemented in utility energy efficiency programs

- Opportunities created by environmental drivers

- Energy resiliency and critical infrastructure

- Other (LEED, Energy Star, net zero facilities, etc.)
CHP Is Used at the Point of Demand

- 4,300 CHP Sites (2013)
- 82,700 MW – installed capacity
- Saves 1.8 quads of fuel each year
- Avoids 241 M metric tons of CO₂ each year
- 87% of capacity – industrial
- 71% of capacity – natural gas fired

Source: ICF International
### Iowa CHP Market Status

- **Number of Existing CHP Projects**: 37 sites<sup>1</sup>
- **CHP Generating Capacity**: 633 MW<sup>1</sup>
- **CHP as % of Total Electric Generation**: ~4 %<sup>2</sup>
- **CHP Technical Potential**: 1,587 MW<sup>3</sup>

#### Table: Iowa CHP Technical Potential (< 100 MW)<sup>3</sup>

<table>
<thead>
<tr>
<th></th>
<th>50–1000 kW (MW)</th>
<th>1–5 MW (MW)</th>
<th>5–20 MW (MW)</th>
<th>20–50 MW (MW)</th>
<th>50–100 MW (MW)</th>
<th>Total (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>74</td>
<td>294</td>
<td>270</td>
<td>108</td>
<td>148</td>
<td>894</td>
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<tr>
<td>Commercial</td>
<td>454</td>
<td>224</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>693</td>
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<tr>
<td>Total</td>
<td>528</td>
<td>518</td>
<td>285</td>
<td>108</td>
<td>148</td>
<td>1,587</td>
</tr>
</tbody>
</table>

**Source:**
2. [www.eia.gov](http://www.eia.gov),
Attractive CHP Markets

Industrial
- Chemical manufacturing
- Ethanol
- Food processing
- Natural gas pipelines
- Petrochemicals
- Pharmaceuticals
- Pulp and paper
- Refining
- Rubber and plastics

Commercial
- Data centers
- Hotels and casinos
- Multi-family housing
- Laundries
- Apartments
- Office buildings
- Refrigerated warehouses
- Restaurants
- Supermarkets
- Green buildings

Institutional
- Hospitals
- Schools (K – 12)
- Universities & colleges
- Wastewater treatment
- Residential confinement

Agricultural
- Concentrated animal feeding operations
- Dairies
- Wood waste (biomass)
Favorable Characteristics for CHP Applications

- Concern about energy costs
- Concern about power reliability
- Concern about sustainability and environmental impacts
- Long hours of operation
- Existing thermal loads
- Central heating and cooling plant
- Future central plant replacement and/or upgrades
- Future facility expansion or new construction projects
- EE measures already implemented
- Access to nearby renewable fuels
- Facility energy champion
Iowa CHP Technical Potential in Commercial/Institutional Sector

Source: [http://files.harc.edu/Sites/GulfCoastCHP/Publications/MarketCHPCommercialSector.pdf](http://files.harc.edu/Sites/GulfCoastCHP/Publications/MarketCHPCommercialSector.pdf)
CHP Technologies
And their Competitive Market Sizes

Reciprocating Engines
- Size Range: 10 kW to over 18 MW
- Advantages
  - Fast start-up and black start capability
  - Relatively low investment cost
  - Operate on low-pressure gas
  - Can be overhauled on site
  - High power efficiency with part-load operation flexibility
- Disadvantages
  - High maintenance costs
  - Limited to lower temperature CHP applications
  - Relatively higher emissions
  - High levels of low frequency noise

Microturbines
- Size Range: 30 kW to 330 kW (modular packages up to 1 MW)
- Advantages
  - Small number of moving parts
  - Compact size and light weight
  - Low NOx combustion capable of meeting CA standards with catalyst
- Disadvantages
  - Higher costs
  - Relatively lower mechanical efficiency
  - Limited to lower temperature CHP applications

## Prime Mover Technologies
### Reciprocating Engines and Microturbines

#### Reciprocating Engines

<table>
<thead>
<tr>
<th>CHP Capacity (kW)</th>
<th>100</th>
<th>633</th>
<th>1,121</th>
<th>3,326</th>
<th>9,341</th>
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</thead>
<tbody>
<tr>
<td>Electric Efficiency (%), HHV</td>
<td>27.0%</td>
<td>34.5%</td>
<td>36.8%</td>
<td>40.4%</td>
<td>41.6%</td>
</tr>
<tr>
<td>Total CHP Efficiency (%), HHV</td>
<td>80.0%</td>
<td>78.9%</td>
<td>78.4%</td>
<td>78.3%</td>
<td>76.5%</td>
</tr>
<tr>
<td>CHP Equipment Cost ($/kW)</td>
<td>$1,900</td>
<td>$1,790</td>
<td>$1,475</td>
<td>$1,140</td>
<td>$925</td>
</tr>
<tr>
<td>Total Installed Cost ($/kW)</td>
<td>$2,900</td>
<td>$2,837</td>
<td>$2,366</td>
<td>$1,801</td>
<td>$1,433</td>
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<tr>
<td>Total O&amp;M Costs ($/kWh)</td>
<td>$0.023 – 0.025</td>
<td>$0.021</td>
<td>$0.019</td>
<td>$0.016</td>
<td>$0.0085</td>
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</table>

#### Microturbines

<table>
<thead>
<tr>
<th>CHP Capacity (kW)</th>
<th>30</th>
<th>65</th>
<th>200</th>
<th>250</th>
<th>333</th>
<th>1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Efficiency (%), HHV</td>
<td>22.0%</td>
<td>23.8%</td>
<td>26.7%</td>
<td>26.1%</td>
<td>28.0%</td>
<td>26.7%</td>
</tr>
<tr>
<td>Total CHP Efficiency (%), HHV</td>
<td>70.0%</td>
<td>70.4%</td>
<td>63.0%</td>
<td>66.09%</td>
<td>67.5%</td>
<td>63.1%</td>
</tr>
<tr>
<td>CHP Package Cost ($/kW)</td>
<td>$2,690</td>
<td>$2,120</td>
<td>$2,120</td>
<td>$1,840</td>
<td>$1,770</td>
<td>$1,710</td>
</tr>
<tr>
<td>Total Installed Cost ($/kW)</td>
<td>$4,300</td>
<td>$3,220</td>
<td>$3,150</td>
<td>$2,720</td>
<td>$2,580</td>
<td>$2,500</td>
</tr>
<tr>
<td>O&amp;M Costs ($/kWh), average 6000 hrs/yr</td>
<td>---</td>
<td>$0.013</td>
<td>$0.016</td>
<td>$0.011</td>
<td>$0.009</td>
<td>$0.012</td>
</tr>
</tbody>
</table>

Source: [http://www.epa.gov/chp/technologies.html](http://www.epa.gov/chp/technologies.html)
ProMedica Health System – Wildwood
Toledo, OH

Capacity: 130 kW
Fuel: Natural Gas
Prime Mover: Microturbines
Installed: 2013

Benefits include a reduction in annual energy costs and greenhouse gas emissions as well as a higher ENERGY STAR building score

Washtenaw Community College
Ann Arbor, MI

Capacity: 130 kW
Fuel: Natural Gas
Prime Mover: Microturbines
Installed: 2014

Benefits include a reduction of $60,000 in annual energy costs and reduced greenhouse gas emissions by an amount equivalent to 146 automobiles.

Sievers Family Farm
Stockton, IA

Capacity: 1,000 kW
Fuel: Biomass
Prime Mover: Recip. Engines
Installed: 2013

Electricity is sold to Alliant Energy, and waste heat is used for heating the anaerobic digesters

Source: http://www.americanbiogascouncil.org/projectProfiles/stocktonIA.pdf
Medina High School
Medina, OH

Capacity: 125 kW
Fuel: Natural Gas
Prime Mover: Recip. Engines
Installed: 2014

The new unit powers the school and heats the Medina Community Recreation Center’s two pools and spa, all while saving the school district $82,000 annually.

Dublin Community Recreation Center
Dublin, OH

Status: **Under Development**
Capacity: **248 kW**
Fuel: **Natural Gas**
Prime Mover: **Recip. Engine**
Complete by: **2015**

“This CHP solution is expected to save us $20,000 in energy costs over the next 5 years. It negates the need for our boiler replacement, which will save us approximately $70,000. The CHP system also provides backup power during a power outage, which will be a benefit to us and our guests.”

–Michelle Crandall, Dublin’s Assistant City Manager

Cedar Rapids Site 2 Landfill

Cedar Rapids, IA

Capacity: 1,600 kW
Fuel: Landfill Gas
Prime Mover: Recip. Engines
Installed: 2013

Instead of being flared off, landfill methane is captured and fuels the 1600 kW engine, saving the county’s Solid Waste Agency $90,000/yr while feeding the rural electrical grid.

Energy production from methane is a bonus for a methane collection system designed firstly to manage the landfill’s methane gas and to cut down on its odor.

Source: https://www.solidwasteagency.org/#/news/2012/08/22/cedar-rapid-gazette-article-about-agency-landfill-gas-to-energy-project
<table>
<thead>
<tr>
<th>Category</th>
<th>10 MW CHP</th>
<th>10 MW PV</th>
<th>10 MW Wind</th>
<th>10 MW NGCC</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>
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<tr>
<td>Annual Useful Heat Provided</td>
<td>103,417 MWh</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<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>
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<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, MMBtu</td>
<td>308,100</td>
<td>196,462</td>
<td>303,623</td>
<td>154,649</td>
</tr>
<tr>
<td>Annual CO₂ Savings, Tons</td>
<td>42,751</td>
<td>17,887</td>
<td>27,644</td>
<td>28,172</td>
</tr>
<tr>
<td>Annual NOx Savings</td>
<td>59.9</td>
<td>16.2</td>
<td>24.9</td>
<td>39.3</td>
</tr>
</tbody>
</table>

Screening and Preliminary Analysis

- Quick screening questions with spreadsheet payback calculator.

Feasibility Analysis

- Uses available site information. Estimate: savings, installation costs, simple paybacks, equipment sizing and type.

Investment Grade Analysis

- 3rd Party review of Engineering Analysis. Review equipment sizing and choices.

Procurement, Operations, Maintenance, Commissioning

- Review specifications and bids, limited operational analysis.
Conclusion

- CHP systems offer numerous benefits
- Emerging drivers are increasing CHP opportunities
- Small-to-mid sized CHP prime movers are typically reciprocating engines and microturbines
- ERC through the Midwest CHP TAP can provide technical assistance resources to investigate CHP opportunities
Questions

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