TVA’s EPA Mitigation Project: Revised Waste Heat Recovery Combined Heat and Power

Webinar
September 16, 2015
Background & Objectives

Background

- April 2011, TVA entered into clean air agreements with the Environmental Protection Agency (EPA), four states and three environmental groups (“EPA Agreements”).
- This revised Waste Heat Recovery (WHR) / Combined Heat & Power (CHP) project is one of the environmental mitigation projects resulting from the agreement.

Objectives

- Establish at least 5 MW of customer-owned generation from WHR or CHP.
- Increase TVA’s industrial customers’ access to clean energy from WHR and CHP.
- Provide a highly leveraged funding opportunity for new clean energy in the Valley.
Scope of the Project

• This project will provide up to $7 million to develop at least 5 MW of WHR or CHP electric generation.

• Scope: Awardee will be responsible for the development, design, engineering, construction, operation and maintenance of the WHR or CHP system.

• Collaboration between industrial customers, technology developers, other organizations and TVA will be key to the success of this initiative.

• TVA expects the life of the WHR or CHP system to be a minimum of twelve years, however projects with a useful life up to twenty years are more desirable.
CHP/WHR Overview

by Isaac Panzarella, DOE Southeast CHP TAP

- What is CHP/WHR?
- Why is CHP efficient?
- What are the benefits of CHP?
- What types of businesses use CHP?
- How much CHP do we have in Tennessee?
- What technologies are used in CHP?
- CHP Project Snapshots
- CHP Technical Potential
- Screening for CHP Projects
- DOE CHP Technical Assistance Partnerships
DOE CHP Technical Assistance Partnerships (CHP TAPs)

DOE's CHP TAPs promote and assist in transforming the market for CHP, waste heat to power, and district energy or microgrid with CHP throughout the United States. Key services include:

- **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 or microgrid with CHP in their facility and to help them through the development process from initial CHP screening to installation.

www.energy.gov/chp
www.southeastchptap.org
What is Combined Heat & Power?

- 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.

What is Waste Heat Recovery and Waste Heat to Power CHP?

• WHR generally refers to capturing waste heat that an industrial site or pipeline compressor station is already emitting, and turning it into clean electricity, recycled thermal energy, or mechanical energy.

• Three essential components are required for waste heat recovery:
  o An accessible source of waste heat
  o A recovery technology
  o A use for the recovered energy

• Waste Heat to Power CHP is specific term for capturing waste heat from an existing source and turning it into electricity
CHP Recaptures Heat, Increasing Overall Efficiency of Energy Services

- Power Plant: 94 units, 32% efficiency (Including T&D)
- Onsite Boiler: 56 units, 80% efficiency
- CHP: 100 units, 75% efficiency

Total Efficiency:
- Power Plant: ~ 50%
- Onsite Boiler: 80% efficiency
- CHP: ~ 75%

with 30 to 55% less greenhouse gas emissions
Defining CHP

The on-site simultaneous generation of two forms of energy (heat and electricity) from a single fuel/energy source

Conventional CHP
(also referred to as Topping Cycle CHP or Direct Fired CHP)

Separate Energy Delivery:
- Electric generation – 33%
- Thermal generation - 80%
- Combined efficiency – 45% to 55%

CHP Energy Efficiency (combined heat and power)
70% to 85%
Defining CHP

The on-site simultaneous generation of two forms of energy (heat and electricity) from a single fuel/energy source

Waste Heat to Power CHP
(also referred to as Bottoming Cycle CHP or Indirect Fired CHP)

- Fuel first applied to produce useful thermal energy for the process
- Waste heat is utilized to produce electricity and possibly additional thermal energy for the process
- Simultaneous generation of heat and electricity
- No additional fossil fuel combustion (no incremental emissions)
- Normally produces larger amounts electric generation (often exports electricity to the grid; base load electric power)
What Are the 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
## 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)
Select CHP Installations in Tennessee

- 194 MW - Eastman Chemical Company, Kingsport
- 100 MW – TVA / DuPont, Johnsonville
- 66 MW – Resolute Forest Products, Calhoun
- 50 MW – Domtar, Kingsport
- 10.2 MW – Vanderbilt University, Nashville
- 5.2 MW – Opryland Hotel, Nashville
- 3.7 MW – Bruce Hardwood / Armstrong Flooring, Memphis
- 2.8MW – University of Tennessee, Knoxville
- 1.5 MW - Alvin C. York VA Medical Ctr., Murfreesboro

See U.S. DOE CHP Installation Database:  https://doe.icfwebservices.com/chpdb/
## All CHP Installations in Tennessee

<table>
<thead>
<tr>
<th>CHP Prime Mover</th>
<th>Sites</th>
<th>Capacity (KW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backpressure Steam Turbine</td>
<td>2</td>
<td>4,203</td>
</tr>
<tr>
<td>Boiler/Steam Turbine</td>
<td>13</td>
<td>519,520</td>
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<tr>
<td>Combustion Turbine</td>
<td>4</td>
<td>40,200</td>
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<tr>
<td>Reciprocating Engine</td>
<td>1</td>
<td>3,200</td>
</tr>
<tr>
<td>Fuel Cell</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Microturbine</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Organic Rankine Cycle</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>13,500</td>
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<tr>
<td>Waste Heat to Power</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>21</strong></td>
<td><strong>580,623</strong></td>
</tr>
</tbody>
</table>

See U.S. DOE CHP Installation Database: [https://doe.icfwebservices.com/chpdb/](https://doe.icfwebservices.com/chpdb/)
Eastman’s Tennessee Operations
Kingsport, TN
FUEL: Natural Gas, Coal
THERMAL USE: Process Heat
MAX CAPACITY: 200 MW
IN OPERATION SINCE: 1930, latest addition in 1993
EQUIPMENT:
• 17 Boilers (Babcock and Wilcox, Alstom Power, and Riley Stoker)
• 19 Steam Turbines (General Electric and Siemens)
ESTIMATED YEARLY SAVINGS: $70 million

Source: Eastman Chemical Company
**Project Snapshot: Environmental Benefit**

SABIC Innovative Plastics
Mt. Vernon, IN

**Application/Industry:** Plastics

**Capacity (MW):** 80 MW

**Prime Mover:** Gas Turbine

**Fuel Type:** Natural Gas

**Thermal Use:** Process Heat

**Expected Installation Year:** 2016

**Testimonial:** SABIC’s new CHP facility is expected to reduce annual emissions by an amount equivalent to 110,000 automobiles. The site was impacted by Boiler MACT emissions standards.

**Project Snapshot: Power Export**

SunCoke Energy  
South Shore, KY

**Application/Industry:** Coke Production  
**Capacity (MW):** 90 MW  
**Prime Mover:** Steam Turbine  
**Fuel Type:** Waste Heat  
**Thermal Use:** Coking Ovens  
**Expected Installation Year:** 2018  
**Energy Savings:** Unknown

**Testimonial:** “The SESS coke plant will be the best-controlled of its type in the United States, if not the world, due to the coke plant design, the air pollution controls, and planned equipment redundancy.”

Source: Suncoke filing with Kentucky PSC,  
Southeast U.S. CHP Technical Potential

Technical Potential by State (MW)

- FL, 5,464 MW
- GA, 4,478 MW
- LA, 3,958 MW
- NC, 3,829 MW
- TN, 3,197 MW
- AL, 2,325 MW
- SC, 2,555 MW
- KY, 1,966 MW
- MS, 1,670 MW
- AR, 1,352 MW
- KY, 1,966 MW

Technical Potential by Application (MW)

- Chemicals, 5,788 MW
- Other Comm., 5,627 MW
- Wood Products, 1,125 MW
- Hospitals, 1,605 MW
- Food, 1,126 MW
- Other Ind., 2,151 MW
- Textiles, 2,218 MW
- Refining, 1,726 MW
- Schools, 2,702 MW
- Colleges/Univ., 2,841 MW
- Paper, 3,887 MW

Source: ICF Internal Estimates (2014)
### Waste Heat to Power CHP

#### Technical/Economic Potential in TVA States

<table>
<thead>
<tr>
<th>State</th>
<th>Technical Potential</th>
<th>Market Penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>293.5</td>
<td>89.1</td>
</tr>
<tr>
<td>GA</td>
<td>27.6</td>
<td>4.3</td>
</tr>
<tr>
<td>KY</td>
<td>247.6</td>
<td>67.9</td>
</tr>
<tr>
<td>MS</td>
<td>242.3</td>
<td>75.9</td>
</tr>
<tr>
<td>NC</td>
<td>90.5</td>
<td>26.0</td>
</tr>
<tr>
<td>TN</td>
<td>121.4</td>
<td>36.0</td>
</tr>
<tr>
<td>VA</td>
<td>84.9</td>
<td>21.1</td>
</tr>
</tbody>
</table>

Based on:
- Waste heat inventory flows/temperatures
- WHP CHP equipment efficiency / costs
- EIA industrial sector electricity price averages
- State average paybacks from 4.5 to 7.2 years

Screening Questions
What makes a “good” CHP project?

• Do energy costs make up a significant part of your company's manufacturing/production costs?
• Are you concerned about the impact of current or future energy costs on your business?
• Are you concerned about power reliability? Is there a substantial financial impact to your business if the power goes out for 1 hour? For 5 minutes?
• Does your facility operate for more than 3000 hours per year?
• Do you have thermal loads throughout the year (including steam, hot water, chilled water, hot air, etc.)?
Screening Questions
What makes a “good” CHP project?

- Does your facility have an existing central plant?
- Do you expect to replace, upgrade, or retrofit central plant equipment within the next 3-5 years?
- Do you anticipate a facility expansion or new construction project within the next 3-5 years?
- Have you already implemented energy efficiency measures and still have high energy costs?
- Are you interested in reducing your facility's impact on the environment?
- Do you have access to on-site or nearby biomass resources (i.e. landfill gas, farm manure, food processing waste, etc.)?
CHP TAP Project Development
Technical Assistance

- Screening and Preliminary Analysis: Quick screening questions with spreadsheet payback calculator.
- Investment Grade Analysis: 3rd Party review of Engineering Analysis. Review equipment sizing and selection.
**TVA’s Role in Project**

- TVA will provide:
  - A minimal level of general oversight.
  - Financial assistance towards project’s capital issued in progress-based payments.
  - TVA will conduct measurement and verification activities to determine the emissions reduction benefits and other benefits of the CHP/WHR installation.
  - Continue to provide regular reports as required to EPA on overall progress of project.
Proposal Evaluation Criteria

- **Project Narrative**
  - Clarity, thoroughness, and demonstrable understanding of project objectives and critical project design elements.

- **Technology**
  - Technical feasibility, likelihood of generating enough electricity to achieve projected emissions reductions over life of the project.

- **Leverage**
  - The greater the proposed level of funding made available by proposer the better; increased leverage is key to the success.

- **Fuel**
  - Use of renewable fuels (biomass, biogas, etc.) will be looked upon favorably.
More Evaluation Criteria

• Team Qualifications and Experience
  – Capabilities and past experience of the project team.

• Innovation
  – Innovative but commercial-ready technologies, potential for long term operations and sustainability.
# Project Milestones

<table>
<thead>
<tr>
<th>MILESTONE / DELIVERABLE</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFP issued to industrial customers</td>
<td>August 3, 2015</td>
</tr>
<tr>
<td>External webinar - RFP Overview</td>
<td>September 16, 2015</td>
</tr>
<tr>
<td>Proposals due</td>
<td>December 7, 2015</td>
</tr>
<tr>
<td>Evaluate proposals &amp; award contract</td>
<td>March 2016</td>
</tr>
<tr>
<td>Environmental permitting and reviews</td>
<td>August 2016</td>
</tr>
<tr>
<td>Detailed design and engineering package</td>
<td>December 2015</td>
</tr>
<tr>
<td>Design review and approval</td>
<td>May 2017</td>
</tr>
<tr>
<td>Equipment procurement</td>
<td>December 2017</td>
</tr>
<tr>
<td>Begin site preparation</td>
<td>June 2018</td>
</tr>
<tr>
<td>Begin construction, develop operating procedures</td>
<td>October 2018</td>
</tr>
<tr>
<td>Construction complete</td>
<td>September 2019</td>
</tr>
<tr>
<td>System prove-out, operator training</td>
<td>December 2019</td>
</tr>
<tr>
<td>Commercial operation and project completion</td>
<td>April 2020</td>
</tr>
<tr>
<td>Final Report to EPA</td>
<td>June 2020</td>
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</tbody>
</table>
Questions

For questions contact:
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