Combined Heat and Power Opportunities In Illinois

Presentation to the Association of Professional Energy Consultants

Graeme Miller
Assistant Director
US DOE Midwest CHP Technical Assistance Partnership
November 12, 2021

CHP Technical Assistance Partnerships
MIDWEST

Agenda

- DOE CHP Technical Assistance Partnerships
- CHP Concepts and Technologies
- CHP Markets
- Updates in Illinois Legislation
- Next Steps in Evaluating CHP

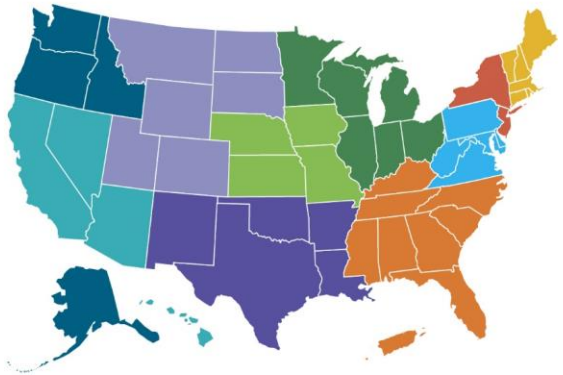
DOE CHP Technical Assistance Partnerships (CHP TAPs)

- **End User Engagement**
  Partner with strategic End Users to advance technical solutions using CHP as a cost effective and resilient way to ensure American competitiveness, utilize local fuels and enhance energy security. CHP TAPs offer fact-based, non-biased engineering support to manufacturing, commercial, institutional and federal facilities and campuses.
- **Stakeholder Engagement**
  Engage with strategic Stakeholders, including regulators, utilities, and policy makers, to identify and reduce the barriers to using CHP to advance regional efficiency, promote energy independence and enhance the nation's resilient grid. CHP TAPs provide fact-based, non-biased education to advance sound CHP programs and policies.
- **Technical Services**
  As leading experts in CHP (as well as microgrids, heat to power, and district energy) the CHP TAPs work with sites to screen for CHP opportunities as well as provide advanced services to maximize the economic impact and reduce the risk of CHP from initial CHP screening to installation.

www.energy.gov/chp

CHP Technical Assistance Partnerships
MIDWEST

DOE CHP Technical Assistance Partnerships (CHP TAPs)



Upper-West
CO, MT, ND, SD, UT, WY
www.uwchptap.org
Gavin Dillingham, Ph.D.
HARC
281-216-7147
gdillingham@harcresearch.og

Midwest
IL, IN, MI, MN, OH, WI
www.mwchptap.org
Cliff Haefke
University of Illinois at Chicago
312-355-3476
chaefke1@uic.edu

New England
CT, MA, ME, NH, RI, VT
www.nechptap.org
David Dvorak, Ph.D., P.E.
University of Maine
207-581-2338
dvorak@maine.edu

Northwest
AK, ID, OR, WA
www.nwchptap.org
David Van Holde, P.E.
Washington State University
360-956-2071
VanHoldeD@energy.wsu.edu

New York-New Jersey
NJ, NY
www.nynjchptap.org
Tom Bourgeois
Pace University
914-422-4013
tbourgeois@law.pace.edu

Western
AZ, CA, HI, NV
www.wchptap.org
Carol Denning
Center for Sustainable Energy
530-513-2799
carol.denning@energycenter.org

Mid-Atlantic
DC, DE, MD, PA, VA, WV
www.machptap.org
Jim Freihaut, Ph.D.
The Pennsylvania State University
814-863-0083
jdf11@psu.edu

Southcentral
AR, LA, NM, OK, TX
www.scchptap.org
Gavin Dillingham, Ph.D.
HARC
281-216-7147
gdillingham@harcresearch.org

Central
IA, KS, MO, NE
www.cchptap.org
Cliff Haefke
University of Illinois at Chicago
312-355-3476
chaefke1@uic.edu

Southeast
AL, FL, GA, KY, MS, NC, PR, SC, TN, VI
www.sechptap.org
Isaac Panzarella, P.E.
North Carolina State University
919-515-0354
ipanzarella@ncsu.edu

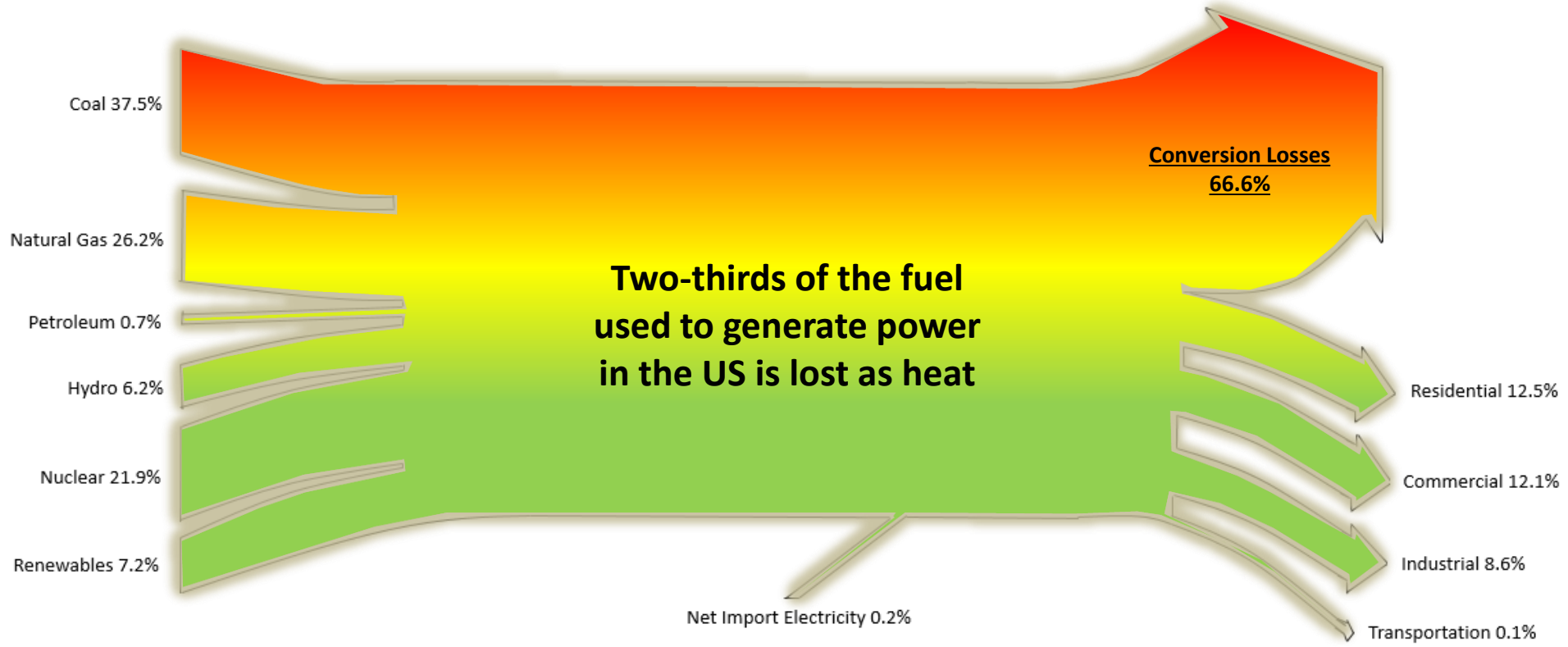
DOE CHP Deployment Program Contacts
www.energy.gov/CHPTAP

Robert "Bob" Schmitt
Technology Manager
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
Robert.Schmitt@ee.doe.gov

Patti Garland
DOE CHP TAP Coordinator [contractor]
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
Patricia.Garland@ee.doe.gov

CHP Technical Assistance Partnerships
MIDWEST

Energy Utilization in the Utility Sector

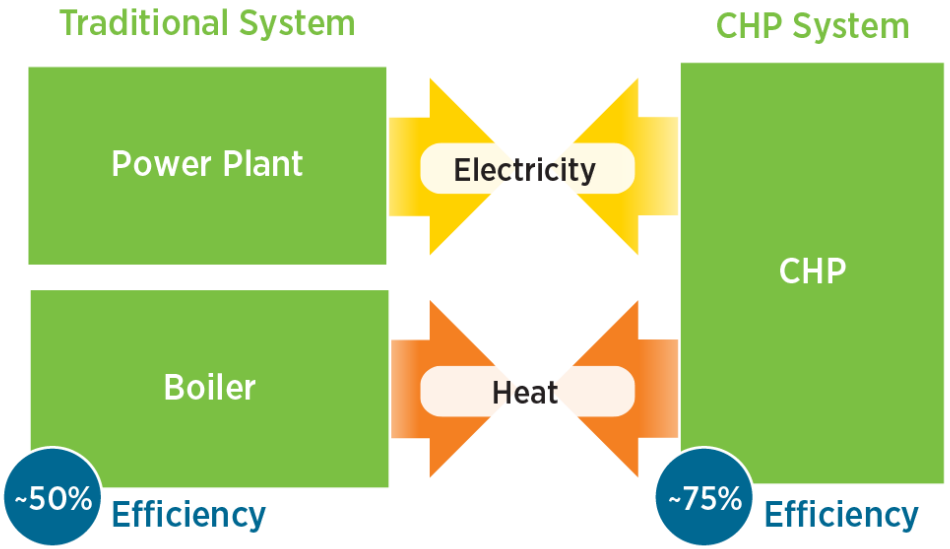


Source: https://flowcharts.llnl.gov/content/assets/images/charts/Energy/Energy_2015_United-States.png

CHP Technical Assistance Partnerships
MIDWEST

CHP: A Key Part of Our Energy Future

- 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

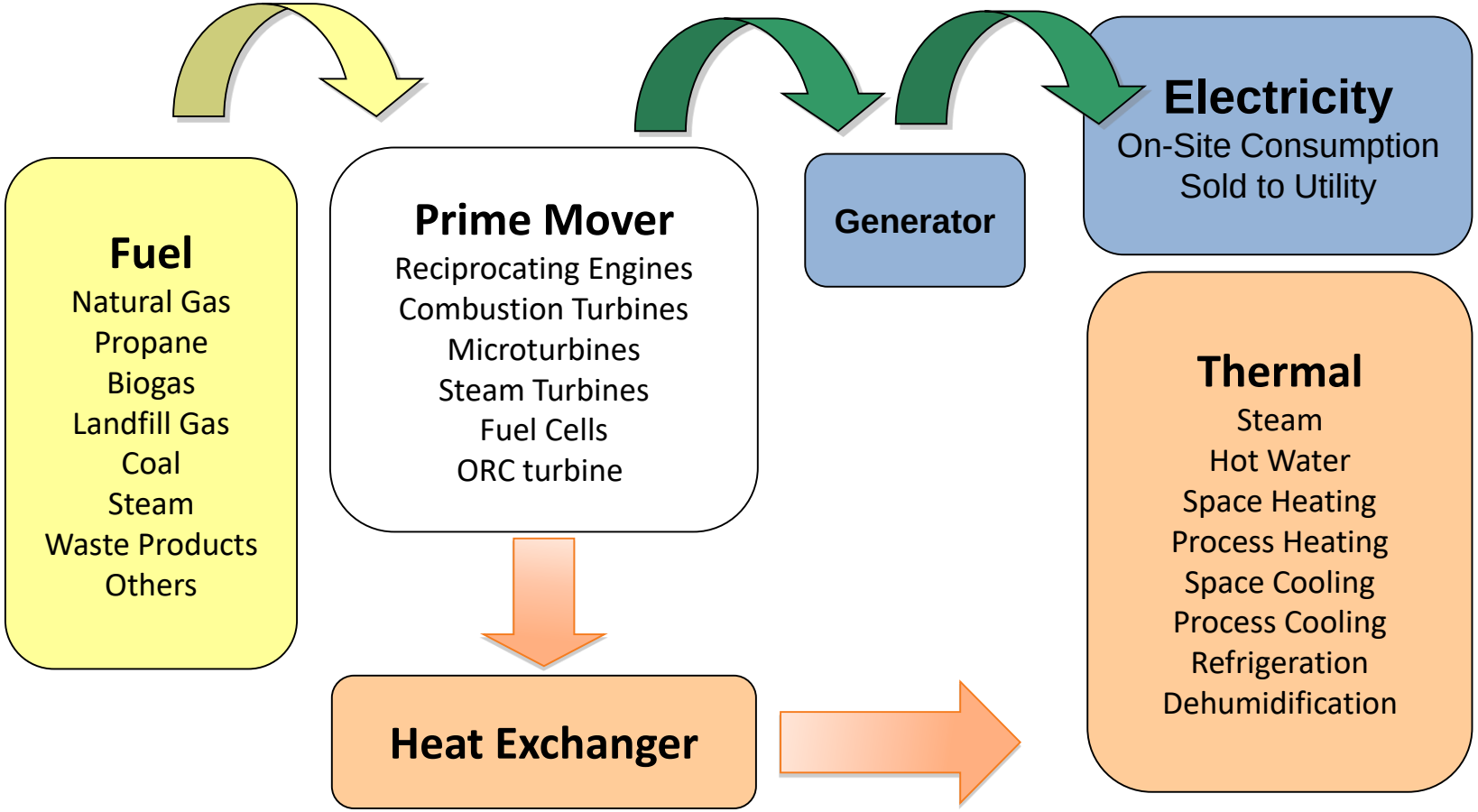


CHP provides efficient, clean, reliable, affordable energy – today and for the future.

Source: www.energy.gov/chp

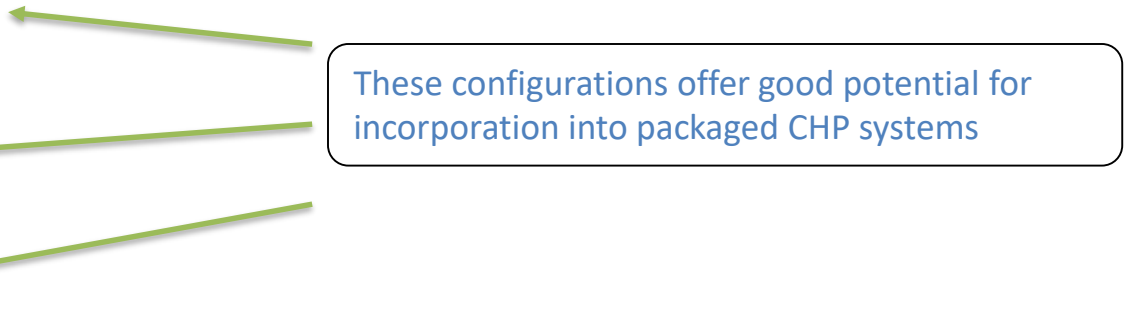
Overview of CHP Technologies

CHP System Schematic



Configurations

- CHP systems are often categorized based on the type of prime mover that drives the system. There are five predominant prime mover technologies used for CHP systems:
  - Reciprocating engines
  - Gas turbines
  - Microturbines
  - Boiler/steam turbines
  - Fuel cells



Prime Mover: Reciprocating Engines

- Size Range: 10 kW to 10 MW
- Characteristics
  - Thermal can produce hot water, low pressure steam, and chilled water (through absorption chiller)
  - High part-load operation efficiency
  - Fast start-up
  - Minimal auxiliary power requirements for black start.
- Example Applications:
  - universities, hospitals, water treatment facilities, industrial facilities, commercial buildings, and multi-family dwellings

Reciprocating engine CHP installation at an industrial facility.
Photo courtesy of Caterpillar.

Prime Mover: Gas Turbines

- Size Range: 1 MW to 300 MW
- Characteristics
  - Produces high quality, high temperature thermal that can include high pressure steam for industrial processes, and chilled water (with absorption chiller)
  - Available in a wide range of capacities and configurations
  - Best efficiency when operated at full load (part-load efficiency is often much lower than full load efficiency)
- Example Applications:
  - hospitals, universities, chemical plants, refineries, food processing, paper, military bases

Gas turbine CHP installation at a university.
Photo courtesy of Solar Turbines

Prime Mover: Microturbines

- Size Range: 30 kW to 330 kW *(modular packages exceeding 1 MW)*
- Characteristics
  - Thermal can produce hot water, steam, and chilled water (through absorption chiller)
  - Compact size and light weight
  - Inverter based generation can improve power quality
- Example Applications:
  - multifamily housing, hotels, nursing homes, waste water treatment, gas & oil production

Microturbine CHP installation at a commercial facility.
Photo courtesy of Capstone Turbine Corporation

Prime Mover: Steam Turbines

- Size Range: 100 kW to over 250 MW
- Characteristics
  - Requires a boiler or other steam source
  - Can be mated to boilers firing a variety of gaseous, liquid or solid fuels (e.g., coal and biomass fuels such wood, waste products, and pellets).
  - Mature technology with very high durability and reliability
  - Can operated over a wide range of steam pressures
  - Backpressure steam turbines can be used to produce power by replacing pressure reducing valves (PRVs) in existing steam systems
- Example Applications:
  - Industrial applications, district heating and cooling systems, forest products, paper mills, chemicals, food processing, PRVs

Steam turbine CHP installation at an industrial facility in New York.
Photo courtesy of Recycled Energy Development

Heat Recovery

- Heat Exchangers
  - Recover exhaust gas from prime mover
  - Transfers exhaust gas into useful heat (steam, hot water) for downstream applications
  - Heat Recovery Steam Generators (HRSG) the most common
- Heat-Driven Chillers
  - Absorption Chiller
    - Use heat to chill water
    - Chemical process (not mechanical)
  - Steam Turbine Centrifugal Chiller

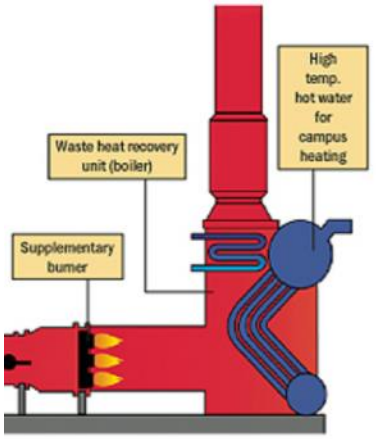


Image Source: University of Calgary

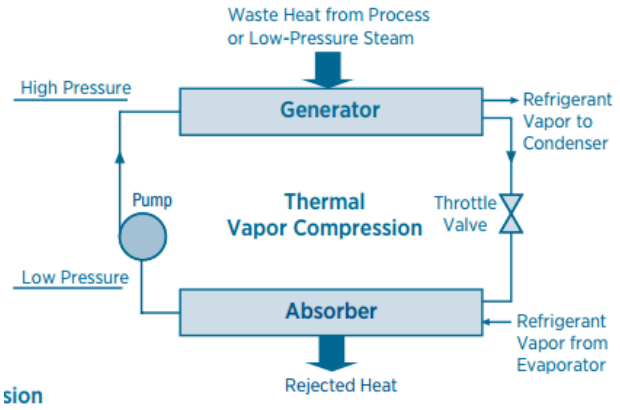


Image Source: DOE - EERE

Heat Recovery: Absorption Chillers

- Absorption chillers are heat operated refrigeration machines that operate on chemical and physical reactions to transfer heat. The absorption cycle substitutes a physiochemical process for the mechanical compressor used in common refrigeration systems.
- Absorption chillers can be driven with hot water, steam, or prime mover exhaust.
- Absorption chillers are available in sizes from 5 to 3,000 refrigeration tons. This capacity correlates to a CHP electric output of approximately 50 to 10,000 kW.
- For 40°F and higher chilling fluid temperatures (e.g., building air conditioning), a common refrigerant solution mixture is water (refrigerant) and lithium bromide (absorbent). For chilling fluid temperatures below 40°F (e.g., cold storage), a common refrigerant solution mixture is ammonia (refrigerant) and water (absorbent).

A 200-ton single-stage absorption chiller integrated with three 600 kW reciprocating engines that also provide hot water for process and space heating. The system is located at a metal fabrication facility in Fitchburg, Massachusetts. *Photo courtesy of Northeast CHP Technical Assistance Partnership (CHP TAP).*

What Are the Benefits of CHP?

- CHP is more efficient than separate generation of electricity and heating/cooling
- Higher efficiency translates to lower operating costs (but requires capital investment)
- Higher efficiency reduces emissions of pollutants
- CHP can also increase energy reliability, energy resiliency, and enhance power quality
- On-site electric generation can reduce grid congestion and avoid distribution costs.

CHP Market Sectors

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

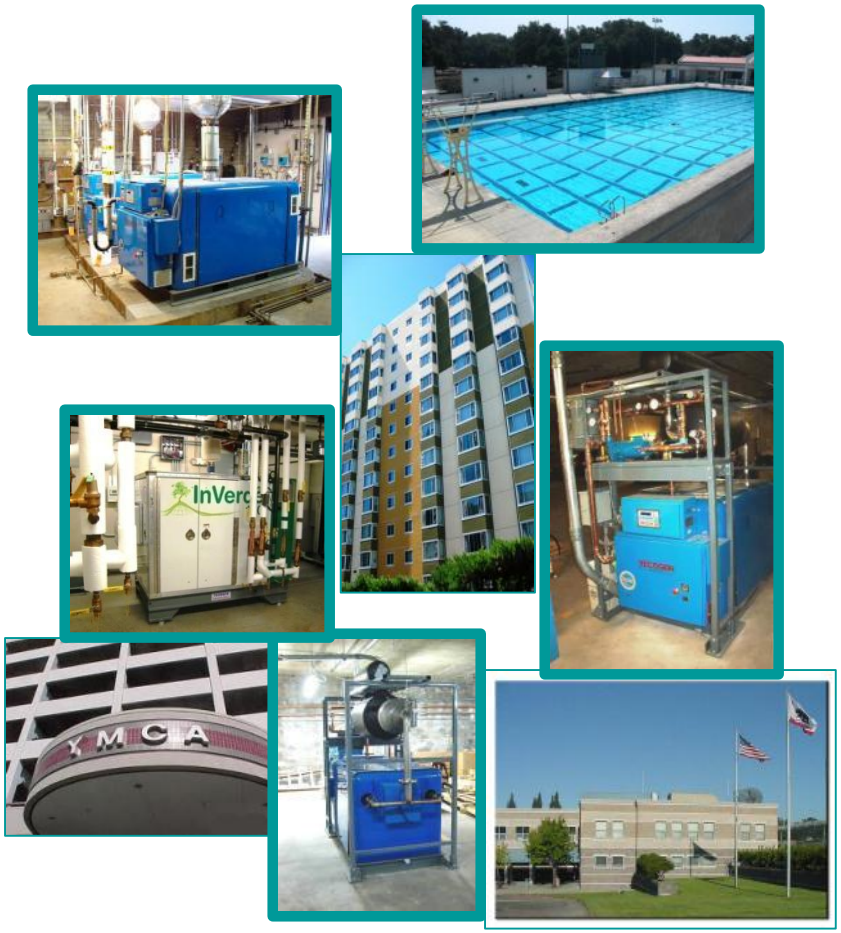
- Hospitals
- Schools (K – 12)
- Universities & colleges
- Wastewater treatment
- Residential confinement

Agricultural

- Concentrated animal feeding operations
- Dairies
- Wood waste (biomass)

Small-Medium CHP Applications

- Hospitals
- Light Industrial
- Apartment Buildings/ Condos
- Community Colleges
- Large Schools
- Nursing Homes
- Community Centers
- Athletic Clubs
- Municipal Pools
- Correctional Institutions



Larger CHP Applications

- Mid-stream Oil & Gas Processing
- Oil Refineries
- Chemical Plants
- Heavy Industrial
- Hospital Campuses
- College Campuses

Illinois Legislative Update

Source: Midwest Cogeneration Association; Midwest Energy Efficiency Alliance

Illinois' New Climate & Equitable Jobs Act: A Role for Cogeneration?

Midwest Cogeneration Association

Thursday, October 28, 2021 Webinar

Big Picture: Issues/ Opportunities

- Incentives:
  - Portfolio Standards
    - NEW Cogeneration included in eligible “Renewable Energy Resources”
  - Energy Efficiency Programs / NEW Opt Out
  - Electrification
  - NEW Distributed Generation Rebate Program (Up to 5 MW)
- Phase out of > 25 MW Fossil Fuel Fired Units
  - Smaller Units Unaffected
- Potential Opportunities for Cogen Under Other New Programs
  - Immediate need for cogen proponents to participate in ICC and other proceedings that will be shaping various new programs

Incentives: Energy Efficiency Programs

- **Energy Efficiency Programs**
  - EE Rate Cap Raised to 4%
  - Electric Utility Cumulative Persisting Annual Savings Targets Extended Beyond 2030
  - Electrification Programming Allowed
- **New EE Program Opt Out Provisions**
  - Replaces the 10MW large customer exemption that had previously been in place
  - Large energy customers are back in utility EE portfolios
  - Eligible large private energy customer for opt-out
    - 10MW peak demand
    - Federal, state, municipal and other public facilities
    - Multiple sites
  - Notice Requirements
    - Independent audit (specialized processes = self audit)
    - Customer's EE plans
  - Opt-out limited to single 4-year plan cycle

Illinois Renewable Portfolio Standard Program

- "Renewable Energy Resources" ae eligible to generate RECs that utilities need to meet their annual RPS targets
- NEW: Cogeneration (both Qualified CHP and WHP) is now included in Definitions of "Renewable Energy Resources" and "Distributed Renewable Generation Device"
- But under ANOTHER NEW PROVISION: 100% of all RECs for new Renewable Energy Resources are to be PROCURED from wind and solar through 2035!
  - End Result: RECs generated by all other RERs (including WHP, Qualified CHP) will not be included in Illinois Power Agency procurement and auction process
- Question: Does being included in these definitions provide other benefits for CHP and WHP?

NEW Definitions of WHP and Qualified CHP

- **"Waste Heat to Power Systems"** means systems that capture and generate electricity from energy that would otherwise be lost to the atmosphere without the use of additional fuel.
- **"Qualified Combined Heat and Power"** means systems that, either simultaneously or sequentially, produce electricity and useful thermal energy from a single fuel source. Such systems are eligible for "renewable energy credits" in an amount equal to its total energy output where a renewable fuel is consumed or in an amount equal to the net reduction in nonrenewable fuel consumed on a total energy output basis.

NEW Distributed Generation Rebate 220 ILCS 5/16 –107.6

- Minimum $250/kw nameplate capacity payment
- More if solar or if include storage
- Increased rebate for value of “Additive Services”
- Limited to Projects:
  - Up to 5 MW capacity
  - Primarily serving the customer’s own load
- NEW “Distributed Energy Resource means a wide range of technologies that are located on the customer side of the customer’s electric meter, including, but not limited to, distributed generation, energy storage, electric vehicles, and demand response technologies.

Amount of rebate and value of additive services may be increased in ICC proceeding by 2024.

NEW 100% Phase Out of > 25 MW Fossil Fuel Fired Electric Generating Units

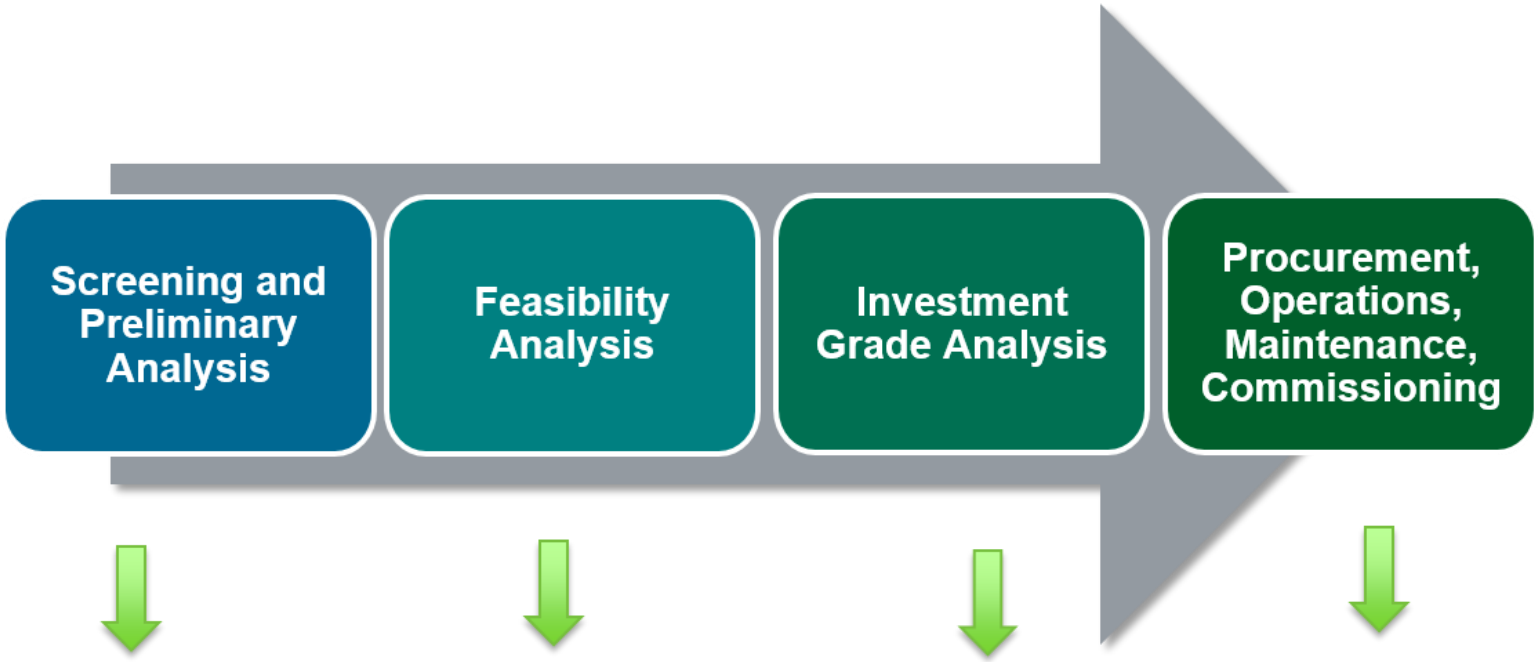
- Defines EGUs (generation for export) and Large Greenhouse Gas Emitting Units (either export or on-site use) with “nameplate capacity” >25 MW.
- Expressly includes a Phase Out of EGUs and LGUS using CHP
- Must “reduce all CO2e and co-pollutant emissions to zero”
- Phase Out Dates:
  - Coal - 2035
  - Public Sector Coal –95% by 2045 (retire unit or carbon sequestration)
  - Natural Gas -2030-2045
  - Cogeneration – 2045

How to Implement a CHP Project with the Help of the CHP TAP

CHP Technical Assistance Partnerships

MIDWEST

CHP TAP Role: Technical Assistance



Quick screening questions with spreadsheet payback calculator; Advanced technical assistance to explore equipment or operational scenarios.

Perform 3rd Party reviews of site feasibility assessments: Estimates on savings, installation costs, simple paybacks, equipment sizing, and type.

Perform 3rd Party reviews of Engineering Analysis. Review equipment sizing and choices.

Review specifications and bids.

Screening Questions

- Do you pay more than $.06/kWh on average for electricity (including generation, transmission and distribution)?
- Are you concerned about the impact of current or future energy costs
  on your operations?
- Are you concerned about power reliability?
  What if the power goes out for 5 minutes… for 1 hour?
- Does your facility operate for more than 3,000 hours per year?
- Do you have thermal loads throughout the year?
  (including steam, hot water, chilled water, hot air, etc.)

Screening Questions (cont.)

- 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.)

Finding the Best Candidates:
Some or All of These Characteristics

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

CHP TAP Resources

CHP Technical Assistance Partnerships

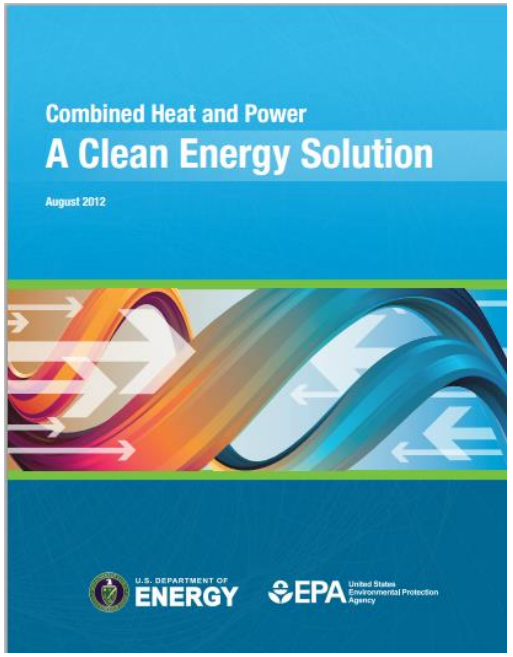
MIDWEST

CHP Project Resources

DOE CHP Technologies Fact Sheet Series

www.energy.gov/chp-technologies

Good Primer Report

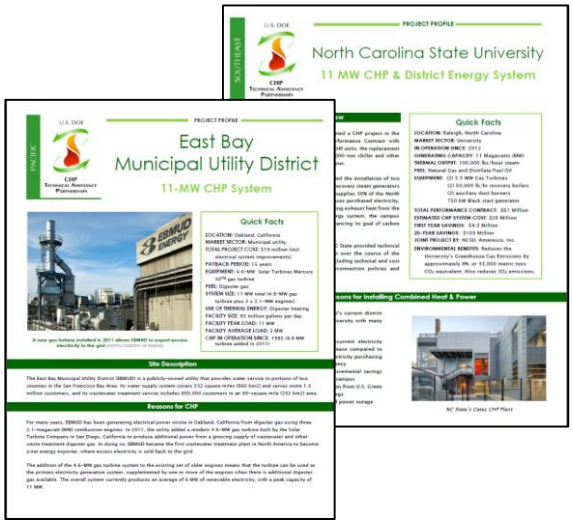


www.eere.energy.gov/chp

CHP Technical Assistance Partnerships
MIDWEST

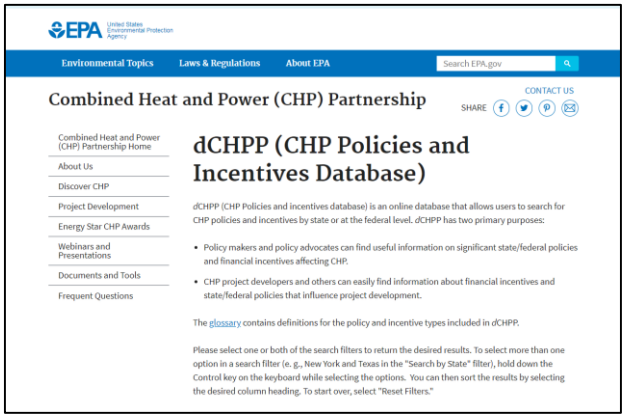
CHP Project Resources

DOE Project Profile Database



energy.gov/chp-projects

EPA dCHPP (CHP Policies and Incentives Database

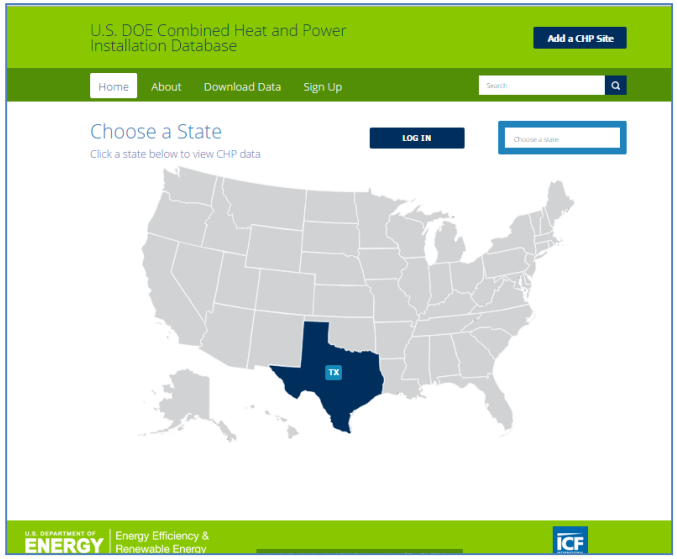


www.epa.gov/chpdchpp-chp-policies-and-incentives-database

CHP Technical Assistance Partnerships
MIDWEST

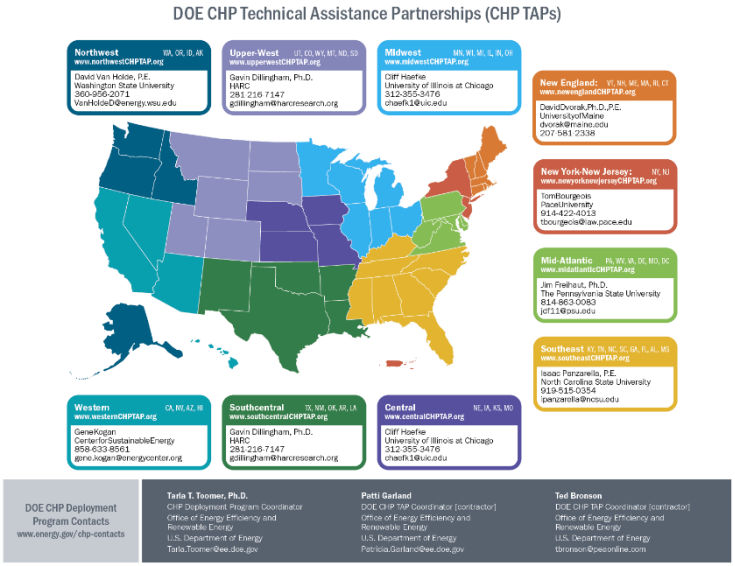
CHP Project Resources

DOE CHP Installation Database
(List of all known
CHP systems in U.S.)



energy.gov/chp-installs

Low-Cost CHP Screening and Other Technical Assistance from the CHP TAP



energy.gov/CHPTAP

CHP Technical Assistance Partnerships
MIDWEST

Summary

- CHP gets the most out of a fuel source, enabling
  - High overall utilization efficiencies
  - Reduced environmental footprint
  - Reduced operating costs
- Emerging drivers are creating new opportunities to evaluate CHP today
- Proven technologies are commercially available and cover a full range of sizes and applications

Next Steps

- Contact Midwest CHP TAP for assistance if:
  - Interested in having a Qualification Screening performed to determine if there is an opportunity for CHP at your site
  - If you already have an existing CHP plant and interested in expanding it
  - Need an unbiased 3rd Party Review of a proposal

Thank You

Graeme Miller
Midwest CHP TAP
Assistant Director

O: (312) 996-3711
M: (773) 715-9850
gmille7@uic.edu

Energy Resources Center
University of Illinois at Chicago

CHP Technical Assistance Partnerships

www.energy.gov/chp

CHP Technical Assistance Partnerships
MIDWEST

Comparison of CHP Characteristics [1, 2]

Characteristic	Technology				
	Reciprocating Engine	Gas Turbine	Microturbine	Fuel Cell	Steam Turbine
Size Range	10 kW – 10 MW	1 – 300 MW	30 kW – 330 kW (larger modular units available)	5 kW – 1.4 MW (larger modular units available)	100 kW – 250 MW
Electric Efficiency (HHV)	30% – 42%	24% – 36%	25% – 29%	38% – 42%	5% – 7%
Overall CHP Efficiency (HHV)	77% – 83%	65% – 71%	64% – 72%	62% – 75%	80%
Total Installed Cost ($/kW) [3]	$1,400 – $2,900	$1,300 – $3,300	$2,500 – $3,200	$4,600 –$10,000	$670 – $1,100 [4]
O&M Cost (¢/kWh)	0.9-2.4	0.9-1.3	0.8-1.6	3.6-4.5	0.6-1.0
Power to Heat Ratio	0.6 – 1.2	0.6 – 1.0	0.5 – 0.8	1.3 – 1.6	0.07 – 0.10
Thermal Output (Btu/kWh)	2,900 --6,100	3,400 --6,000	4,400 --6,400	2,200 --2,600	30,000 --50,000

Notes:

1) Unless noted otherwise, information based on U.S. Department of Energy, CHP Technology Fact Sheet Series, 2016, 2017.
2) All performance and cost characteristics are typical values and are not intended to represent a specific product.
3) Costs will vary depending on site specific conditions and regional variations.
4) Costs shown are for a steam turbine only, and do not include costs for a boiler, fuel handling equipment, steam loop, and controls.

Comparison of CHP Characteristics

continued…

Characteristic	Technology				
	Reciprocating Engine	Gas Turbine	Microturbine	Fuel Cell	Steam Turbine
Fuel Pressure (psig) [1]	1-75	100-500 (may require fuel compressor)	50-140 (may require fuel compressor)	0.5-45	n/a
Part Load Efficiency	Good at both part-load and full-load	Better at full-load	Better at full-load	Better at full-load	Good at both part-load and full-load
Type of Thermal Output	LP steam, hot water, space heating, chilled water	LP-HP steam, hot water, process heating, chilled water	LP steam, hot water, chilled water	LP steam, hot water, chilled water	LP-HP steam, hot water, chilled water
Fuel	Can be operated with a wide range of gas and liquid fuels. For CHP, the most common fuel is natural gas.			Hydrogen, natural gas, propane, methanol	Steam turbines for CHP are used primarily where a solid fuel (e.g., coal or biomass) is used in a boiler. [2]

Notes:
1) Adapted from Catalog of CHP Technologies, U.S. Environmental Protection Agency Combined Heat and Power Partnership, 2015.
2) Backpressure steam turbines can be used to produce power by replacing pressure reducing valves (PRVs) in existing steam systems.

Comparison of CHP Characteristics

continued…

Characteristic	Technology				
	Reciprocating Engine	Gas Turbine	Microturbine	Fuel Cell	Steam Turbine
Emissions	CHP technologies are capable of meeting or exceeding air quality regulations throughout the United States, including states such as California that have demanding limits for NOx, CO, and VOC emissions. To achieve compliance, a CHP technology may need to integrate an exhaust treatment technology such as an oxidation catalyst or a selective catalytic reduction system.				
Other	Reciprocating engines start quickly and operate on typical natural gas delivery pressures.	Gas turbines and microturbines have low engine-out emissions and require no cooling. A fuel gas compressor may be required to deliver the specified inlet gas pressure.		Fuel cells are quiet, have low emissions, and produce high quality power.	Steam turbines require a boiler or other steam source.