Combined Heat and Power Opportunities In Illinois

Presentation to the Association of Professional Energy Consultants

David Baker
Assistant Director
US DOE Central CHP Technical Assistance Partnership
Mt. Vernon, Illinois
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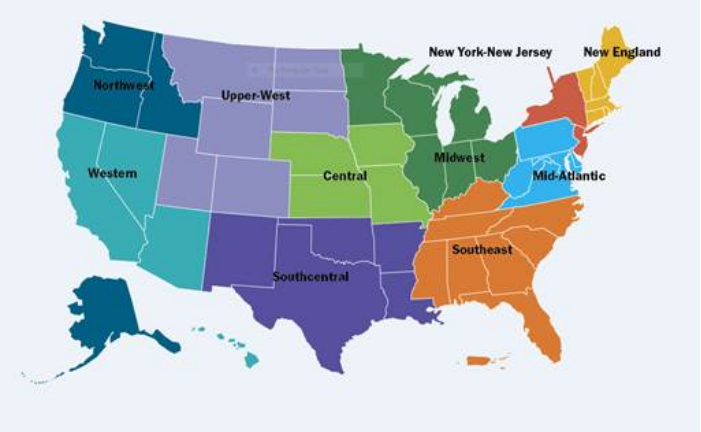
Agenda

- DOE CHP Technical Assistance Partnerships
- CHP Concepts and Technologies
- CHP Markets and Potential in Illinois
- CHP Project Profiles
- Available Utility Incentives
- 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

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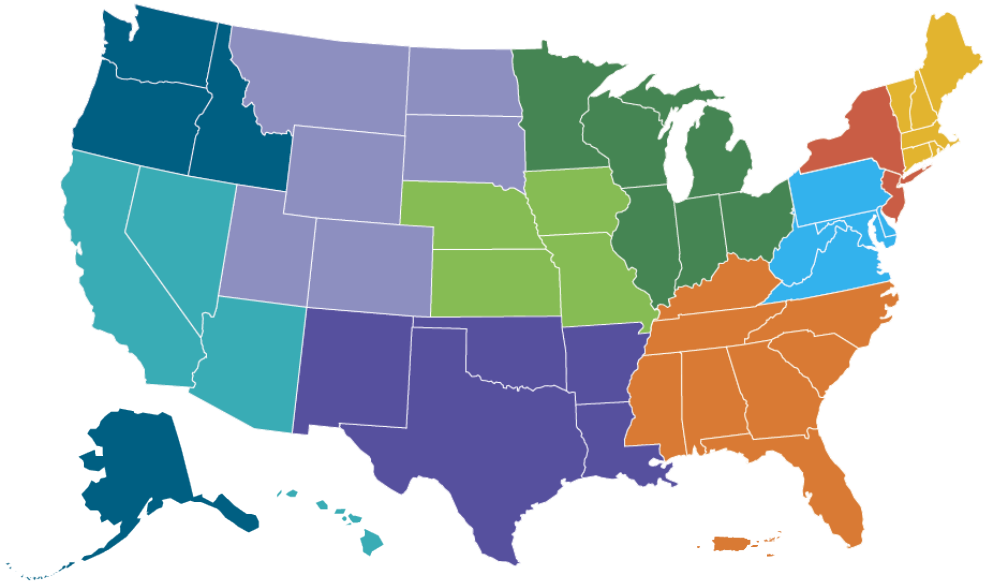
DOE CHP Technical Assistance Partnerships (CHP TAPs)



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

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

Midwest MN, WI, MI, IL, IN, OH
www.midwestCHPTAP.org
Cliff Haefke
University of Illinois at Chicago
312-355-3476
chaefk1@uic.edu

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

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

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

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

Western CA, NV, AZ, HI
www.westernCHPTAP.org
Gene Kogan
Center for Sustainable Energy
858-633-8561
gene.kogan@energycenter.org

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

Central NE, IA, KS, MO
www.centralCHPTAP.org
Cliff Haefke
University of Illinois at Chicago
312-355-3476
chaefk1@uic.edu

DOE CHP Deployment Program Contacts

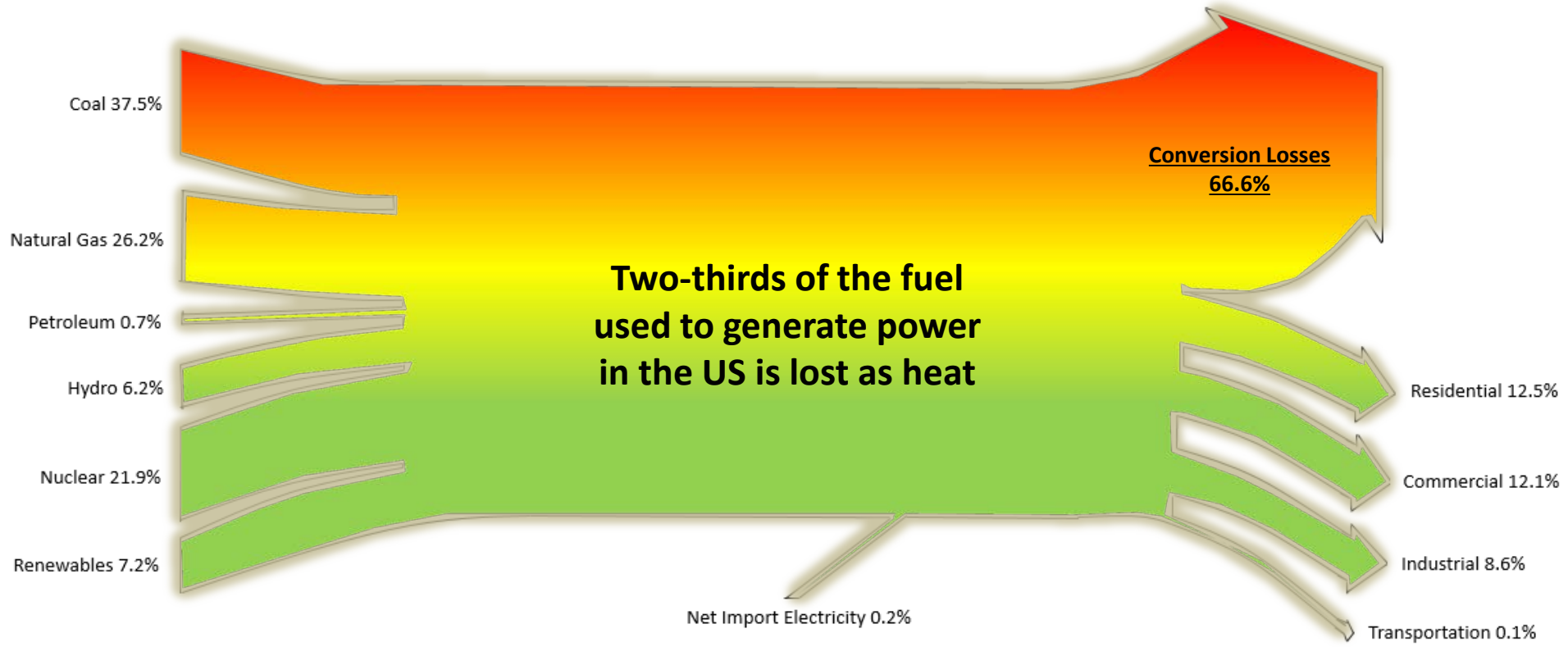
www.energy.gov/CHPTAP

Tarla T. Toomer, Ph.D.
CHP Deployment Manager
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
Tarla.Toomer@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

Ted Bronson
DOE CHP TAP Coordinator [contractor]
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
tbronson@peaonline.com

Energy Utilization in the Utility Sector



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

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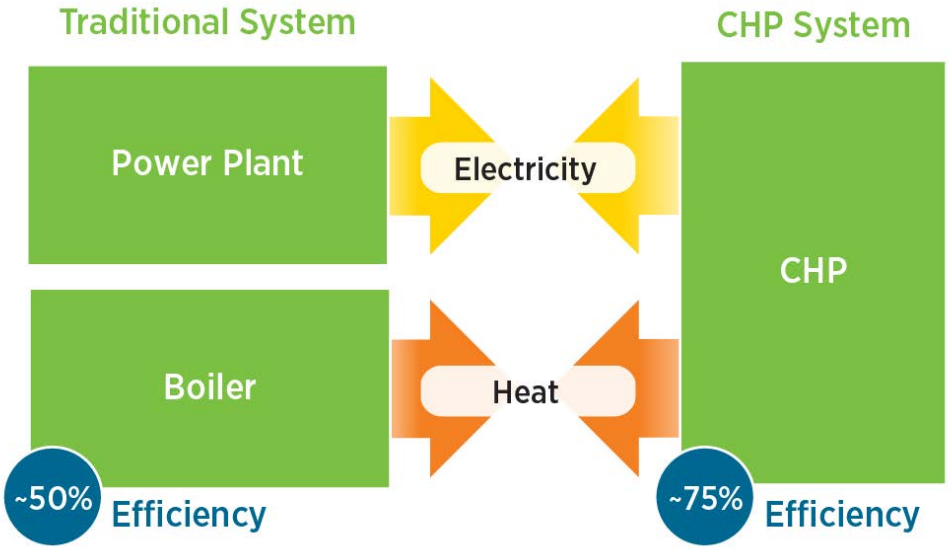
CHP: A Key Part of Our Energy Future

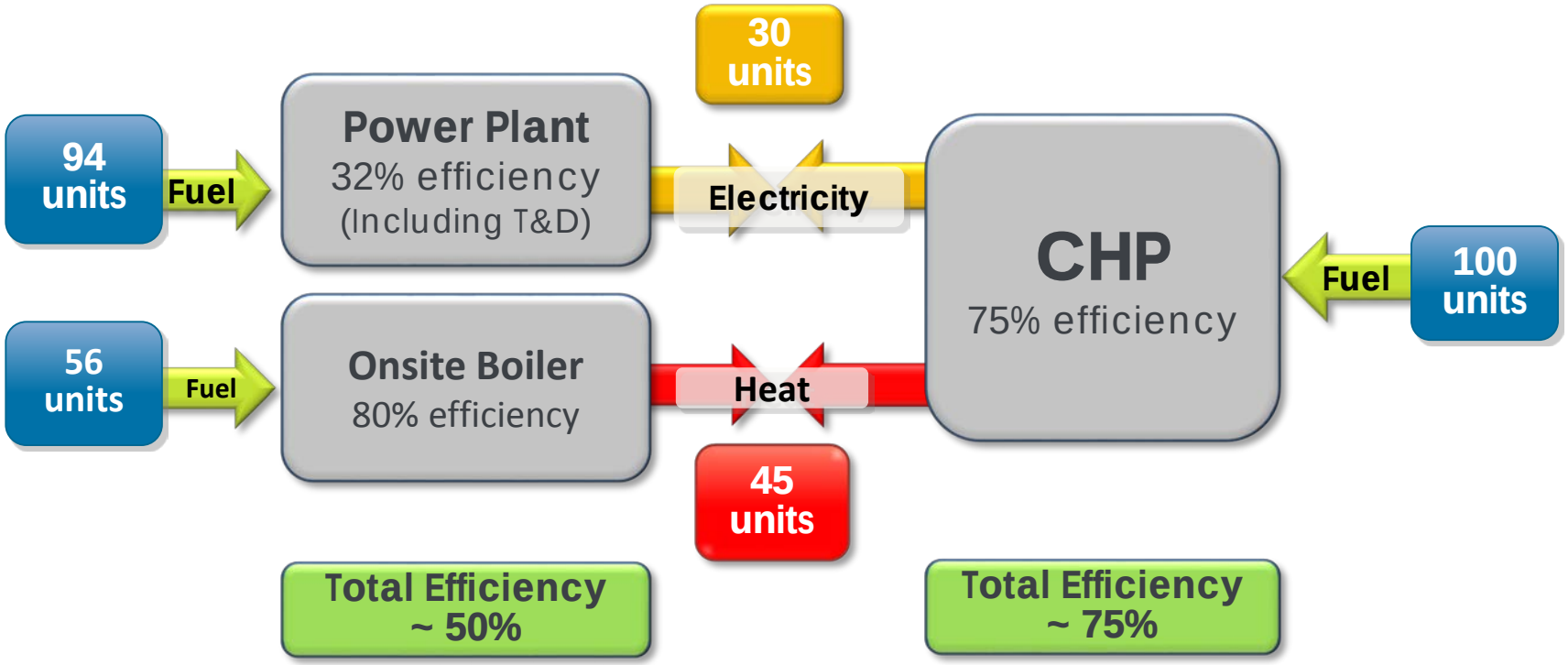
- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification



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

Source: www.energy.gov/chp

CHP Recaptures Heat of Generation, Increasing Energy Efficiency, and Reducing GHGs



30 to 55% less greenhouse gas emissions

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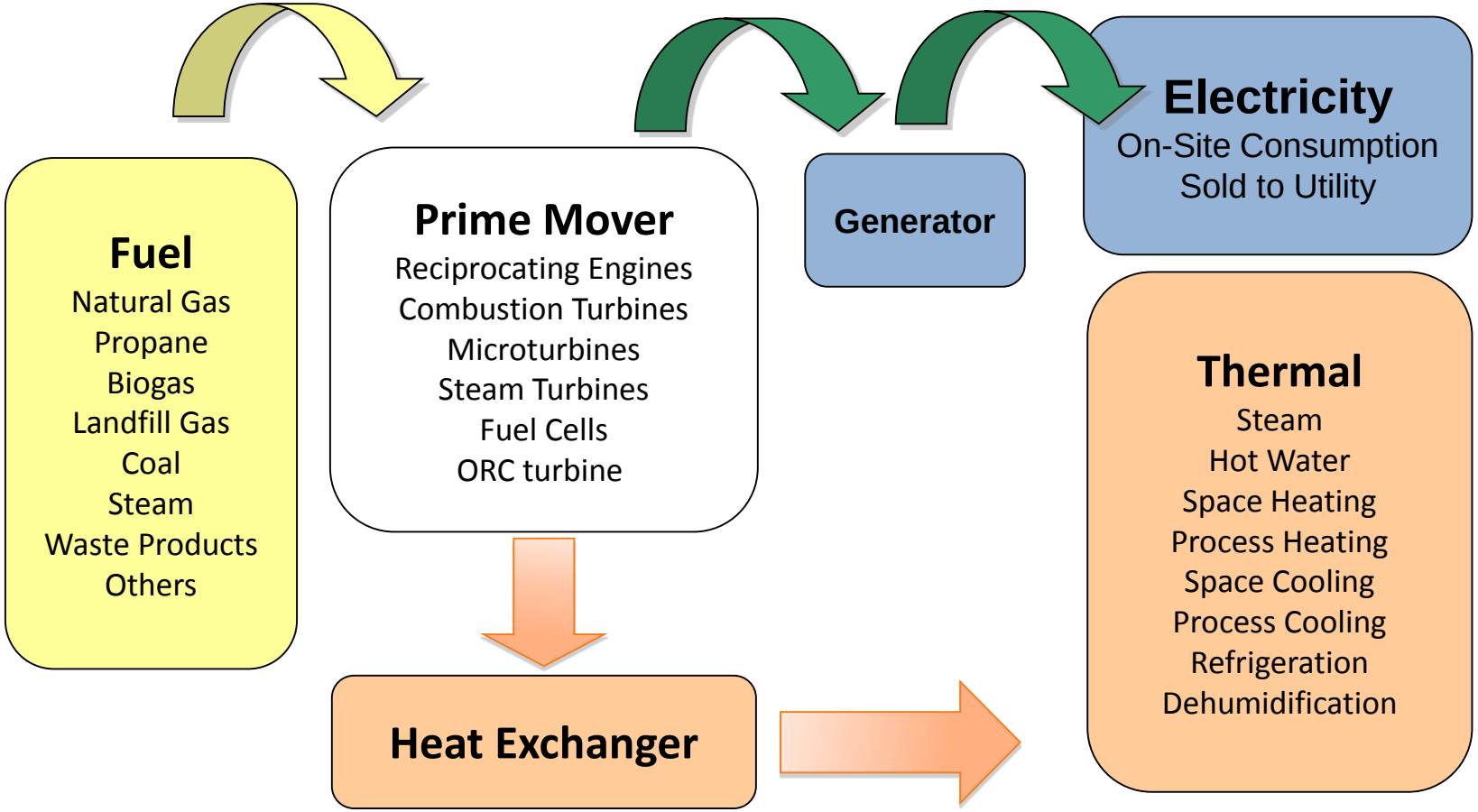
CHP System Schematic



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*

Critical Infrastructure and Resiliency Benefits of CHP

"Critical infrastructure" refers to those assets, systems, and networks that, if incapacitated, would have a substantial negative impact on national security, national economic security, or national public health and safety."

Patriot Act of 2001 Section 1016 (e)

Applications:

- Hospitals and healthcare centers
- Water / wastewater treatment plants
- Police, fire, and public safety
- Centers of refuge (often schools or universities)
- Military/National Security
- Food distribution facilities
- Telecom and data centers

CHP (if properly configured):

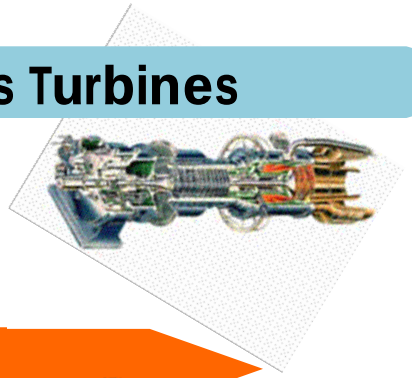
- Offers the opportunity to improve Critical Infrastructure (CI) resiliency
- Can continue to operate, providing uninterrupted supply of electricity and heating/cooling to the host facility

Overview of CHP Technologies

Common CHP Technologies

Microturbines

Gas Turbines



Reciprocating Engines

Fuel Cells

Steam Turbines

50 kW | 100 kW | 1 MW | 10 MW | 20 MW

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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: Fuel Cells

- Size Range: 5 kW to 2.8 MW
- Characteristics
  - Relatively high electrical efficiencies due to electrochemical process
  - Uses hydrogen as the input fuel; requiring processing unless pure hydrogen is used
  - Relatively low emissions without controls due to absence of combustion process (other than reformer)
  - Inverter based generation can improve power quality
  - Relatively high installed cost
- Example Applications:
  - data centers, hotels, office buildings, waste water treatment

CHP fuel cell installation at Verizon data center.[1]
Photo courtesy of Verizon Communications.

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
- Dessiccant Dehumidifiers
  - Separates Latent from Sensible Load
  - Reduces Humidity and Reduces AC Load

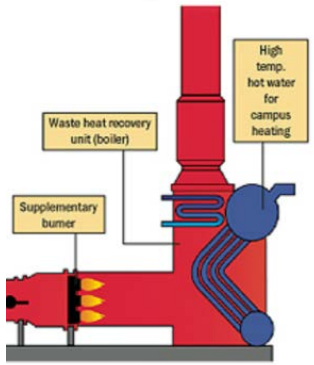


Image Source: University of Calgary

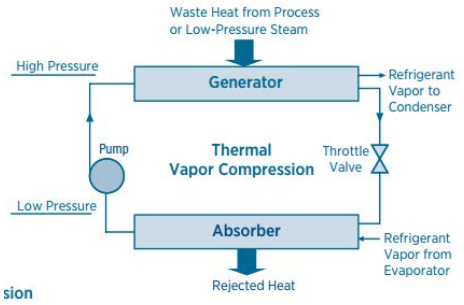
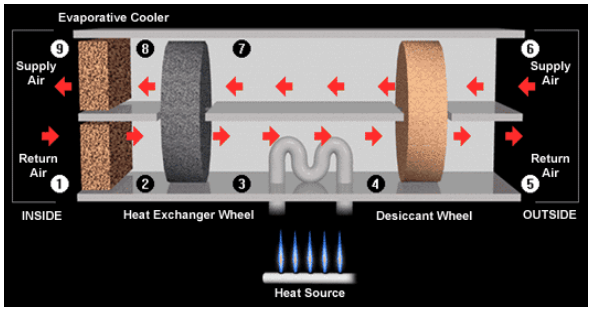
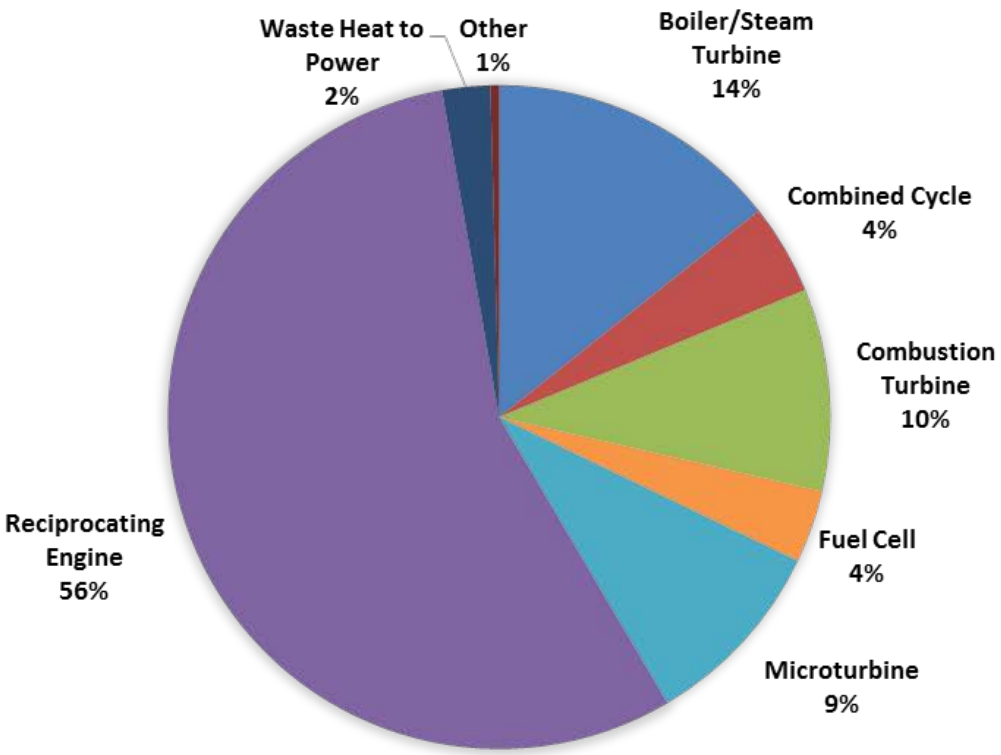


Image Source: DOE - EERE

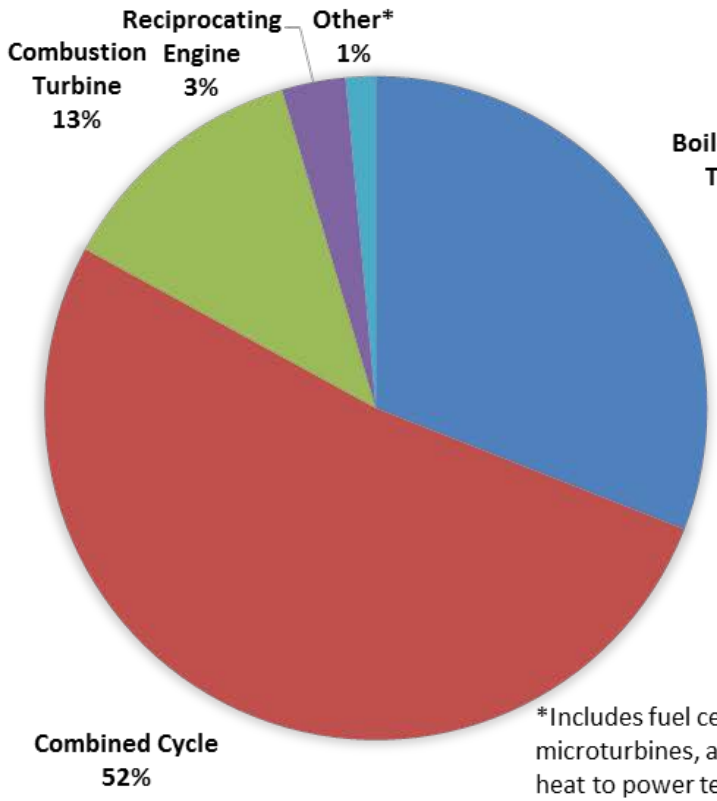


Existing CHP by Technology

By Site – 4,434 Sites



By Capacity – 81.3 GW



Source: DOE CHP Installation Database (U.S. installations as of December 31, 2017)

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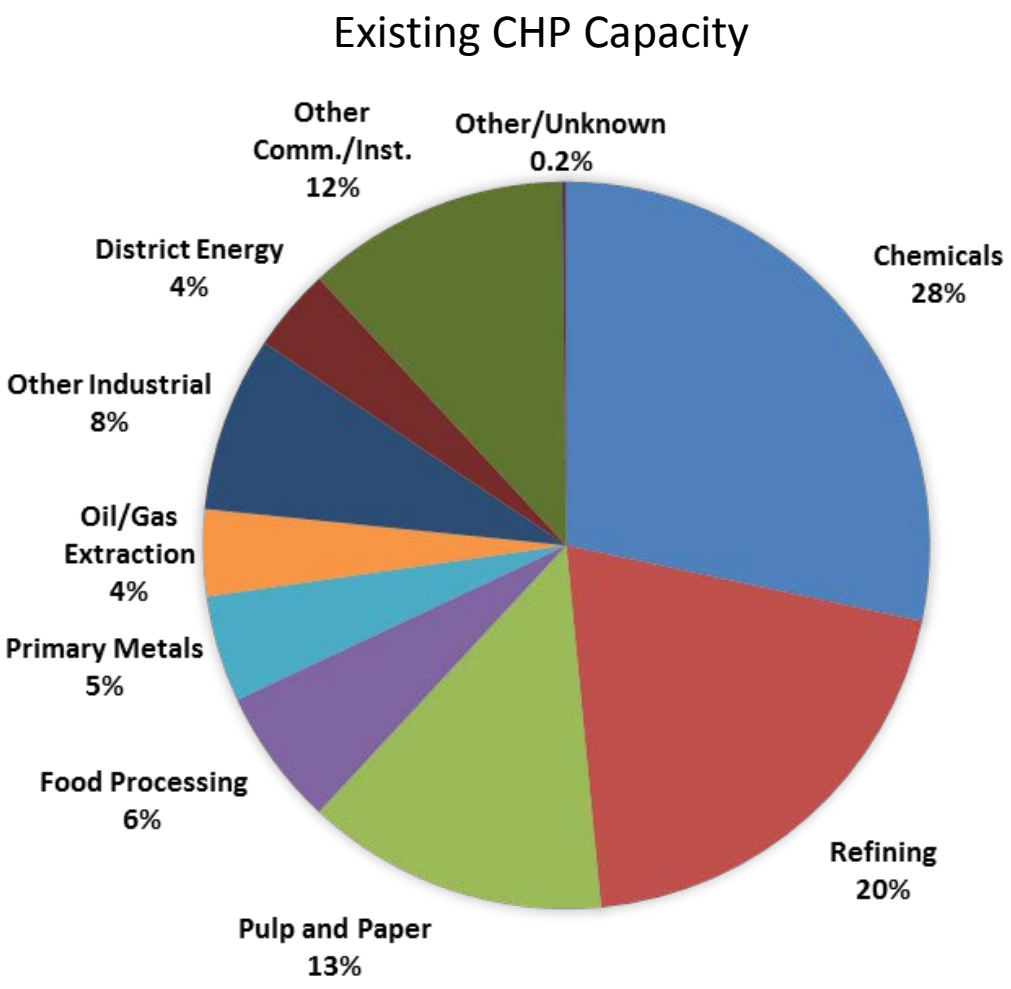
Slide prepared on 7-3-18

CHP Markets

CHP Today in the United States



- **81.3 GW** of installed CHP at more than 4,400 industrial and commercial facilities
- 8% of U.S. Electric Generating Capacity; 14% of Manufacturing
- Avoids more than **1.8 quadrillion Btus** of fuel consumption annually
- Avoids **241 million metric tons of CO_2** compared to separate production

Source: DOE CHP Installation Database (U.S. installations as of December 31, 2017)

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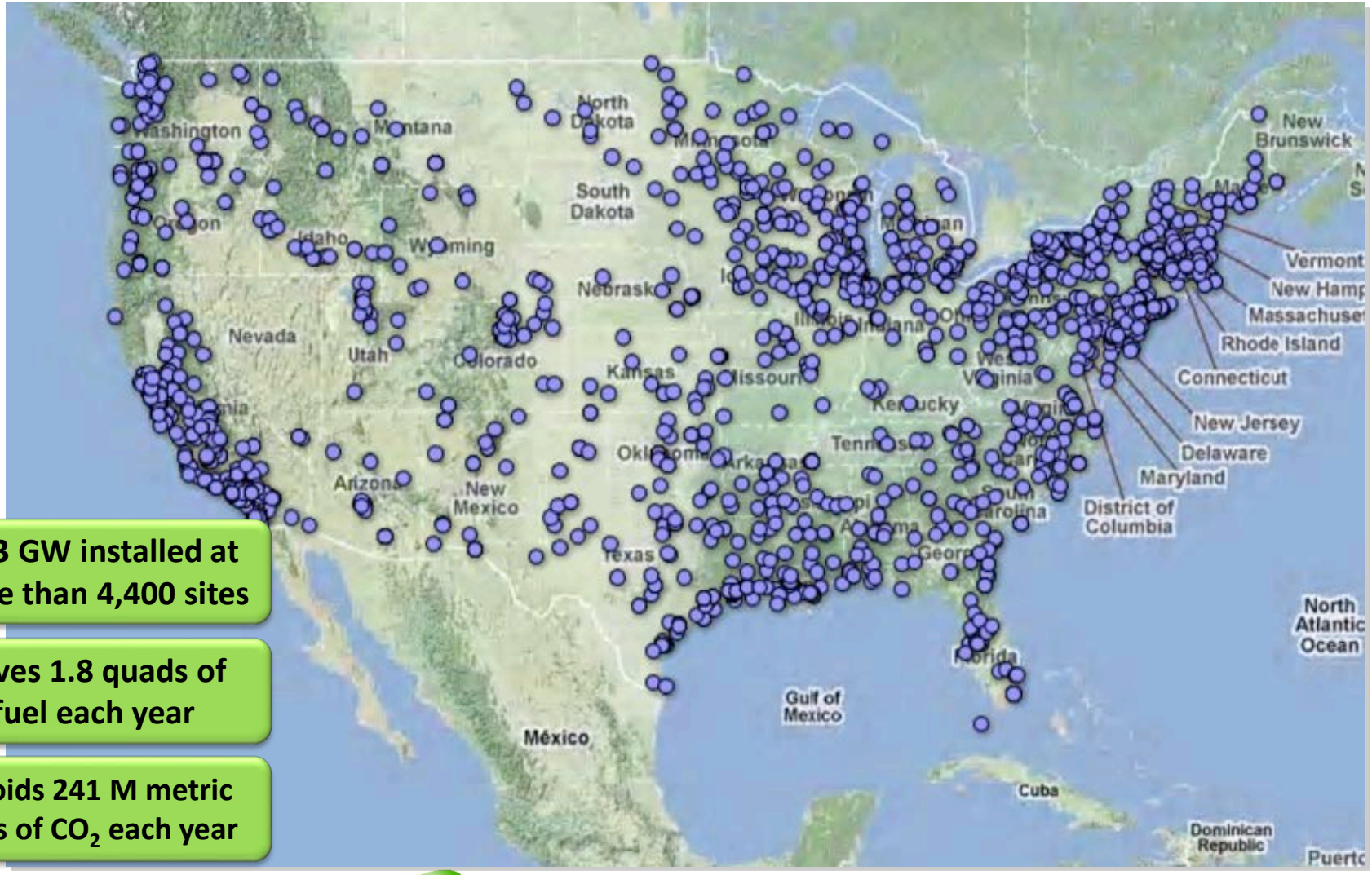
CHP Is Used Nationwide In Several Types of Buildings/Facilities



81.3 GW installed at more than 4,400 sites

Saves 1.8 quads of fuel each year

Avoids 241 M metric tons of CO_2 each year

Source: DOE CHP Installation Database (U.S. installations as of Dec 31, 2017)

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

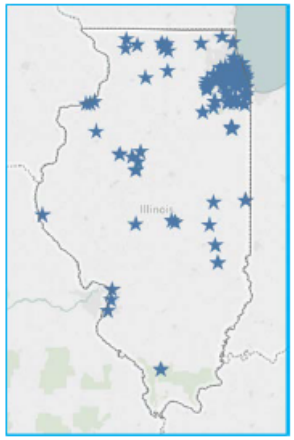
- Concentrated animal feeding operations
- Dairies
- Wood waste (biomass)

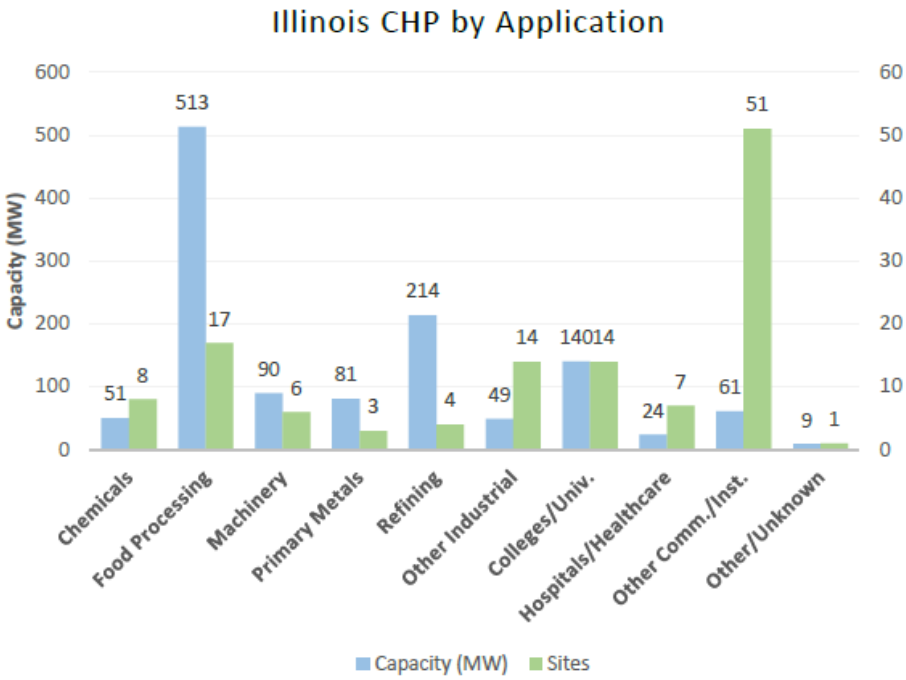
Illinois Installed Base of CHP

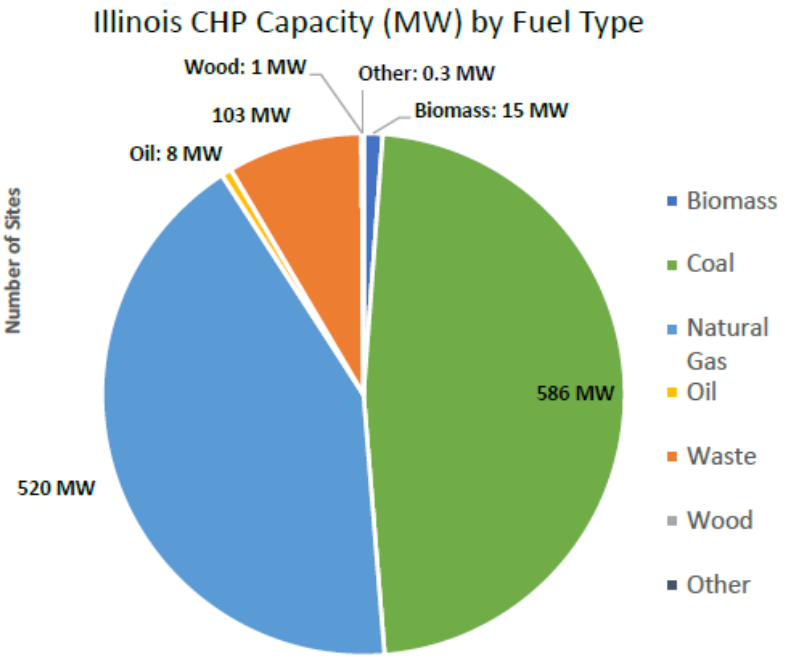
U.S. DOE Combined Heat and Power Installation Database

Sector	Installations	Capacity (MW)
Industrial	46	978
Commercial/Institutional	72	226
Other	7	28
Total	125	1,233

The Midwest CHP Technical Assistance Partnership has compiled information on certain illustrative CHP projects in Illinois. You can access these by visiting the Department of Energy's CHP Project Profiles Database.







Source: www.energy.gov/chp-potential

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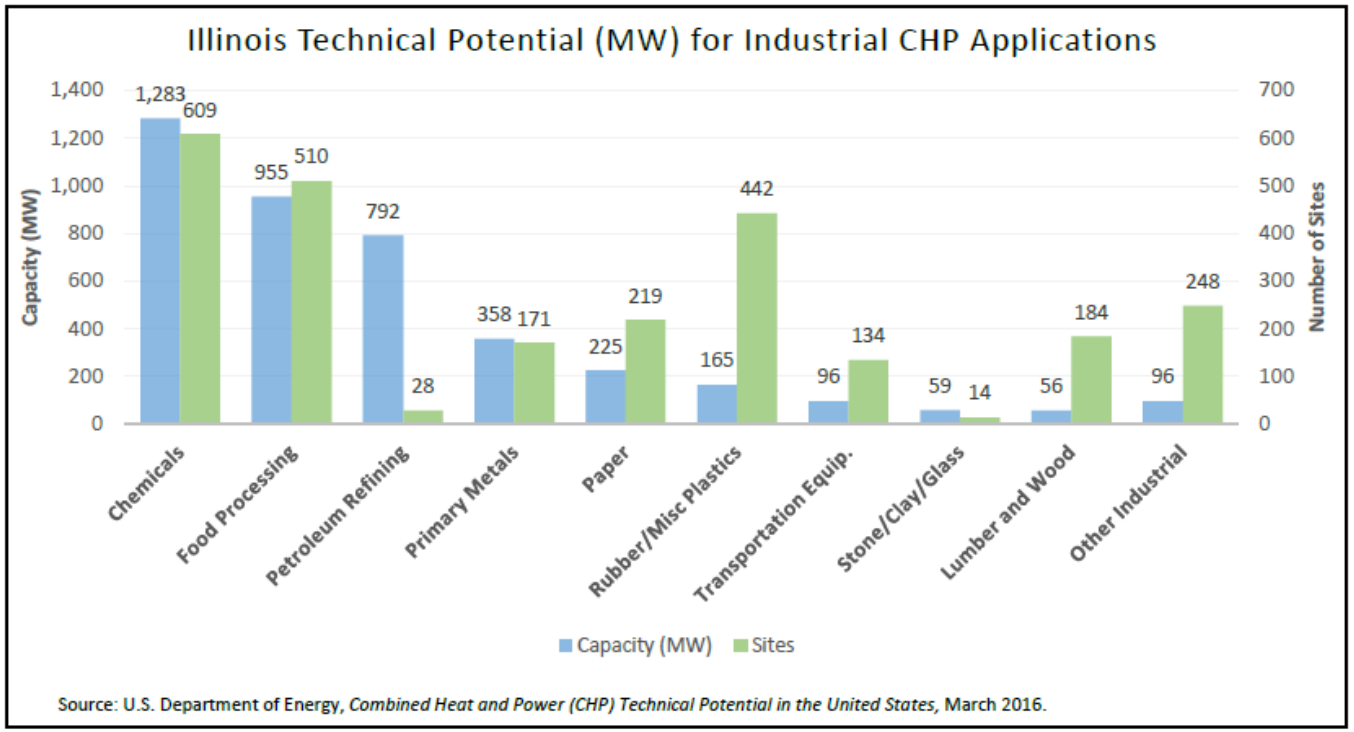
Illinois Industrial CHP Technical Potential



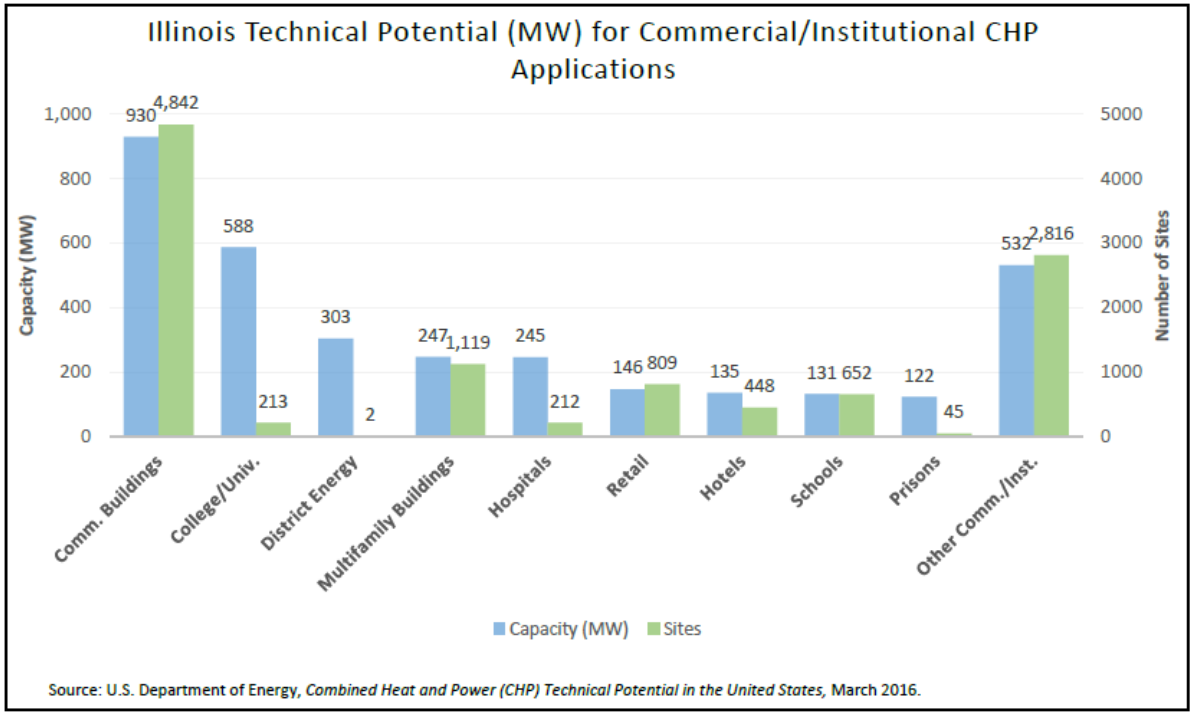
Source: U.S. Department of Energy, *Combined Heat and Power (CHP) Technical Potential in the United States*, March 2016.

Technical Potential by CHP Size Range for Top Five Industrial Sectors

	50-500 kW		0.5 - 1 MW		1 - 5 MW		5 - 20 MW		>20 MW		Total	
Application	Sites	MW	Sites	MW	Sites	MW	Sites	MW	Sites	MW	Total Sites	Total MW
Chemicals	344	65	73	54	129	280	49	455	14	429	609	1,283
Food Processing	331	66	55	40	95	175	22	189	7	484	510	955
Petroleum Refining	0	0	5	4	10	21	2	15	11	753	28	792
Primary Metals	83	21	36	26	38	82	10	128	4	101	171	358
Paper	136	34	38	27	39	88	5	56	1	20	219	225
Other Industrial	860	137	84	57	65	147	12	104	1	28	1,022	473
Total	1,754	323	291	207	376	793	100	947	38	1,815	2,559	4,085

Source: U.S. Department of Energy, *Combined Heat and Power (CHP) Technical Potential in the United States*, March 2016.

Illinois Commercial CHP Technical Potential



Source: U.S. Department of Energy, *Combined Heat and Power (CHP) Technical Potential in the United States*, March 2016.

Technical Potential by CHP Size Range for Top Five Commercial/Institutional Sectors

	50-500 kW		0.5 - 1 MW		1 - 5 MW		5 - 20 MW		>20 MW		Total	
Application	Sites	MW	Sites	MW	Sites	MW	Sites	MW	Sites	MW	Total Sites	Total MW
Commercial Buildings	3,099	155	1,356	542	387	232	0	0	0	0	4,842	930
College/Univ.	106	18	15	10	63	189	23	207	6	163	213	588
Multifamily Buildings	789	59	286	143	44	44	0	0	0	0	1,119	247
Hospitals	70	17	48	34	92	183	2	12	0	0	212	245
Retail	766	112	35	21	8	13	0	0	0	0	809	146
Other Comm./Inst.	3,714	500	151	98	86	170	9	114	3	341	3,963	1,223
Total	8,544	862	1,891	848	680	831	34	332	9	504	11,158	3,378

Source: U.S. Department of Energy, *Combined Heat and Power (CHP) Technical Potential in the United States*, March 2016.

Source: www.er

CHP Project Profiles

Project Snapshot:

Enhanced-Use Leasing of a CHP Project

Jesse Brown VA Medical Center

Chicago, IL

Application/Industry: Healthcare
Capacity (MW): 3.4 MW
Prime Mover: Combustion Turbine
Fuel Type: Natural Gas
Thermal Use: Building Heat and Absorption Cooling
Installation Year: 2003

Highlights: Reliable power is critical in hospitals to maintain patient safety and staff and patient satisfaction. The CHP system maintains an annual availability of over 98% and the remaining <2% of the time the system may be down for maintenance. This allows for the system to provide a reliable source of prime power to the medical center and another layer of electric redundancy in combination with the grid connection and emergency generators to ensure electricity is available when needed.

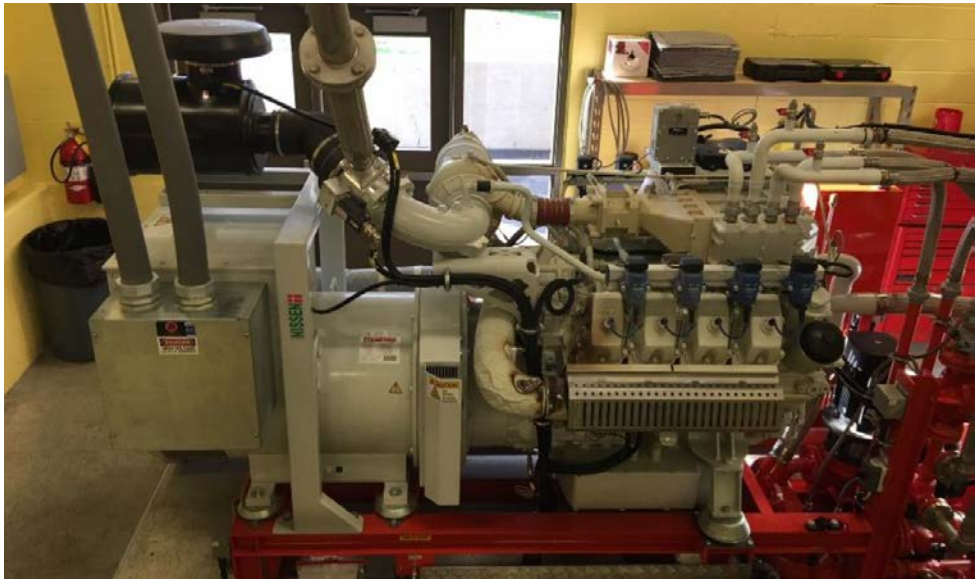
Source: http://www.midwestchptap.org/profiles/ProjectProfiles/JesseBrownVA%20.pdf

Project Snapshot:

Targeting Net-Zero

Downers Grove Sanitary District
Downers Grove, IL

Application/Industry:
Wastewater Treatment
Capacity (MW): 655 kW
Prime Mover: Reciprocating Engines
Fuel Type: Biomass
Thermal Use: Heat for Digestion Process
Installation Year: 2014, 2017



Highlights: In 2014, DGSG installed a 280 kW engine-driven generator with heat recovery, along with a gas conditioning system. The plant began processing waste grease from nearby restaurants within the digester system to increase gas production. To fully utilize this resource, it installed an additional 375 kW engine and generator in 2017 with incentives from utility ratepayer Energy Efficiency Portfolio Funds.

Source:
http://www.midwestchptap.org/profiles/ProjectProfiles/DownersGrove.pdf

Project Snapshot:

Interactive CHP System

Washtenaw Community College

Ann Arbor, MI

Application/Industry: College
Capacity (MW): 130 kW
Prime Mover: Microturbine
Fuel Type: Natural Gas
Thermal Use: Hot Water, Cooling
Installation Year: 2014
Energy Savings: >$60,000/year

Highlights: The microturbine CHP system at Washtenaw Community College is equipped with a FlexSet control system. The web-based system allows facility managers to monitor the system on computers or cell phones. The system's designer, GEM Energy, also donated an additional microturbine to the school for the training of future energy professionals.

Source: http://www.gemenergy.com/wp-content/uploads/2014/10/CHP-Washtenaw-102814.pdf

Slide prepared 2016

Project Snapshot:

Resilient High School

Maine South High School
Park Ridge, Illinois

Application/Industry: High School
Capacity: 1,600 kW
Prime Mover: Reciprocating Engines
Fuel Type: Natural Gas
Thermal Use: Heating, cooling, hot water (previously)
Installation Year: 1992

Highlights: In the year preceding CHP installation, the school experienced 13 extended electric outages, costing the school district $170,000 per day in operating expenses for a single 30-minute outage. In 2007 during a violent rain storm that forced 630,000 ComEd customers to lose power, the school disengaged from the grid, operated its CHP system, and maintained building operation throughout the weather event. The two 800 kW Caterpillar engines have full black start capability, using a battery to start the engines if grid electricity in not available.

Source: http://www.midwestchptap.org/

Project Snapshot:

Cow Power (5 Cows = 1 kW)

HUNTERS HAVEN FARM

Hunter Haven Farms
Pearl City, IL

Application/Industry: Dairy Farm
Capacity: 260 kW
Prime Mover: Caterpillar engines (2)
Fuel Type: Anaerobic digester biogas
Thermal Use: Heating the digester
Installation Year: 2008
Energy Savings: Unknown

Highlights: Hunter Havens Farm owns and operates 24/7 a 260 kW anaerobic digester and biogas-fired combined heat and power (CHP) system. The system produces electricity for the site and to sell to the local utility. The recovered heat is used to maintain the temperature of the digester, heat farm buildings, and provide the farm with hot water. The system can manage the waste for up to 1,200 dairy cows.

Source:
http://www.midwestchptap.org/profiles/ProjectProfiles/HunterHavenFarms.pdf

Project Snapshot:

Energy Independence, Reliability, and Energy Savings

Adkins Energy LLC
Lena, IL

Application/Industry: Ethanol plant
Capacity: 5 MW
Thermal Capacity: 25,700 lbs/hr
Prime Mover: Gas turbine
Fuel Type: Natural gas
Thermal Use: Process heat
Installation Year: 2002
Annual Savings (2015): $903,000

Testimonials:

"The CHP system has been a very reliable and cost effective energy solution for our ethanol plant. I would install the same energy system again."
- Mert Green, Safety Manager, Adkins Energy LLC

"The CHP system provides stability for our electricity supply regardless of electricity grid failure."
- Ray Baker, Finance Manager, Adkins Energy LLC

Source: http://www.midwestchptap.org/profiles/ProjectProfiles/AdkinsEnergy.pdf

Project Snapshot:

Data Center CHP with 99.9999% Reliability

First National Bank Omaha

First National Bank of Omaha
Omaha, NE

Application/Industry: Computing Facility/ Data Center
Capacity: 400 kW
Prime Mover: Fuel Cells
Fuel Type: Natural Gas
Thermal Use: heating, snow melting, dehumidification
Installation Year: 2013
Energy Savings: Unknown

Testimonial: *"We have had a great experience with the reliability afforded our data center operations since installing our first fuel cells in 1999".*
- Brenda Dooley, President, First National Buildings, Inc.

Source:
http://www.midwestchptap.org/profiles/ProjectProfiles/FirstNationalBank.pdf

Slide prepared 4/2017

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Available Incentives

Federal

- Investment Tax Credit (ITC)
  - It's Back until 2021!
  - The credit is equal to 10% of expenditures.
  - No maximum limit stated.
  - Eligible for CHP systems up to 50 MW, minimum 60% energy efficiency
  - Efficiency requirement does not apply to CHP systems that use biomass for at least 90% of the system's energy source,
  - Applicable to tax paying entities with property placed in service after October 3, 2008.

Source: https://www.energy.gov/savings/business-energy-investment-tax-credit-itc

Illinois Utilities

- **Ameren (https://www.ameren.com/illinois/energy-efficiency)**
  - Incentive – $0.12/kWh and $1.20/therm for eligible electricity and natural gas savings, under Custom Program
  - Electric cap at $500,000, natural gas cap at $100,000
  - Feasibility Studies – up to 50% of costs or 25% of annual savings identified, capped at $20k
- **Nicor (https://nicorgasrebates.com)**
  - Incentive – $1/therm for eligible natural gas savings, under Customer Program, Capped at $500,000
  - Feasibility Studies – up to $12.5k, in addition to ComEd incentive
- **Peoples Gas (https://accel.peoplesgasdelivery.com)**
  - Incentive – $1/therm for eligible natural gas savings, under Custom Program

Illinois Utilities (cont'd)

ComEd CHP Program Changes

- Eligibility – expanded to ≥500 kW peak customers (from ≥1 MW), customers ≥10 MW exempt under FEJA
- Production Incentive
  - Still $0.07/eligible kWh after 1 year and M&V, but pre-payment of $60/kW available after 1 month of operation
  - Sliding scale incentivizing higher efficiency projects
  - No longer a cap (previously $2 million)
- Feasibility Study Incentive (no longer capped at 50%)
  - Up to $10k for CHP projects <400 kW (new)
  - Up to $25k for CHP projects ≥400 kW
- Implementation Contractor/Outreach Provider
  - ERC selected to manage a network of Technical Service Providers and to provide outreach and marketing of the ComEd CHP Program

Source: https://www.comed.com/WaysToSave/ForYourBusiness/FactSheets/CHP_FactSheet.pdf

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

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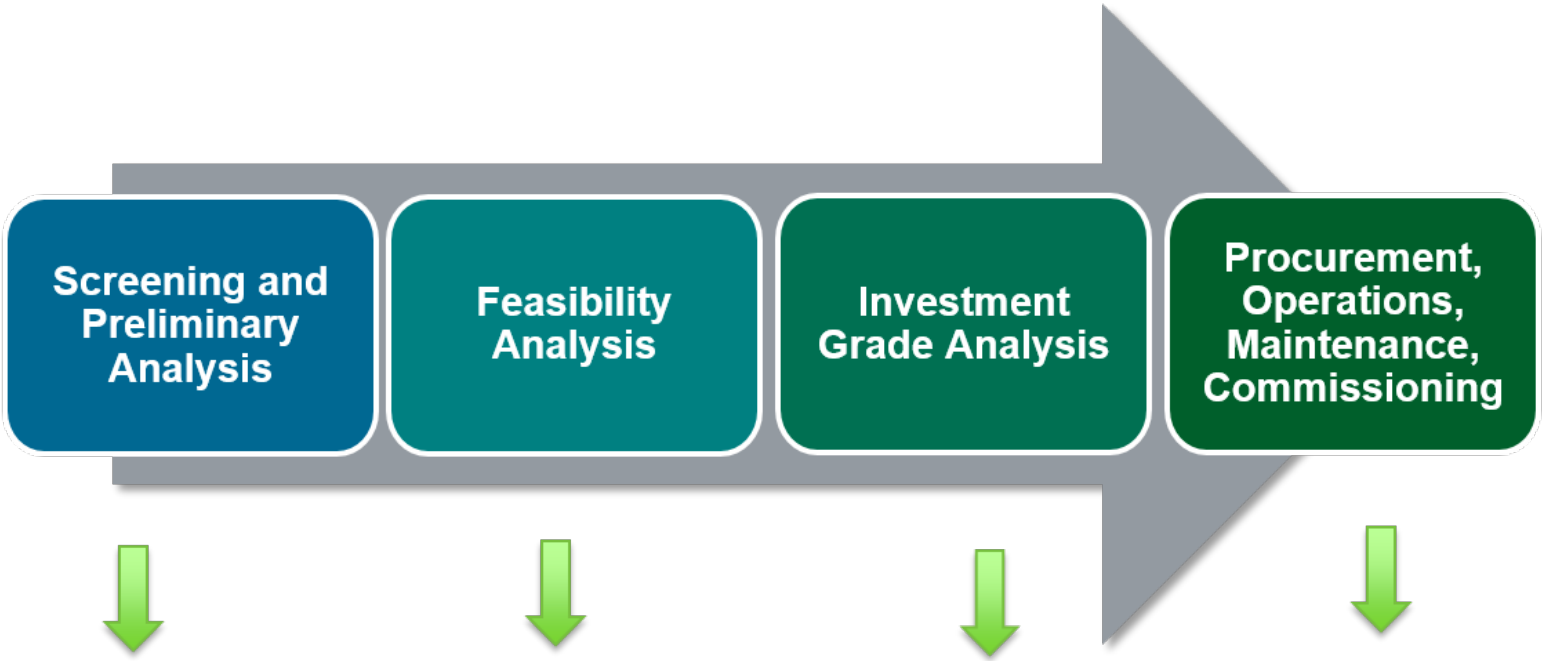
CHP TAP Role: Technical Assistance



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.

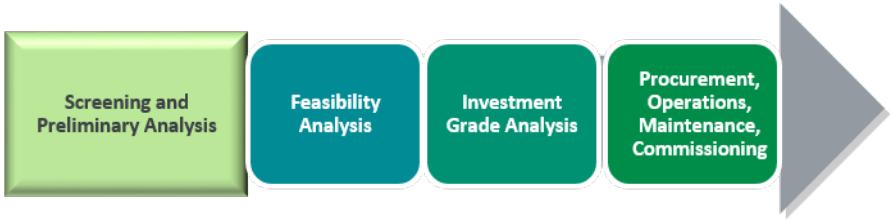
Review specifications and bids.

DOE TAP CHP Screening Analysis

- High level assessment to determine if site shows 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

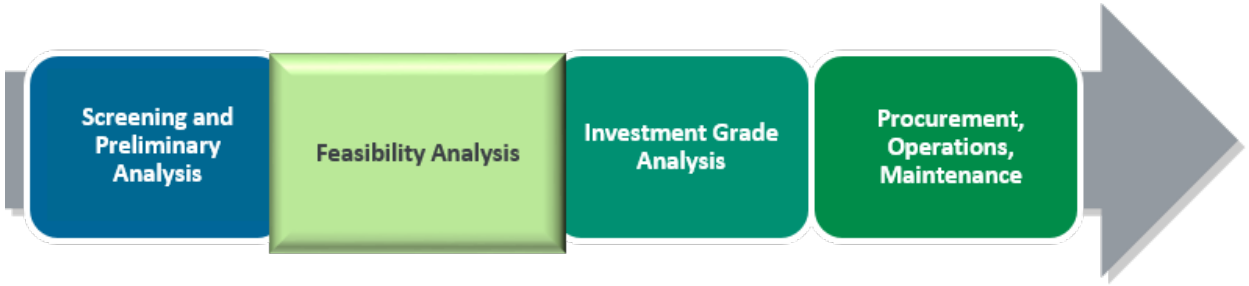
Annual Energy Consumption		
	Base Case	CHP Case
Purchased Electricty, kWh	88,250,160	5,534,150
Generated Electricity, kWh	0	82,716,010
On-site Thermal, MMBtu	426,000	18,872
CHP Thermal, MMBtu	0	407,128
Boiler Fuel, MMBtu	532,500	23,590
CHP Fuel, MMBtu	0	969,845
Total Fuel, MMBtu	532,500	993,435
Annual Operating Costs		
Purchased Electricity, $	$7,060,013	$1,104,460
Standby Power, $	$0	$0
On-site Thermal Fuel, $	$3,195,000	$141,539
CHP Fuel, $	$0	$5,819,071
Incremental O&M, $	$0	$744,444
Total Operating Costs, $	$10,255,013	$7,809,514
Simple Payback		
Annual Operating Savings, $		$2,445,499
Total Installed Costs, $/kW		$1,400
Total Installed Costs, $/k		$12,990,000
Simple Payback, Years		**5.3**
Operating Costs to Generate		
Fuel Costs, $/kWh		$0.070
Thermal Credit, $/kWh		($0.037)
Incremental O&M, $/kWh		$0.009
Total Operating Costs to Generate, $/kWh		**$0.042**

Screening Questions



1. Do you pay more than $.06/kWh on average for electricity (including generation, transmission and distribution)?
2. Are you concerned about the impact of current or future energy costs on your operations?
3. Are you concerned about power reliability?
   What if the power goes out for 5 minutes… for 1 hour?
4. Does your facility operate for more than 3,000 hours per year?
6. Do you have thermal loads throughout the year?
   (including steam, hot water, chilled water, hot air, etc.)
   Does your facility have an existing central plant?
7. Do you expect to replace, upgrade, or retrofit central plant equipment within the next 3-5 years?
8. Do you anticipate a facility expansion or new construction project within the next 3-5 years?
9. Have you already implemented energy efficiency measures and still have high energy costs?
10. Are you interested in reducing your facility's impact on the environment?
11. Do you have access to on-site or nearby biomass resources?
    (i.e., landfill gas, farm manure, food processing waste, etc.)

A Feasibility Analysis Typically Involves:



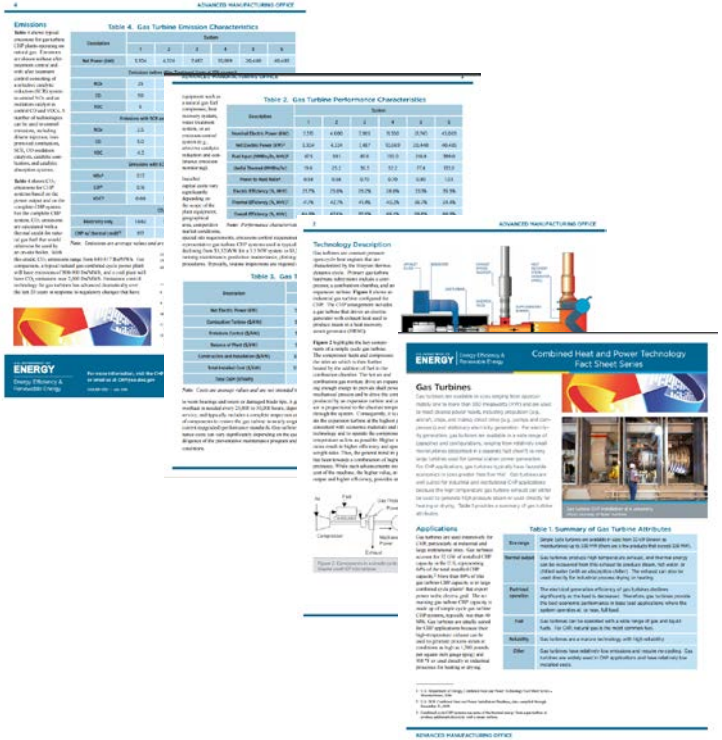
- Electrical load profiling
- Thermal load profiling
- Unit sizing
- Thermal use determination (what to do with the heat)
- Installation cost estimations
- Financial calculations (simple payback, ROI, etc.)
- Cost/savings information compared to what your facility would pay if the CHP system were not installed

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

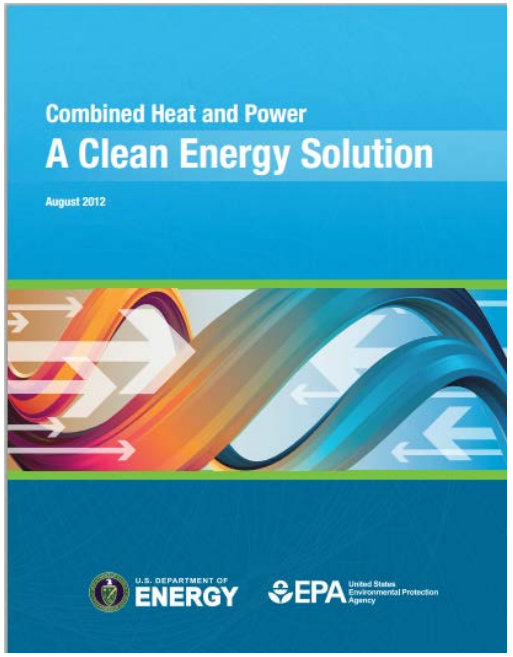
CHP Project Resources

DOE CHP Technologies Fact Sheet Series



www.energy.gov/chp-technologies

Good Primer Report



www.eere.energy.gov/chp

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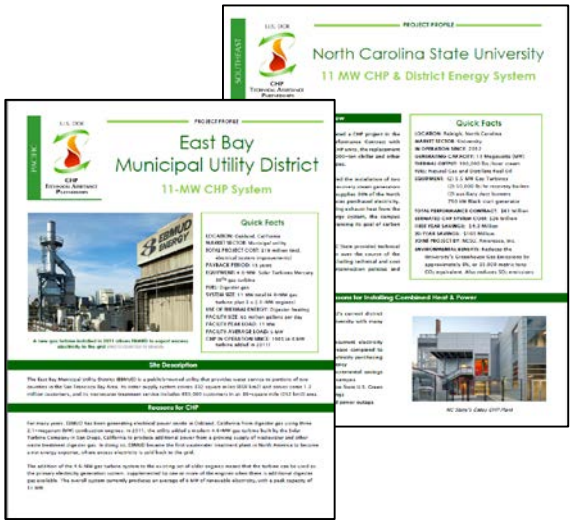
CHP Project Resources

DOE Project Profile Database



energy.gov/chp-projects

EPA dCHPP (CHP Policies and Incentives Database

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

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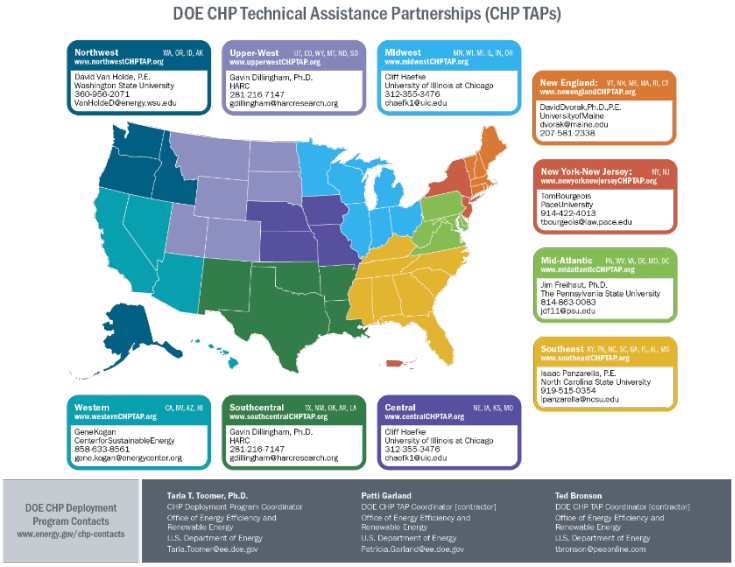
CHP Project Resources

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

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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
- Take advantage of available incentives
  - Utility incentives for feasibility studies
  - Utility incentives for projects (production incentives)
  - Federal investment tax credits

Thank You

Cliff Haefke
Director
(312) 355-3476
chaefk1@uic.edu

Graeme Miller
Assistant Director, Midwest
(312) 996-3711
gmille7@uic.edu

David Baker
Assistant Director, Central
312-996-2615
dsbaker@uic.edu