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

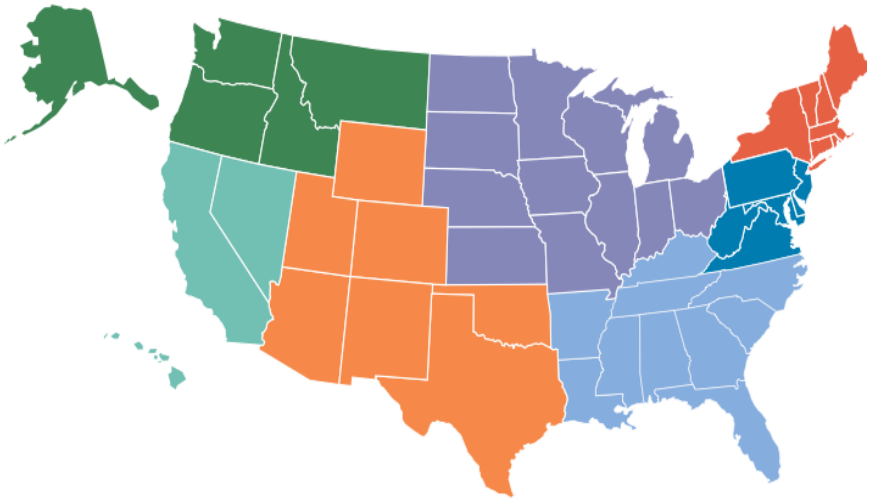
by Isaac Panzarella, DOE Southeast CHP TAP

- 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)

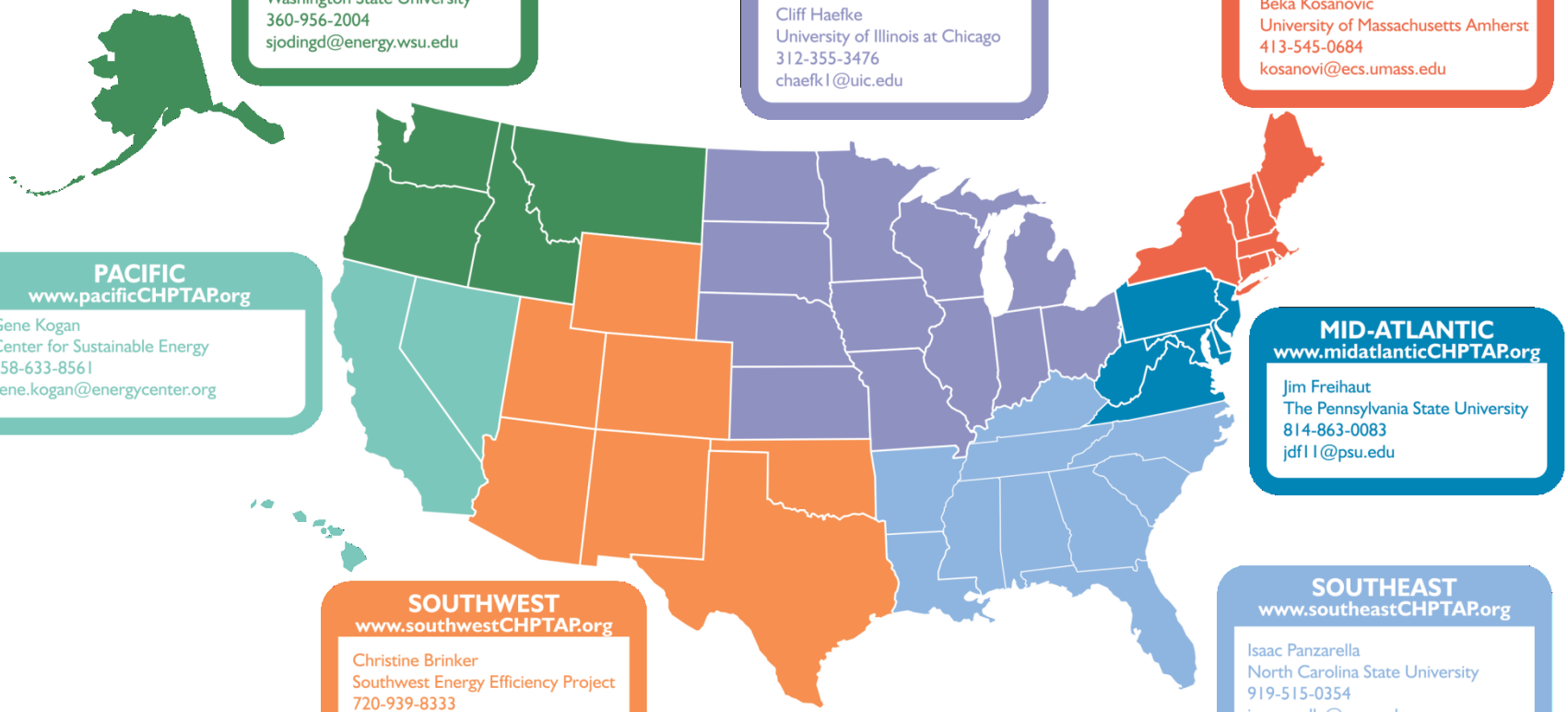
DOE's CHP TAPs promote and assist in transforming the market for CHP, waste heat to power, and district energy or microgrid with CHP throughout the United States. Key services include:

- 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

DOE CHP Technical Assistance Partnerships (CHP TAPs)



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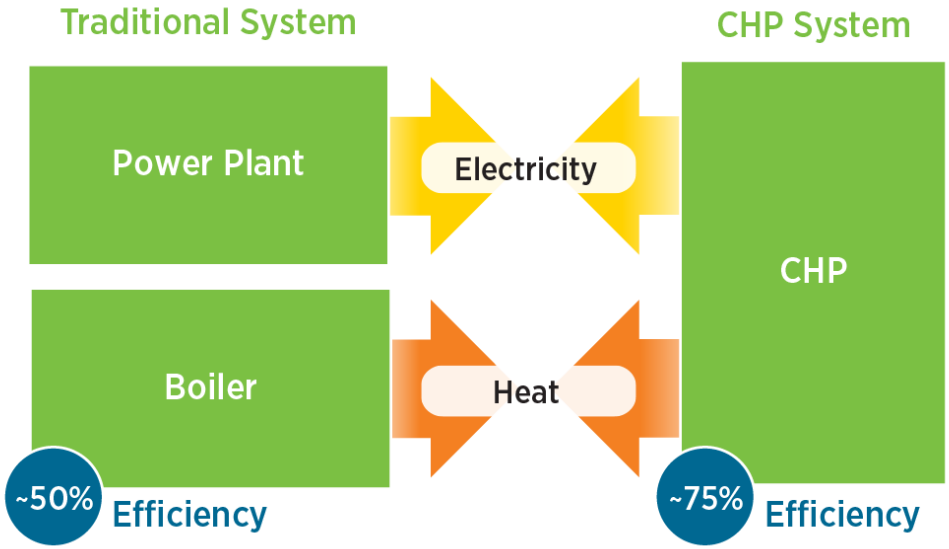
What is Combined Heat & Power?

- 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



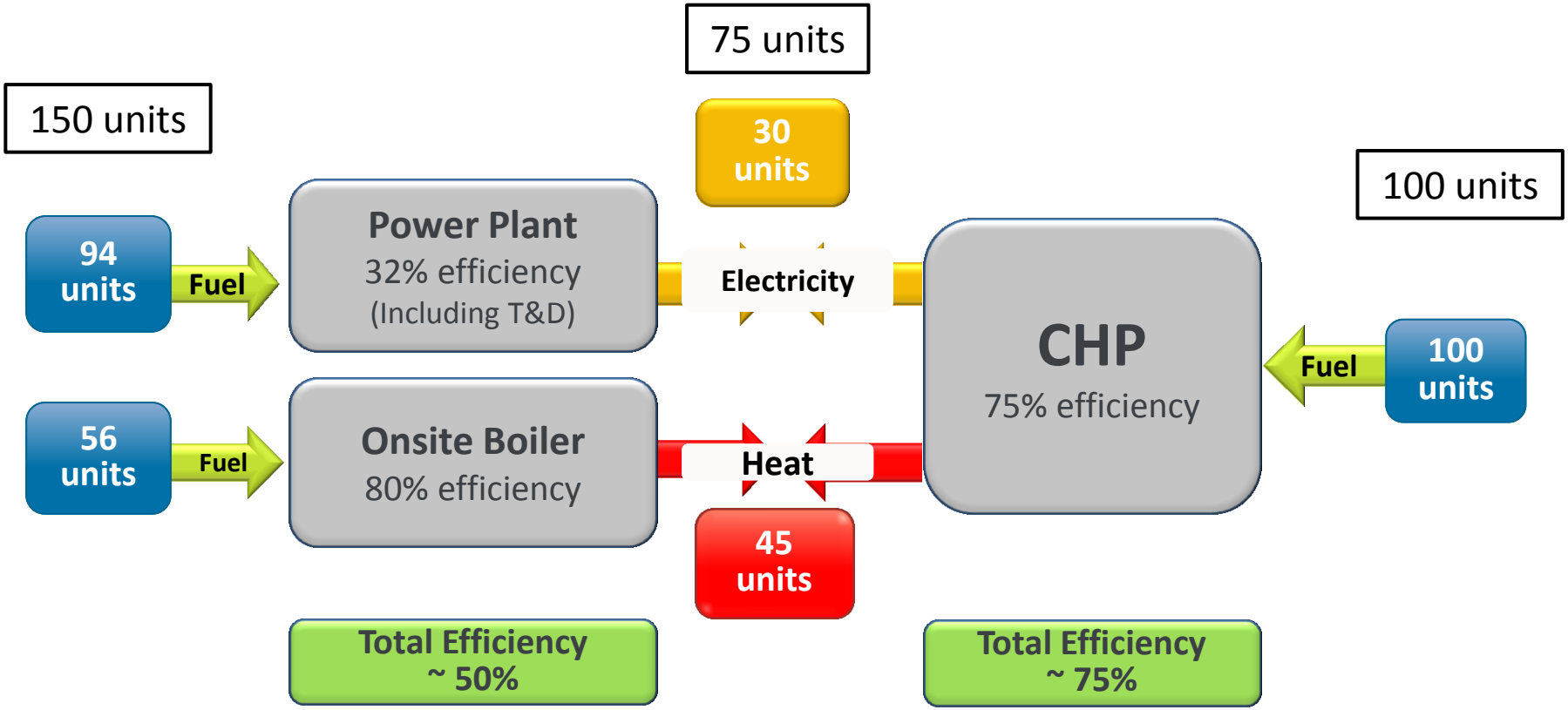
CHP provides efficient, clean, reliable, affordable energy – today and for the future.

See CHP Basics: http://www.energy.gov/eere/amo/combined-heat-and-power-basics

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:
  - An accessible source of waste heat
  - A recovery technology
  - 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



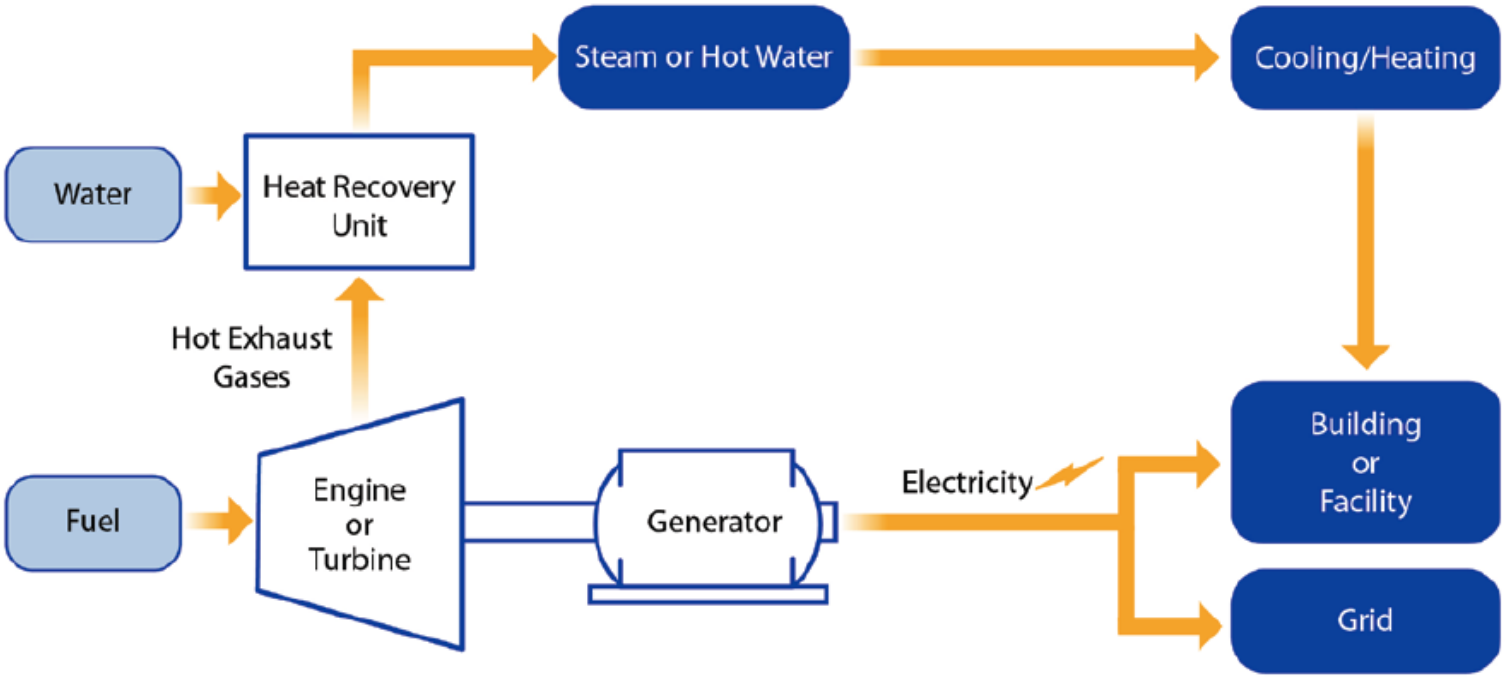
with 30 to 55% less greenhouse gas emissions

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%

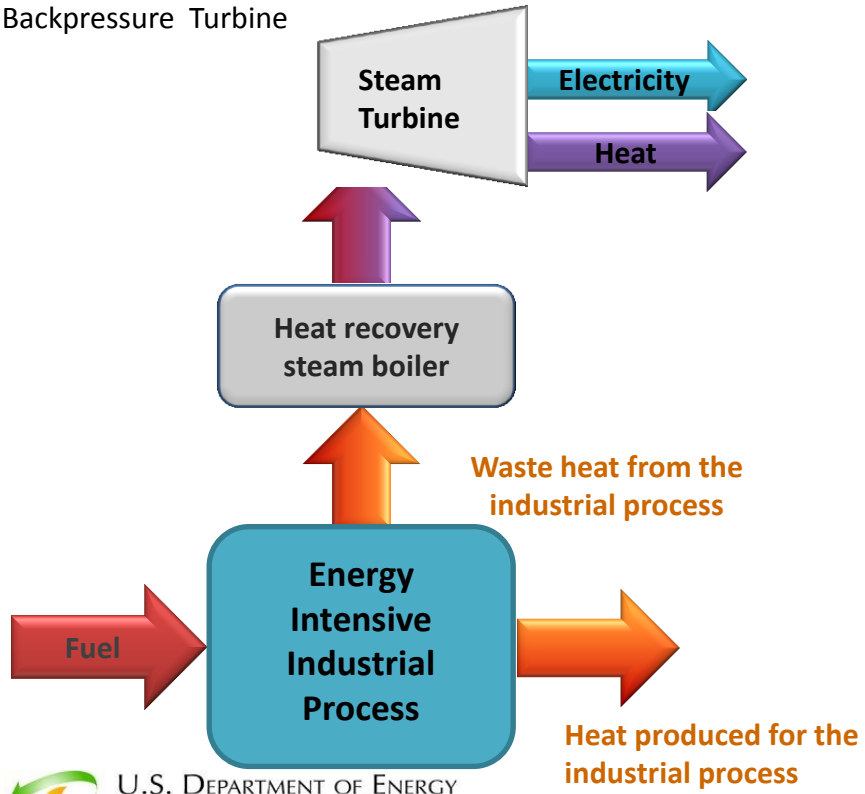
Defining CHP

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)

HRSG/Steam Turbine
Organic Rankine Cycle
Backpressure Turbine



- 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

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

See U.S. DOE CHP Installation Database: https://doe.icfwebservices.com/chpdb/

Project Snapshot: *Efficiency and Cost Savings*

Eastman's Tennessee Operations

Kingsport, TN

FUEL: Natural Gas, Coal

THERMAL USE: Process Heat

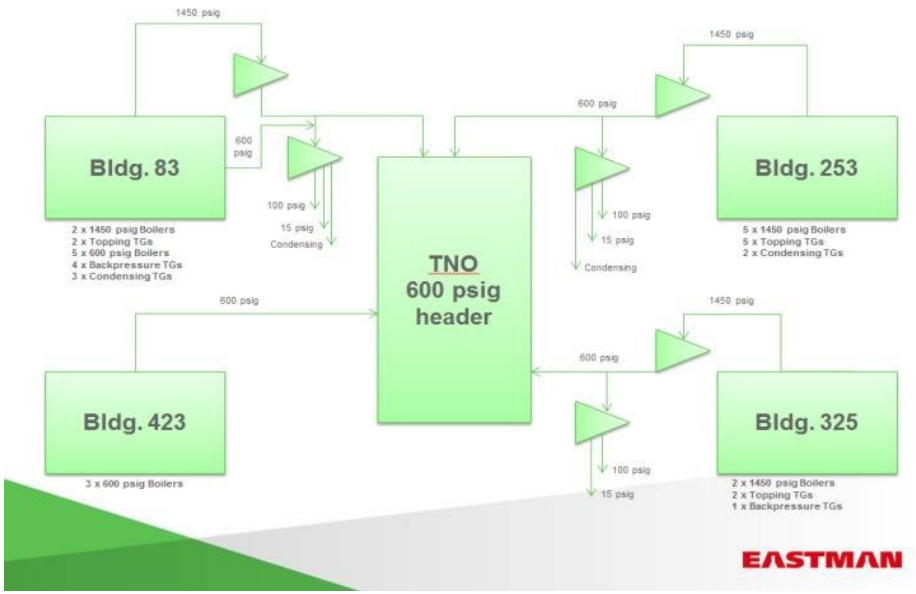
MAX CAPACITY: 200 MW

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.

Source: http://www.industrysourcing.com/articles/286116.aspx https://www.sabic-ip.com/gep/en/NewsRoom/PressReleasePrint/december_03_2013_sabicsinnovativeplastics.html

Project Snapshot: *Power Export*

SunCoke Energy

South Shore, KY

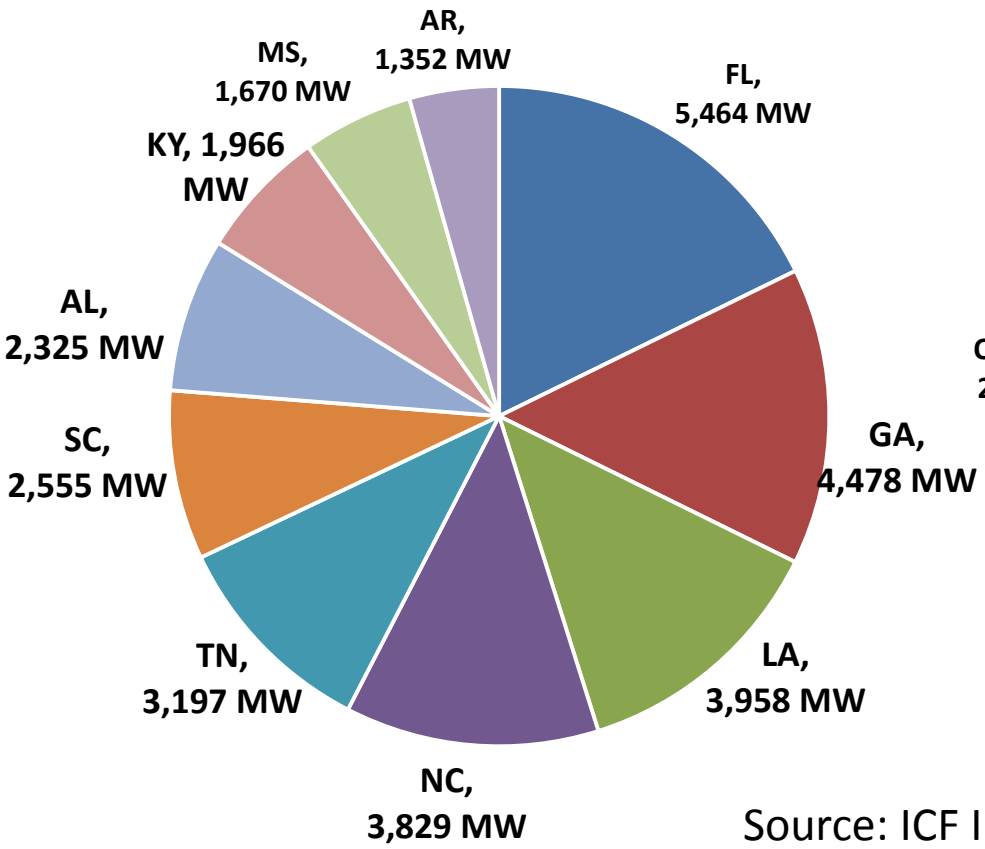
Application/Industry: Coke Production
Capacity (MW): 90 MW
Prime Mover: Steam Turbine
Fuel Type: Waste Heat
Thermal Use: Coking Ovens
Expected Installation Year: 2018
Energy Savings: Unknown

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."

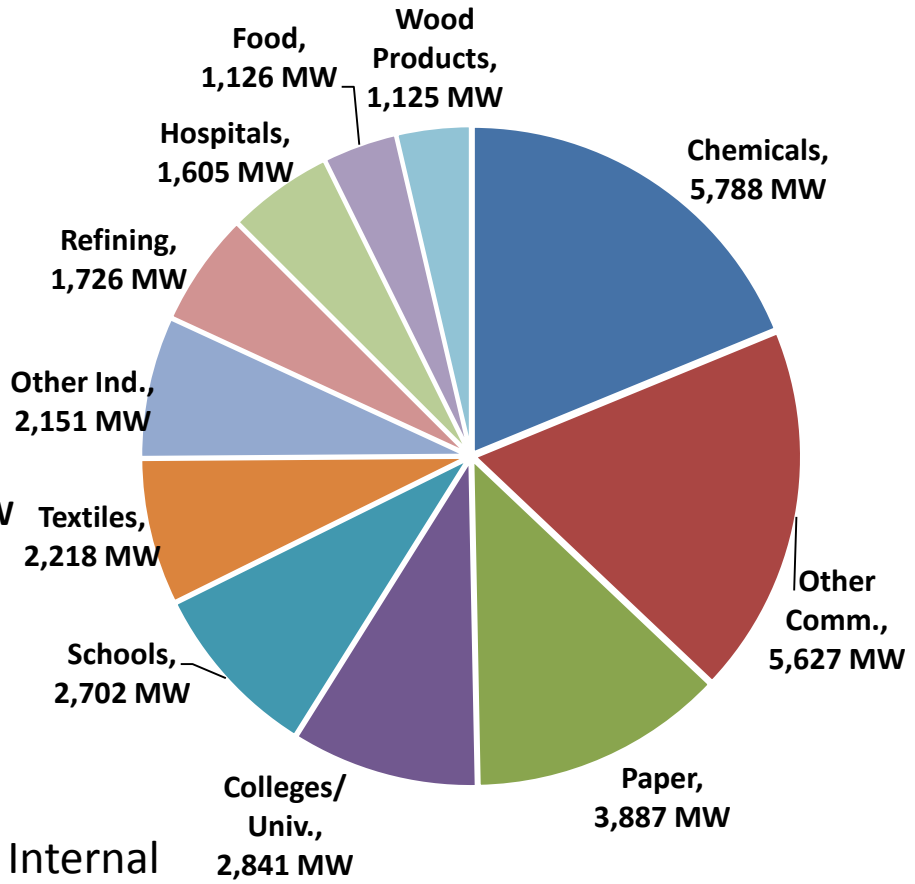
Source: Suncoke filing with Kentucky PSC, http://psc.ky.gov/PSCSCF/2014%20cases/2014-00162/20141215_Suncoke%20Energy%20South%20Shore%20LLC_Response%20to%20Staff%20First%20Data%20Request.pdf

Southeast U.S. CHP Technical Potential

Technical Potential by State (MW)



Technical Potential by Application (MW)

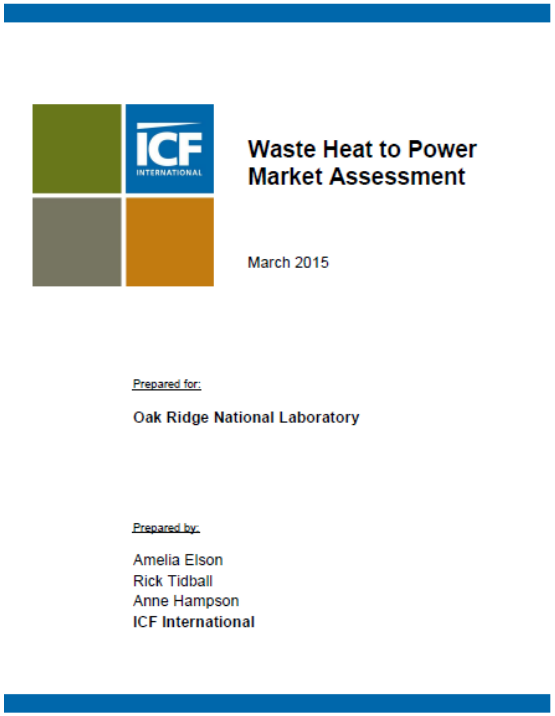


Source: ICF Internal Estimates (2014)

U.S. Department of Energy
CHP Technical Assistance Partnerships
SOUTHEAST

Waste Heat to Power CHP

Technical/Economic Potential in TVA States



State	Technical Potential	Market Penetration	
		MW	(%)
AL	293.5	89.1	30%
GA	27.6	4.3	16%
KY	247.6	67.9	27%
MS	242.3	75.9	31%
NC	90.5	26.0	29%
TN	121.4	36.0	30%
VA	84.9	21.1	25%

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

See ICF WHP Market Assessment: http://info.ornl.gov/sites/publications/Files/Pub52953.pdf

Screening Questions

What makes a "good" CHP project?

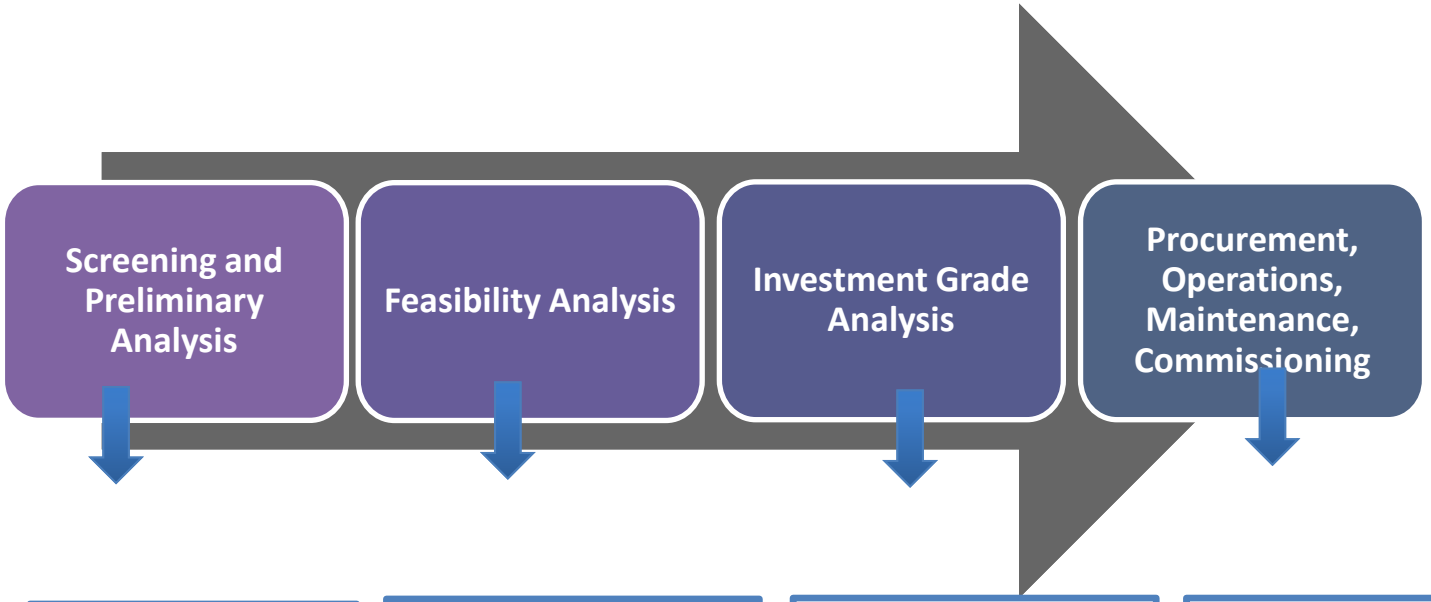
- Do energy costs make up a significant part of your company's manufacturing/production costs?
- Are you concerned about the impact of current or future energy costs on your business?
- Are you concerned about power reliability? Is there a substantial financial impact to your business if the power goes 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



US DOE CHP TAP Services:

Screening and Preliminary Analysis	Feasibility Analysis	Investment Grade Analysis	Procurement, Operations, Maintenance, Commissioning
Quick screening questions with spreadsheet payback calculator.	Uses available site information. Estimate: savings, Installation costs, simple paybacks, equipment sizing and type.	3rd Party review of Engineering Analysis. Review equipment sizing and selection.	Review specifications and bids. Limited operational analysis

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

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

Questions

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