Western CHP TAP for WWTPs

CASA CWEA Biosolids Seminars

September 11, 2019

John Woolsey, PE
DOE CHP Technical Assistance Partnerships

Program Objectives

• End User Engagement
• Stakeholder Engagement
• Technical Services
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Presentation Outline

- What is Combined Heat & Power (CHP)?
- Self Generation Incentive Program for Biogas
- CHP Project Implementation: CHP TAP Assistance
- Case Studies
- Q&A
Combined Heat & Power Overview
CHP: A Key Part of Our Energy Future

- Form of Distributed Generation (DG)
- Integrated system
- Located at or near a building / facility
- Offsets portion of the electrical load
- Thermal energy used for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification

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

Source: www.energy.gov/chp
CHP Recaptures Heat of Generation, Increasing Energy Efficiency, and Reducing GHGs

- **Power Plant**: 32% efficiency (including T&D)
  - 94 units Fuel → 30 units Electricity

- **Onsite Boiler**: 80% efficiency
  - 56 units Fuel → 45 units Heat

**Total Efficiency**: ~ 50%

**CHP**: 75% efficiency
- 100 units Fuel → 30 units Heat

**Total Efficiency**: ~ 75%

30 to 55% greenhouse gas emissions reductions
Common CHP Technologies

- Microturbines
- Gas Turbines
- Reciprocating Engines
- Fuel Cells
- Steam Turbines

Sizes:
- 50 kW
- 100 kW
- 1 MW
- 10 MW
- 20 MW
CHP System Schematic

- **Fuel**
  - Natural Gas
  - Propane
  - Biogas
  - Landfill Gas
  - Coal
  - Steam
  - Waste Products
  - Others

- **Prime Mover**
  - Reciprocating Engines
  - Combustion Turbines
  - Microturbines
  - Steam Turbines
  - Fuel Cells
  - ORC turbine

- **Generator**

- **Electricity**
  - On-Site Consumption
  - Sold to Utility

- **Heat Exchanger**

- **Thermal**
  - Steam
  - Hot Water
  - Space Heating
  - Process Heating
  - Space Cooling
  - Process Cooling
  - Refrigeration
  - Dehumidification
Benefits of CHP?

- **More efficient** than separate coincident generation of electricity and heating/cooling
- Higher efficiency translates to **lower operating costs**
- Higher efficiency **reduces emissions** of pollutants
- Can increase **energy reliability** and enhance power quality
- On-site electric generation can **reduce grid congestion** and avoid distribution costs.
Favorable CHP Candidate Sites

• High and constant thermal load
• Favorable spark spread
• Need for high reliability
• Concern over future electricity prices
• Interest in reducing environmental impact
• Planned facility expansion, new construction or equipment replacement within the next 3-5 years
Attractive CHP Markets

Industrial
- Chemicals
- Refining
- Food processing
- Petrochemicals
- Natural gas pipelines
- Pharmaceuticals
- Rubber and plastics
- Pulp and paper

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
- Correctional Facilities

Agricultural
- Dairies
- Wood waste (biomass)
- Concentrated animal feeding operations
Existing CHP WWTP CHP Applications – CA

California Self-Generation Incentive Program (SGIP)
# SGIP Eligible Technologies

<table>
<thead>
<tr>
<th>Technology Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Turbine</td>
</tr>
<tr>
<td>Waste Heat to Power</td>
</tr>
<tr>
<td>Pressure Reduction Turbine*</td>
</tr>
<tr>
<td>Internal Combustion Engine*</td>
</tr>
<tr>
<td>Microturbine*</td>
</tr>
<tr>
<td>Gas Turbine*</td>
</tr>
<tr>
<td>Steam Turbine*</td>
</tr>
<tr>
<td>Fuel Cell*</td>
</tr>
<tr>
<td>Advanced Energy Storage</td>
</tr>
</tbody>
</table>

*Eligible for SGIP biogas adder
SGIP Biogas Requirements

• Renewable fuel from digester gas, landfill gas or biomass qualifies
• Both “onsite” and “directed” biogas projects qualify for additional SGIP incentives
• Directed Biogas: RPS eligibility requirements for pipeline biomethane apply
• Eligible directed biogas must be sourced from within the WECC (aligned with the CEC’s current RPS requirement)

<table>
<thead>
<tr>
<th>Application Year</th>
<th>% Renewable Fuel Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>0%</td>
</tr>
<tr>
<td>2017</td>
<td>10%</td>
</tr>
<tr>
<td>2018</td>
<td>25%</td>
</tr>
<tr>
<td>2019</td>
<td>50%</td>
</tr>
<tr>
<td>2020</td>
<td>100%</td>
</tr>
</tbody>
</table>
California Rebates and Incentives

- Self Generation Incentive Program
  - Incentives for distributed generation and storage technologies
  - Customer’s side of the utility meter
  - Retail electric and gas customers of PG&E, SCE, SoCalGas, and SDG&E

<table>
<thead>
<tr>
<th>Generation Technology</th>
<th>Step 1: Initial Incentive Rate</th>
<th>Step 1: Max Incentive w/ biogas adder</th>
<th>Step 2: Initial Incentive Rate</th>
<th>Step 2: Max Incentive w/ biogas adder</th>
<th>Step 3: Initial Incentive Rate</th>
<th>Step 3: Max Incentive w/ biogas adder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Heat to Power</td>
<td>$0.60/W</td>
<td>n/a</td>
<td>$0.50/W</td>
<td>n/a</td>
<td>$0.40/W</td>
<td>n/a</td>
</tr>
<tr>
<td>Pressure Reduction Turbine</td>
<td>$0.60/W</td>
<td>$1.20/W</td>
<td>$0.50/W</td>
<td>$1.10/W</td>
<td>$0.40/W</td>
<td>$1.00/W</td>
</tr>
<tr>
<td>CHP: ICE, GT, MT, ST, FC*</td>
<td>$0.60/W</td>
<td>$1.20/W</td>
<td>$0.50/W</td>
<td>$1.10/W</td>
<td>$0.40/W</td>
<td>$1.00/W</td>
</tr>
</tbody>
</table>

*Internal Combustion Engine, Gas Turbine, Microturbine, Steam Turbine, Fuel Cell
SGIP Renewable Capacity - Biogas Source

Source: SELF-GENERATION INCENTIVE PROGRAM: RENEWABLE FUEL USE REPORT NO. 27
Example of Biogas CHP

Cogeneration System

1. Bacteria in digester create methane
2. Methane fuels the engine
3. Engine turns the generator
4. Generator creates green electricity that is used to help power the plant
5. Heat from the engine and generator is captured in a series of heat exchangers to heat the digesters

Source: King County, Seattle WA
Parameters for Success

• CHP Champion
• Interaction and Relationship with local utility
• System design
  • Collaborate with DOE CHP TAPs
  • Experienced project developer preferred
  • Biogas scrubbing a key Balance of Plant (BOP) component
  • Visit DOE CHP website database for project profiles*
• Operation and Maintenance
  • Appropriate CHP O&M training for staff
  • Biogas scrubbing and maintenance experience

*https://betterbuildingssolutioncenter.energy.gov/chp/chp-project-profiles-database
CHP Project Implementation: CHP TAP Assistance
CHP TAP Role: Technical Assistance

- **Screening and Preliminary Analysis**: Quick screening questions with spreadsheet payback calculator; Advanced technical assistance to explore equipment or operational scenarios.

- **Feasibility Analysis**: Perform 3rd Party Reviews of site Feasibility Assessments: Estimates on savings, installation costs, simple paybacks, equipment sizing, and type.

- **Investment Grade Analysis**: Perform 3rd Party reviews of Engineering Analysis. Review equipment sizing and choices.

- **Procurement, Operations, Maintenance, Commissioning**: Review specifications and bids.
DOE TAP CHP Screening Analysis

- High-level technical and economic assessment
- Determines potential for a CHP project
- Qualitative Analysis
  - Energy Consumption & Costs
  - Estimated Energy Savings & Payback
  - CHP System Sizing
- Quantitative Analysis
  - Understanding project drivers
  - Understanding site peculiarities

### Annual Energy Consumption

<table>
<thead>
<tr>
<th></th>
<th>Base Case</th>
<th>CHP Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchased Electricity, kWh</td>
<td>86,250,160</td>
<td>5,334,150</td>
</tr>
<tr>
<td>Generated Electricity, kWh</td>
<td>0</td>
<td>82,716,010</td>
</tr>
<tr>
<td>On-site Thermal, MMBtu</td>
<td>426,000</td>
<td>28,872</td>
</tr>
<tr>
<td>CHP Thermal, MMBtu</td>
<td>0</td>
<td>407,128</td>
</tr>
<tr>
<td>Boiler Fuel, MMBtu</td>
<td>532,500</td>
<td>23,500</td>
</tr>
<tr>
<td>CHP Fuel, MMBtu</td>
<td>0</td>
<td>969,845</td>
</tr>
<tr>
<td>Total Fuel, MMBtu</td>
<td>532,500</td>
<td>993,435</td>
</tr>
</tbody>
</table>

### Annual Operating Costs

<table>
<thead>
<tr>
<th></th>
<th>Base Case</th>
<th>CHP Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchased Electricity, $</td>
<td>$7,060,013</td>
<td>$1,104,460</td>
</tr>
<tr>
<td>Standby Power, $</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>On-site Thermal Fuel, $</td>
<td>$3,195,000</td>
<td>$141,539</td>
</tr>
<tr>
<td>CHP Fuel, $</td>
<td>$0</td>
<td>$5,819,071</td>
</tr>
<tr>
<td>Incremental O&amp;M, $</td>
<td>$0</td>
<td>$744,444</td>
</tr>
<tr>
<td>Total Operating Costs, $</td>
<td>$10,255,013</td>
<td>$7,809,514</td>
</tr>
</tbody>
</table>

### Simple Payback

- Annual Operating Savings, $ | $2,445,499
- Total Installed Costs, $/kW | $1,400
- Simple Payback, Years | 5.3

### Operating Costs to Generate

<table>
<thead>
<tr>
<th></th>
<th>$/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Costs</td>
<td>$0.070</td>
</tr>
<tr>
<td>Thermal Credit</td>
<td>($0.037)</td>
</tr>
<tr>
<td>Incremental O&amp;M</td>
<td>$0.009</td>
</tr>
<tr>
<td>Total Operating Costs to Generate</td>
<td>$0.042</td>
</tr>
</tbody>
</table>
# Project Profile - Burlingame WWTF

## 177-kW CHP System

<table>
<thead>
<tr>
<th>Quick Facts</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Burlingame, CA</td>
</tr>
<tr>
<td><strong>Market Sector</strong></td>
<td>Wastewater Treatment Facility (WWTF)</td>
</tr>
<tr>
<td><strong>Facility Size</strong></td>
<td>5.5 million gallons per day (MGD)</td>
</tr>
<tr>
<td><strong>Facility Peak Load</strong></td>
<td>650 MW</td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
<td>177-kW Caterpillar engine, biogas cleanup skid and control panel</td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
<td>Digester gas</td>
</tr>
<tr>
<td><strong>Use of Thermal Energy</strong></td>
<td>Digester heating</td>
</tr>
<tr>
<td><strong>CHP Total Efficiency</strong></td>
<td>85%</td>
</tr>
<tr>
<td><strong>Environmental Benefits</strong></td>
<td>Nox reductions 42% below legal limits</td>
</tr>
<tr>
<td><strong>Total Project Cost</strong></td>
<td>$912k</td>
</tr>
<tr>
<td><strong>Annual Energy Savings</strong></td>
<td>$92k</td>
</tr>
<tr>
<td><strong>SGIP Incentive</strong></td>
<td>$160k</td>
</tr>
<tr>
<td><strong>Payback</strong></td>
<td>8 years</td>
</tr>
</tbody>
</table>
# Project Profile – Sievers Family Dairy Farm

## 1-MW CHP System

<table>
<thead>
<tr>
<th>Quick Facts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
</tr>
<tr>
<td><strong>Market Sector</strong></td>
</tr>
<tr>
<td><strong>Facility Size</strong></td>
</tr>
<tr>
<td><strong>Biogas production</strong></td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
</tr>
<tr>
<td><strong>Use of Thermal Energy</strong></td>
</tr>
<tr>
<td><strong>Environmental Benefits</strong></td>
</tr>
<tr>
<td><strong>Total Project Cost</strong></td>
</tr>
<tr>
<td><strong>Annual Energy Savings</strong></td>
</tr>
<tr>
<td><strong>Incentives</strong></td>
</tr>
<tr>
<td><strong>Awarded Biogas Project of the Year by American Biogas Council, 2014</strong></td>
</tr>
</tbody>
</table>
## Project Profile - East Bay Municipal Utility District

### 11-MW CHP System

<table>
<thead>
<tr>
<th>Quick Facts</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Oakland, CA</td>
</tr>
<tr>
<td><strong>Market Sector</strong></td>
<td>Wastewater Treatment Facility (WWTF)</td>
</tr>
<tr>
<td><strong>Facility Size</strong></td>
<td>65 million gallons per day</td>
</tr>
<tr>
<td><strong>Facility Peak Load</strong></td>
<td>10 MW</td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
<td>4.6 MW Solar Turbines Mercury 50™ gas turbine and 3 x 2.1 MW Enterprise engines</td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
<td>Digester gas</td>
</tr>
<tr>
<td><strong>Use of Thermal Energy</strong></td>
<td>Digester heating</td>
</tr>
<tr>
<td><strong>CHP Total Efficiency</strong></td>
<td>80%</td>
</tr>
<tr>
<td><strong>Environmental Benefits</strong></td>
<td>Methane destruction reduces GHG emissions</td>
</tr>
<tr>
<td><strong>Total Project Cost</strong></td>
<td>$19 million (includes turbine and related equipment modifications made in 2011)</td>
</tr>
<tr>
<td><strong>Annual Energy Savings</strong></td>
<td>$1.2 million</td>
</tr>
<tr>
<td><strong>Payback</strong></td>
<td>15 years</td>
</tr>
</tbody>
</table>
Summary

• CHP maximizes fuel source, enabling
  • High overall utilization efficiencies
  • Reduced environmental footprint
  • Reduced operating costs
• Different strategies, including critical infrastructure resiliency and emergency planning
• Proven technologies commercially available today
• Full range of sizes and applications
Next Steps: Contact Us

Western CHP TAP services:

- Perform Qualification Screening: Is CHP right for your site?
- Expanding existing CHP plant
- Unbiased 3rd Party CHP Proposal Review
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