Combined Heat and Power

Rod Schwass
MBA, LEED® AP

Renewable Energy Markets Conference
October 2010
Burns & McDonnell Overview

- 100% Employee Owned
- 3000 Employees
- $1 Billion Revenue
- Headquartered in Kansas City
- 18 Regional Offices

Over 110 years of power generation, utility and infrastructure experience
CHP Overview
Definitions...

Co-Generation

or Tri-Generation

or BCHP = Building Cooling Heating & Power

or CHP = Combined Heat & Power

or CHP = Cooling, Heating & Power

or IES = Integrated Energy System

or CHP = Clean Heat and Power
What is CHP?

- An Integrated Energy System
- Located At or Near a Building/Facility
- Provides all or a Portion of the Electrical Load
- Utilizes Waste Heat to Generate Useful Thermal Energy
  - Cooling
  - Heating
  - Dehumidification
  - Process Heat
  - Additional Power
- Thermal Load Drives System Size
Components of a CHP System

- **Typical Prime Mover Components**
  - Low Emission Gas Turbine Generators
  - Natural Gas-Fired Engine Generators
  - Fuel Cells

- **Thermal Energy Components**
  - Electric / Absorption Chillers
  - Heat Recovery Steam Generators
  - Thermal Energy Storage Systems
The Key is Systems Integration and System Sizing

Distributed Generation Technology
- Gas-turbine
- Micro-turbine
- I.C. Engine

Solid Oxide
- PEM Fuel Cell

Phosphoric Acid Fuel Cell

Thermally-Activated Technology
- Triple-Effect Absorption
- Double-Effect Absorption
- Desiccant Technology

Single-Effect Absorption

Temperature Ranges:
- 950°F
- 600°F
- 360°F
- 180°F

950ºF
600ºF
360ºF
180ºF
Benefits of CHP Systems

- Produce Cooling, Heating and Power at 70 to 80% efficiencies
- Obtain “free” cooling and/or heating by recycling the waste heat
- Achieve reliabilities of near 100%
- Significantly reduce $\text{SO}_2$, $\text{NO}_x$ and $\text{CO}_2$ Emissions (Possible GHG credits)
CHP Increases Reliability

- Mitigate impact of power outages and poor power quality fluctuations
- Use high reliability on-site generation technologies
- Can use more than one prime mover
- Integrated control systems
CHP Reduces Emissions

- Recycling waste heat reduces total fuel required for cooling, heating and power
- Natural gas is a “clean” fuel
- CHP prime mover technologies have lower NOx than traditional stand-by generators
- Can meet emission standards without exhaust gas clean-up
Ideal CHP Site Profile

- Where CHP makes sense:
  - CHP - Coincident electric and thermal loads
    (Process, heating, cooling, hot water)
  - Campus environments with 24/7 operation
  - Need to replace/upgrade existing central utility plant infrastructure
  - Additional capacity needed to support growing loads
  - High reliability requirement for business continuity / mission accomplishment (6-9’s)
Ideal CHP Owners/End Users

- Municipal Utilities
- Hospitals
- University/College Campuses
- Data Centers
- Large Airports
- Large Commercial Developments
- Government Campuses
Shands Cancer Center

Gainesville, FL
GRU South Energy Center

PROJECT FACTS
Owner: Gainesville Regional Utilities
EPC Contractor: Burns & McDonnell
Total Project Cost: $35,000,000
Project Completion: December 2008
Hospital Complete: June 2009

TECHNOLOGY HIGHLIGHTS
High Heat Rate Efficiency
Low Emissions
Grid Interconnect – Parallel & Island Mode
Integrated Controls System
LEED EA 1 Efficiency Credits for CHP

FEATURES
State-of-the-Art Technology
Modular & Packaged Components
Built-in Redundancy
Operational Flexibility

BENEFITS
Increased Efficiency
Improved Reliability
Reduced Emissions
Provides 100% of the Hospital’s Electrical and Thermal Needs
System Modules

Generator

Inlet Air Cooling Coil

4.5 MW 12.47 kV

Turbine Exhaust Hot By-Pass Stack

5 PPM NoX

Steam Turbine Chiller 1200 Ton

Deaerator

Process Steam

5 PPM NoX

Cooling Tower

Heat Recovery Steam Generator

14,000 lbs/hr

Greater Than 75% IES Efficiency

HRSG Exhaust Cold Stack

Natural Gas

Prime mover 38% Heat Rate Efficiency

Exhaust Diverter Valve

700°F

CondR W

Water

CHWS CHWR

5 PPM NoX

350°F

HRSG Exhaust Stack
At a Coal Fired Power Station, about 35% of the primary fuel is converted into electricity; the remainder is lost “up the stack”. An additional 6% efficiency drop occurs in transmission to the site. Overall, at the Hospital’s meter, the result is roughly a 29% efficient primary fuel conversion to useful energy.
Efficiency
CHP Model

GRU’s South CHP Energy Center at the Shands Cancer Hospital will be 75% efficient at primary fuel conversion to useful energy.

This is a 46% savings in primary energy utilization compared to the Typical Hospital Power Service Model.
Environmental Comparison

GRU’s Fleet
Central Power Plants

Carbon Dioxide: 68% reduction
Sulphur Oxide: 99% reduction
NOx: 98% reduction

CO2 1,937 lbs/MWh
SO2 8.44 lbs/MWh
NOx 4.02 lbs/MWh

GRU South Energy Center
CHP Plant

CO2 615 lbs/MWh
SO2 0.003 lbs/MWh
NOx .043 lbs/MWh
TECO Site
TECO Growth

**Current**
- 80,000 tons chilled water
- 16 MW on-site generation
- 750,000 pph steam packaged boilers

**Planned Growth**
- 80,000 tons chilled water
- 152,000 ton hrs chilled water storage (16,000 tons)
- 100 MW CHP on-site generation
- 540,000 pph heat recovery steam generator
Efficiency Comparisons

- **Existing TECO Plant Efficiency** = 40%
  - 80,000 tons chilled water (2 - 5,000 ton steam turbine drive)
  - 16 MW on-site generation
  - 750,000 pph steam packaged boilers

- **TECO Plant Efficiency after installation of CHP System** = 80%
  - 80,000 tons chilled water
  - 152,000 ton hrs chilled water storage (16,000 tons)
  - 100 MW CHP on-site generation
  - 540,000 pph heat recovery steam generator
Environmental Efficiency

- **CO2 Regulation**
  - Currently not regulated
  - Carbon cap/trade/tax?

- **Regulatory Obstacles**
  - Non-Attainment Area
  - Clean Air Act – New Source Review (NSR)
  - Prevention of Significant Deterioration (PSD)
Environmental Efficiency

CHP Results

The results generated by the CHP Emissions Calculator are intended for educational and outreach purposes only. It is not designed for use in developing emission inventories or preparing air permit applications.

<table>
<thead>
<tr>
<th>Annual Emissions Analysis</th>
<th>CHP System</th>
<th>Displaced Electricity Production</th>
<th>Displaced Thermal Production</th>
<th>Emissions/Fuel Reduction</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx (tons/year)</td>
<td>3.06</td>
<td>132.14</td>
<td>223.02</td>
<td>382.11</td>
<td>98%</td>
</tr>
<tr>
<td>SO2 (tons/year)</td>
<td>0.80</td>
<td>481.94</td>
<td>1.34</td>
<td>282.48</td>
<td>100%</td>
</tr>
<tr>
<td>CO2 (tons/year)</td>
<td>161.042</td>
<td>169.709</td>
<td>266.738</td>
<td>406.465</td>
<td>66%</td>
</tr>
<tr>
<td>Carbon (metric tons/year)</td>
<td>39.819</td>
<td>49.300</td>
<td>65.986</td>
<td>75.524</td>
<td>65%</td>
</tr>
<tr>
<td>Fuel Consumption (MMEtu/year)</td>
<td>2,706.593</td>
<td>2,416.446</td>
<td>4,560.474</td>
<td>4,279.327</td>
<td>61%</td>
</tr>
</tbody>
</table>

This CHP project will reduce emissions of Carbon Dioxide (CO2) by 305,455 tons per year. This is equal to 75,527 metric tons of carbon equivalent (MTCE) per year.

This reduction is equal to removing the carbon that would be absorbed by 62,939 acres of forest.

This reduction is equal to removing the carbon emissions of 50,452 cars.
TECO Summary

- TECO expansion will deliver:
  - Greater reliability by increasing on-site generation capacities
  - Significantly higher electric and thermal efficiency when compared to central generation
  - Significantly lower emissions as compared on lb/MW/hr basis than central generation
  - Phase 1 (48 MW) complete, benefited from a $10 million DOE grant
CHP Project Methodology

Stakeholder Involvement Options
1. Self Fund Project
2. Outsource/Leaseback Project
3. Put the Project on the Shelf

Phase 1
- Screening Analysis
- Report
- 2 Weeks

Phase 2
- Feasibility Study
- Report + NPV Economic Analysis + Preliminary Lease Agreement
- 4 Weeks

Phase 3
- Preliminary Design
- Report + GMP for Final Design & Construction + Lease Agreement
- 3 Months

Phase 4
- Pre-Purchase
- Final Design
- Construction Phase Services
- Pre-Construction Services
- Environmental Permits
- 6 to 9 Months
Features

- Proven Technology
- Modular Design
- Scaleable Packages
- Higher Efficiency
- Lower Emissions
- Increased Reliability

Benefits

- Capital Cost Reduction
- Shorter & Less Expensive Installation
- Replicable
- Simplified Systems
- Modularity
Thank You for Your Interest and Attention!

Rod Schwass
Burns & McDonnell Engineering

rschwass@burnsmcd.com
(816) 822-4213