CHP Technical Potential in South Carolina

Prepared for the South Carolina Biomass Council by the

DOE Southeast CHP Technical Assistance Partnership

September 2015

Authors:

Keith McAllister, Southeast CHP TAP Senior Technical Advisor

Art Samberg, Southeast CHP TAP Assistant Director

Isaac Panzarella, Southeast CHP TAP Director

Introduction

What is Combined Heat and Power?

Combined Heat and Power (CHP) is an efficient approach to generating power and useful thermal energy (heating or cooling) from a single fuel source at the point of use. Instead of purchasing electricity from the local utility and using fuel in an onsite boiler or furnace to produce needed thermal energy, an industrial or commercial facility can use CHP to provide both services onsite in one energy efficient step. By recovering the heat normally wasted in power generation and avoiding transmission and distribution losses in delivering electricity from the power plant to the user, CHP reduces overall energy use, lowers emissions and, depending on local conditions, provides operating savings and increased reliability to the user.

CHP can be configured either as a topping or bottoming cycle. In a topping cycle, fuel is combusted in a prime mover such as a gas turbine or reciprocating engine, generating electricity or mechanical power. Energy normally lost in the prime mover's hot exhaust and/or cooling systems is recovered to provide process heat, hot water, or space heating/cooling for the site. In a bottoming cycle, also referred to as waste heat to power, heat energy is recovered from the hot exhaust of a furnace or kiln to generate mechanical power or electricity for the site. Common thermal loads for CHP applications can be used to produce process steam or process heat for industrial facilities; cooling, heating, and humidity control systems for buildings; or domestic hot water wherever the need exists.

The diagram below, for a topping cycle CHP application, illustrates how delivering power and thermal energy to a site with CHP improves overall efficiency compared to separate delivery of power and heat. By using a single fuel source, CHP can deliver the needed energy to a site at an efficiency of 70-80%, and reduces greenhouse gas emissions by 33-50%.

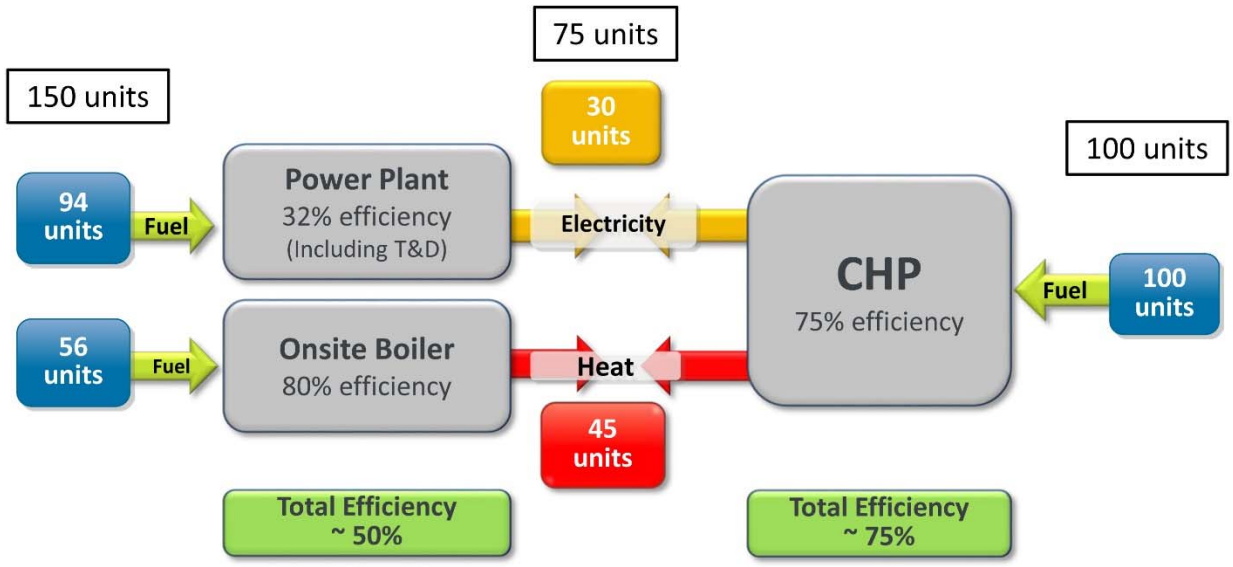


Figure 1: CHP Delivers the Same Energy, at Greater Efficiency

A key strength of CHP technology lies in its flexibility. Although natural gas is the most prevalent fuel source, CHP can also utilize opportunity fuels such as LFG, biomass, and digester gas. CHP is particularly effective when byproducts from industrial processes can be used as fuel.

Existing CHP in South Carolina

The US DOE Combined Heat and Power Installation Database currently shows 29 CHP installations in South Carolina[1]. The total capacity of the sites is more than 1,392 MW with individual sites as small as 5 kW and as large as 630 MW. Table 1 shows the types of industries that employ CHP as well as the capacity for each industrial sector.

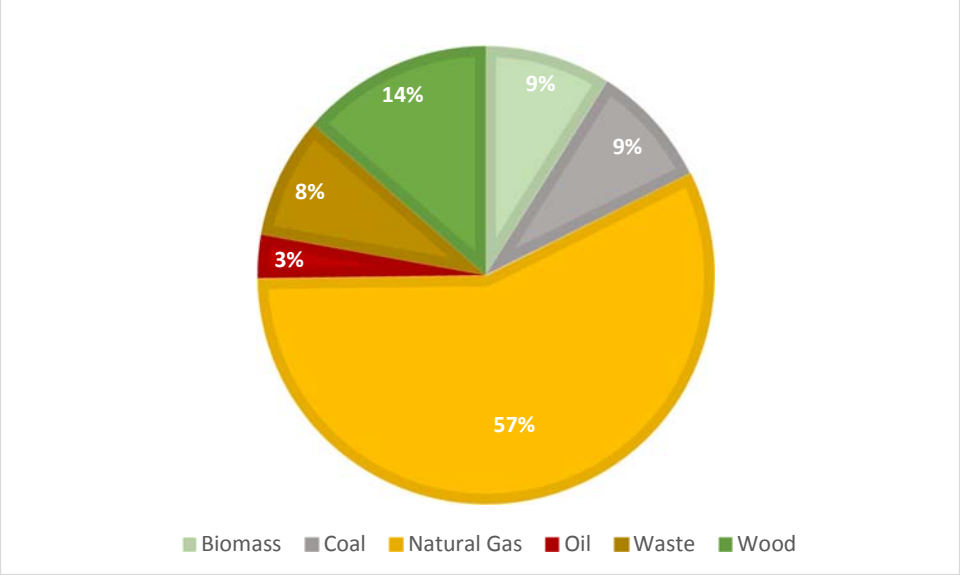
Table 1: CHP capacity by industrial sector

Industry	CHP Electrical Capacity [kW]
Agriculture	1,808
Chemicals	777,700
Colleges / Universities	14,084
General Government.	20,000
Military / National Security	19,505
Pulp and Paper	475,400
Textiles	7,290
Transportation Equipment	41,000
Utilities	13,150
Wastewater Treatment	22,440
Total	**1,392,377**

These existing CHP sites utilize a variety of fuel sources. While natural gas is by far the primary fuel choice, biomass and wood combine to supply approximately 23% of the CHP capacity in the state. Figure 2 shows the amount of capacity supplied by fuel type.

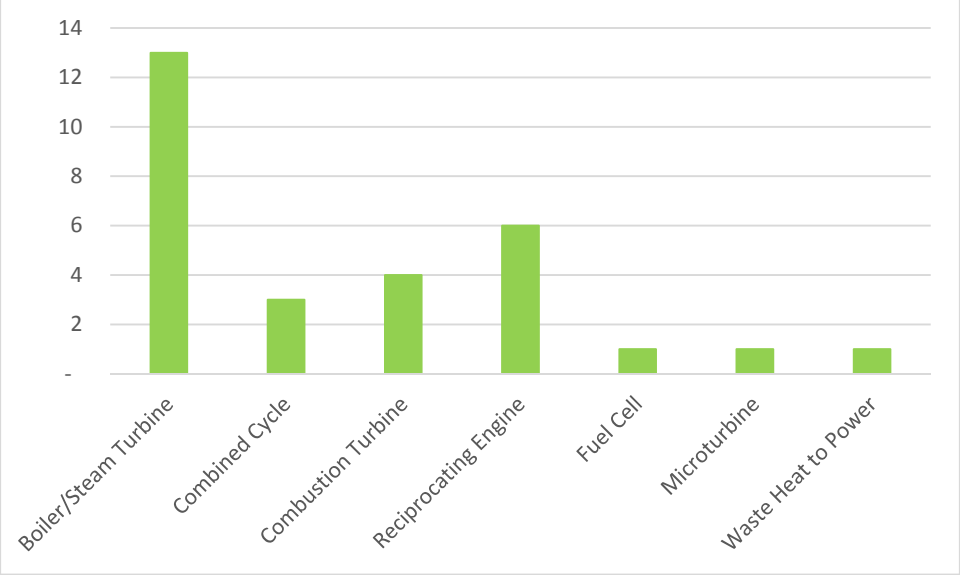
[1] https://doe.icfwebservices.com/chpdb/state/SC

Figure 2: CHP capacity in SC by fuel source



The existing sites use a variety of CHP technologies as well. Figure 3 shows the number of each type of CHP technology currently deployed in South Carolina.

Figure 3: Quantity of each technology type



The CHP profile in South Carolina is dominated by one site, the Columbia Energy Center, which is a Combined Cycle facility that provides thermal energy to a DAK Americas (formally Eastman Chemical) plant in Gaston, SC[2]. Two natural gas fired Combustion Turbines rated at nearly 345 MW electrical, generate 1,100 °F exhaust which is fed into two Heat Recovery Steam Generators (HRSGs). The HRSGs

[2] http://www.power-technology.com/projects/columbia-energy/

generate enough steam to provide an additional 285 MW of electricity while also providing steam to the chemical plant. The reduced fuel consumption of the CHP system compared to onsite thermal generation and purchased electricity results in estimated CO_2 reductions of 142,000 tons per year. Combined Cycle power plants have recently been a leading technology choice to replace coal fired power plants[3].

Technical Potential for CHP in South Carolina

ICFI has completed an analysis of technical potential for CHP in South Carolina for the Environmental Protection Agency (EPA). The following description of how the technical potential was derived was taken from the ICFI report[4].

The estimation of technical market potential consists of the following elements:

• Identification of applications where CHP provides a reasonable fit to the electric and thermal needs of the user.

• Quantification of the number and size distribution of target applications / facilities.

• Estimation of CHP potential by megawatt (MW) capacity utilizing proprietary analysis tools.

• Subtraction of existing CHP from the identified sites to determine the remaining technical market potential.

The technical market potential does not consider screening for economic rate of return or other factors such as ability to retrofit, owner interest in applying CHP, capital availability, natural gas (or other fuel) availability, and variation of energy consumption within customer application/size class. The technical potential as outlined is useful in understanding the potential size and size distribution of the target CHP markets in the state. Identifying technical market potential is a preliminary step in the assessment of market penetration.

Based on this methodology, ICF analyzed three scenarios:

- Industrial technical potential where the size of the system was limited to the plant electrical load (no export of electricity).
  Technical Potential: 1,809 MW
- Industrial technical potential where the size of the system was limited to the plant thermal load (export of electricity allowed if applicable),
  Technical Potential: 4,278 MW
- Commercial technical potential.
  Technical Potential: 864 MW

The following three tables outline South Carolina's CHP technical potential. Table 2 shows the Industrial CHP technical potential for onsite electrical use. In other words, the size of the CHP system is constrained so that electricity is not exported to the grid. Table 3 shows the Industrial CHP technical potential with export of electricity allowed while Table 4 shows the Commercial CHP technical potential.

[3] http://www.powermag.com/replacing-coal-u-s-combined-cycle-development-trends-challenges/
[4] ICF International, Assessment of the Technical and Economic Potential for CHP in Oregon, pgs 4-6, 2014

Table 2: South Carolina Industrial CHP Technical Potential – Onsite Electrical Power Use Only[5]

SIC	Application	50-500 kW (MW)	.5-1 MW (MW)	1-5 MW (MW)	5-20 MW (MW)	>20 MW (MW)	Total MW
20	Food	6	4	17	0	0	26
22	Textiles	17	19	158	160	0	353
24	Lumber and Wood	21	7	42	5	32	108
25	Furniture	0	0	0	0	0	0
26	Paper	9	8	27	65	505	614
27	Printing	2	0	0	0	0	2
28	Chemicals	16	22	87	139	210	473
29	Petroleum Refining	0	0	0	0	0	0
30	Rubber/Misc Plastics	19	7	17	71	0	115
32	Stone/Clay/Glass	0	0	9	0	0	10
33	Primary Metals	6	9	28	0	0	43
34	Fabricated Metals	3	0	0	0	0	3
35	Machinery/Computer Equip	1	0	5	0	0	6
37	Transportation Equip.	6	15	24	7	0	52
38	Instruments	1	0	1	0	0	2
39	Misc. Manufacturing	1	0	0	0	0	1
49	Gas Processing	0	0	0	0	0	0
	Total	**109**	**90**	**415**	**447**	**747**	**1,809**

[5] ICF International Estimates, October 2013.

Table 3: South Carolina Industrial CHP Technical Potential – with Exported Electrical Power[6]

SIC	Application	50-500 kW (MW)	.5-1 MW (MW)	1-5 MW (MW)	5-20 MW (MW)	>20 MW (MW)	Total MW
20	Food	6	2	32	0	0	40
22	Textiles	17	19	158	160	0	353
24	Lumber and Wood	21	7	55	30	191	305
25	Furniture	0	0	0	0	0	0
26	Paper	9	8	17	41	2,098	2,173
27	Printing	0	0	0	0	0	0
28	Chemicals	14	22	107	202	771	1,116
29	Petroleum Refining	0	0	0	0	0	0
30	Rubber/Misc Plastics	20	7	19	34	40	120
32	Stone/Clay/Glass	0	0	0	0	61	62
33	Primary Metals	6	9	28	0	0	43
34	Fabricated Metals	2	1	0	0	0	3
35	Machinery/Computer Equip	1	0	5	0	0	6
37	Transportation Equip.	6	15	24	7	0	52
38	Instruments	1	0	2	0	0	3
39	Misc. Manufacturing	1	0	0	0	0	1
49	Gas Processing	0	0	0	0	0	0
	Total	**106**	**89**	**448**	**474**	**3,162**	**4,278**

[6] ICF International Estimates, October 2013.

Table 4: South Carolina Commercial CHP Technical Potential[7]

SIC	Application	50-500 kW (MW)	.5-1 MW (MW)	1-5 MW (MW)	5-20 MW (MW)	>20 MW (MW)	Total MW
43	Post Offices	1	0	0	0	0	1
52	Retail	28	6	0	0	0	33
4222	Refrigerated Warehouses	1	0	0	0	0	1
4581	Airports	0	1	13	0	0	14
4952	Water Treatment	2	0	0	0	0	2
5411	Food Stores	20	1	2	0	0	23
5812	Restaurants	36	1	0	0	0	36
6512	Commercial Buildings	37	120	45	0	0	202
6513	Multifamily Buildings	4	9	3	0	0	16
7011	Hotels	38	11	10	0	0	59
7211	Laundries	4	0	0	0	0	4
7374	Data Centers	2	1	0	0	0	4
7542	Car Washes	2	0	0	0	0	2
7832	Movie Theaters	0	0	0	0	0	0
7991	Health Clubs	3	0	0	0	0	3
7997	Golf/Country Clubs	15	0	0	0	0	15
8051	Nursing Homes	16	2	1	0	0	19
8062	Hospitals	10	16	62	11	0	98
8211	Schools	51	29	1	0	0	81
8221	College/Univ.	6	8	57	5	0	77
8412	Museums	0	0	0	0	0	0
9100	Government Buildings	34	9	26	14	0	83
9223	Prisons	2	3	54	0	0	60
9711	Military	2	0	21	10	0	32
Total		**315**	**216**	**294**	**39**	**0**	**864**

[7] ICF International Estimates, October 2013.

CHP as a Boiler MACT Compliance Strategy

On January 31, 2013, the U.S. Environmental Protection Agency (EPA) published their National Emissions Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters (known as the Boiler MACT). This rule applied to large and small boilers in a wide range of industrial facilities and institutions. The U.S. Department of Energy (DOE) offered technical assistance to ensure that major sources burning coal or oil have information on cost-effective clean energy strategies for compliance, including combined heat and power, and to promote cleaner, more efficient boilers to cut harmful pollution and reduce operational costs. The technical assistance program evaluated sites based on their reported boiler type and fuel usage. The program looked at the cost of implementing Maximum Achievable Control Technologies (MACT) to existing systems, converting the systems to natural gas fired boilers and converting the systems to natural gas fired CHP. In South Carolina, a total of 30 sites were identified. The Southeast CHP TAP (then known as the Southeast Clean Energy Application Center) reached out to the thirty sites and offered technical support. Table 5 summarizes the results of this effort.

Table 5: Summary of SC Boiler MACT Plant Status

Status	Number
Plant closed	6
In compliance	5
Switched to NG	5
Switched to biomass	2
Declined TAP support	2
No response	6
Not subject to MACT	4
Total	30

Some of these facilities may be candidates for CHP depending upon their current Boiler MACT compliance status.

Next Steps

U.S. Department of Energy's (DOE) Regional CHP Technical Assistance Partnerships (CHP TAPs) promote and assist in transforming the market for CHP, waste heat recovery, and district energy CHP technologies and concepts throughout the United States.

The Southeast CHP TAP, based at the NC Clean Energy Technology Center at NC State University, serves ten states in the Southeastern United States, including South Carolina. Key services of the Regional CHP TAPs 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, energy 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 project development process from initial CHP screening to installation.

The attached flyer presents an overview of the DOE Southeast CHP TAP and the technical assistance offered to promote CHP and assist end-users in evaluating the CHP potential for their particular facility.

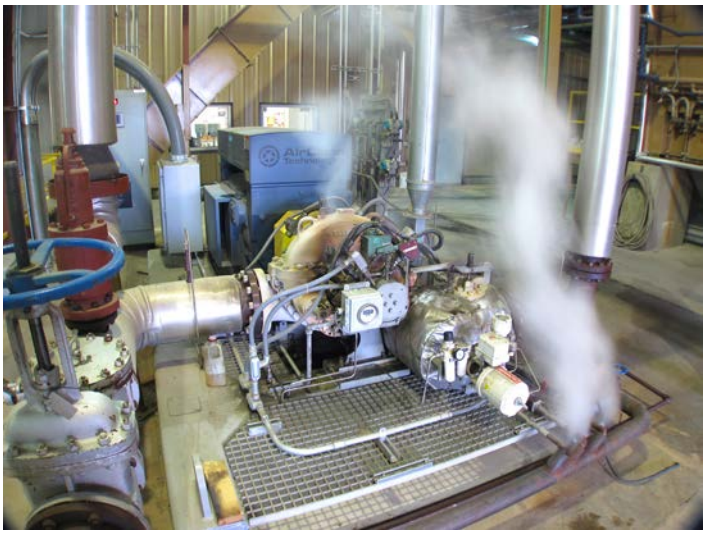
U.S. Department of Energy
CHP Technical Assistance Partnerships
SOUTHEAST

About Us

The U.S. DOE Southeast Combined Heat and Power Technical Assistance Partnership (CHP TAP) is one of seven regional CHP TAPs formed by the U.S. Department of Energy to promote and assist in transforming the market for CHP, waste heat recovery, and district energy technologies and concepts throughout the United States. We are based at the North Carolina Clean Energy Technology Center at NC State University, and together with our project partners, we serve ten Southeastern states.

CHP Target

Working with a wide range of stakeholders, the U.S. DOE Southeast CHP TAP, formerly known as the Southeast Clean Energy Application Center, has helped the U.S. to nearly double the installed CHP capacity from 46 GW in 2000 to over 80 GW in 2012.
Now, there is a new goal: 40 GW of new CHP by 2020, as stated in the Executive Order of August 30, 2012 -- Accelerating Investment in Industrial Energy Efficiency.



CHP systems are based on prime movers that produce electricity such as this backpressure steam turbine and generator; thermal energy from the outlet of the turbine is recovered for useful purposes. Other prime movers include reciprocating engines or combustion turbines.

Technical Assistance and Project Support

We provide technical information to energy end-users and others to help them consider if CHP, waste heat recovery or district energy makes sense for them. Services include:

- Qualification Screenings and Feasibility Analyses from our staff to help determine if a CHP project is a good fit for your site. Screenings can be done either on-site or remotely. Any industrial, commercial or institutional site is eligible.
- Expert advice as you proceed with project development.
- Installation and implementation; utility, emissions, and siting issues.
- Third-party review of vendor proposals.
- Information on any available grants or incentives.
- Case studies of similar businesses that have installed CHP.
- Research of business climate and CHP market potential in key economic sectors.

Isaac Panzarella
Director
919-515-0354
ipanzarella@ncsu.edu

Christina Kopitopoulou
Project Support
919-515-7147
ckopito@ncsu.edu

Kevin Witchger
Project Support
919-513-4224
kwwitchg@ncsu.edu

Keith McAllister
Senior Engineer
keith@kestavaenergy.com

Art Samberg
Assistant Director
919-515-5959
asamber@ncsu.edu

Steve Kalland
Senior Policy Advisor
steve_kalland@ncsu.edu

NC CLEAN ENERGY TECHNOLOGY CENTER
Formerly the NC Solar Center

NC STATE UNIVERSITY

Project Partners

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

DEDI
KENTUCKY DEPARTMENT for ENERGY DEVELOPMENT & INDEPENDENCE

Project Sponsor

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Education and Outreach
The U.S. DOE Southeast CHP Technical Assistance Partnership develops case studies, fact sheets, technology briefs, sector-by-sector information, and other resources on the benefits and applications of CHP for state and local policy makers, regulators, energy end-users, trade associations, and others. We also organize or support outreach through presentations, webinars or workshops for particular market sectors or stakeholder groups with interest in CHP.

Market Assessments
Analysis of CHP market potential in diverse sectors such as health care, industrial sites, hotels, and new commercial and institutional buildings, as well as strategic market areas including chemicals, pulp and paper, biomass, military and critical infrastructure.

What are CHP, District Energy, and Waste Heat Recovery?

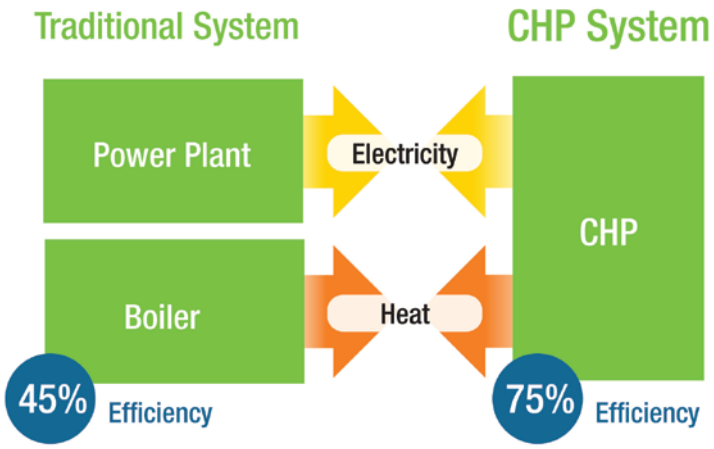
Combined Heat and Power (CHP) is... an efficient and clean approach to generating electric power and useful thermal energy from a single fuel source at the point of use. Every CHP application involves the recovery of otherwise-wasted thermal energy to produce cooling, heating or process thermal energy or electricity, improving energy efficiency and reducing greenhouse gas (GHG) emissions. CHP already supplies over 10% of our nation's electricity, and can and should supply more.

District Energy is... CHP, heating, and/or cooling applied to an entire university, office park, medical campus, mixed use sustainable development, or downtown. Over 400 building networks in the U.S. already use district energy, and the number is on the rise.

Waste Heat Recovery or Waste Heat to Power CHP is... capturing waste heat that an industrial site or pipeline compressor station is already emitting, and producing electricity with no additional fuel input or emissions output.

Where are these technologies used?
Many industrial, commercial, institutional and agricultural operations have the right characteristics for CHP, including:

- Chemical manufacturing
- Food Processing
- Hotels and casinos
- Hospitals
- Landfills
- Office buildings
- Military installations
- Pulp and paper
- Universities
- Wastewater treatment



The U.S. DOE Southeast CHP TAP is supported by funding by the U.S. Department of Energy, Advanced Manufacturing Office, Distributed Energy / Combined Heat and Power Program – Award No. DE-EE-0006278 and through funding from the State of North Carolina for the North Carolina Clean Energy Technology Center at NC State University.

Project partners include the International District Energy Association, the Kentucky Department of Energy Development and Independence and the North Carolina State Energy Office.