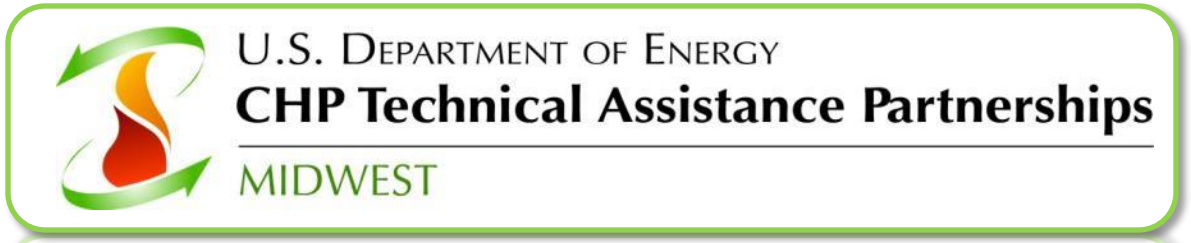
Combined Heat and Power Opportunities (CHP) in Minnesota

Natural Gas Conservation Conference
Minnesota BLUE FLAME GAS Association

September 22, 2015

Cliff Haefke
US DOE Midwest CHP TAP Director



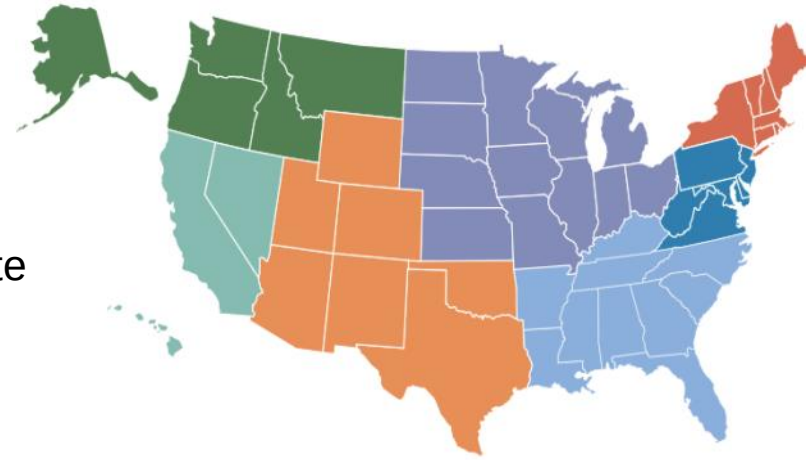
Presentation Topics

- US DOE CHP TAPs
- CHP the Concept
- CHP Technologies
- CHP System Highlights
- Next Steps

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



http://www.energy.gov/chp

U.S. Department of Energy
CHP Technical Assistance Partnerships
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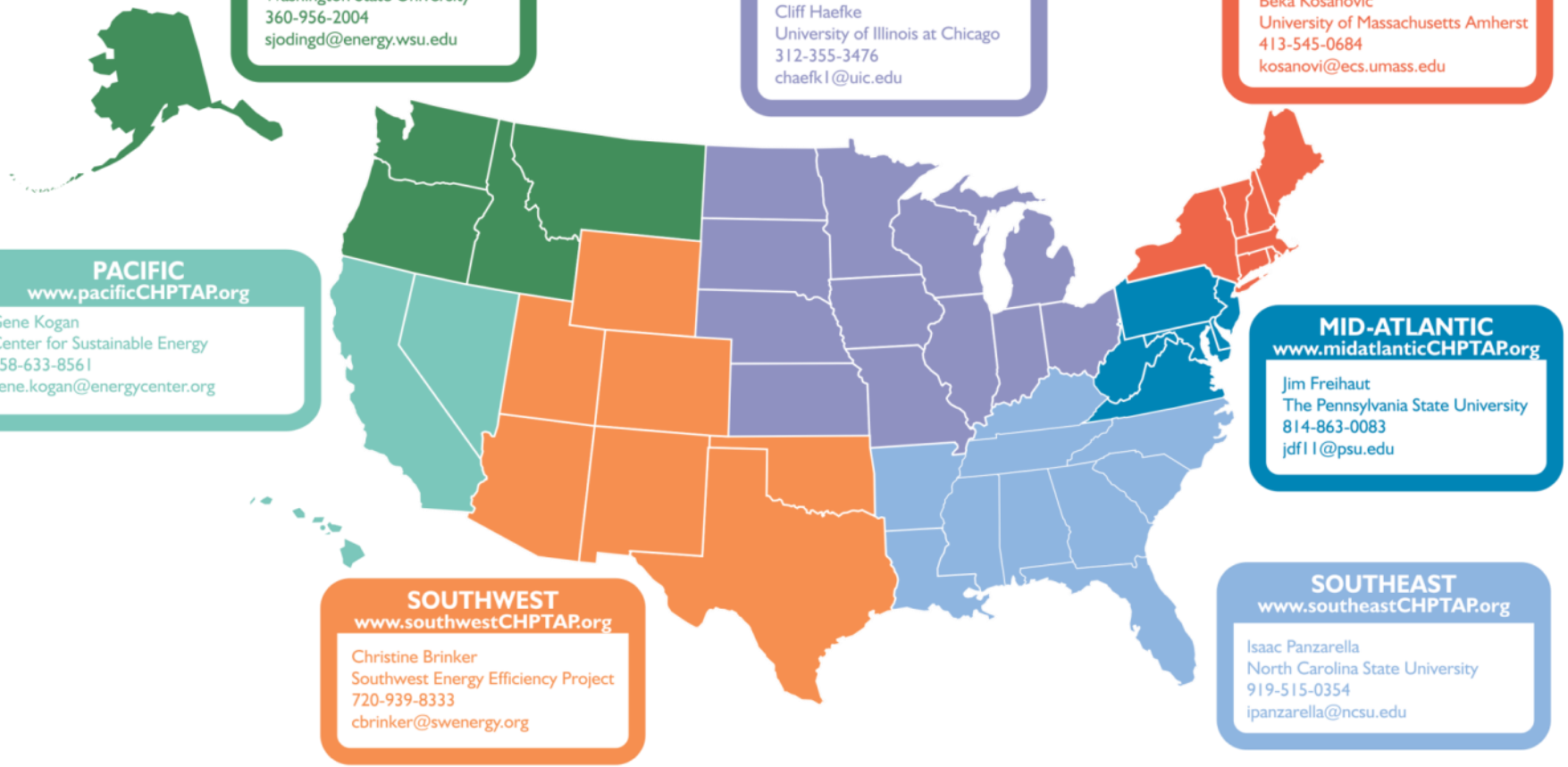
DOE CHP Technical Assistance Partnerships (CHP TAPs)



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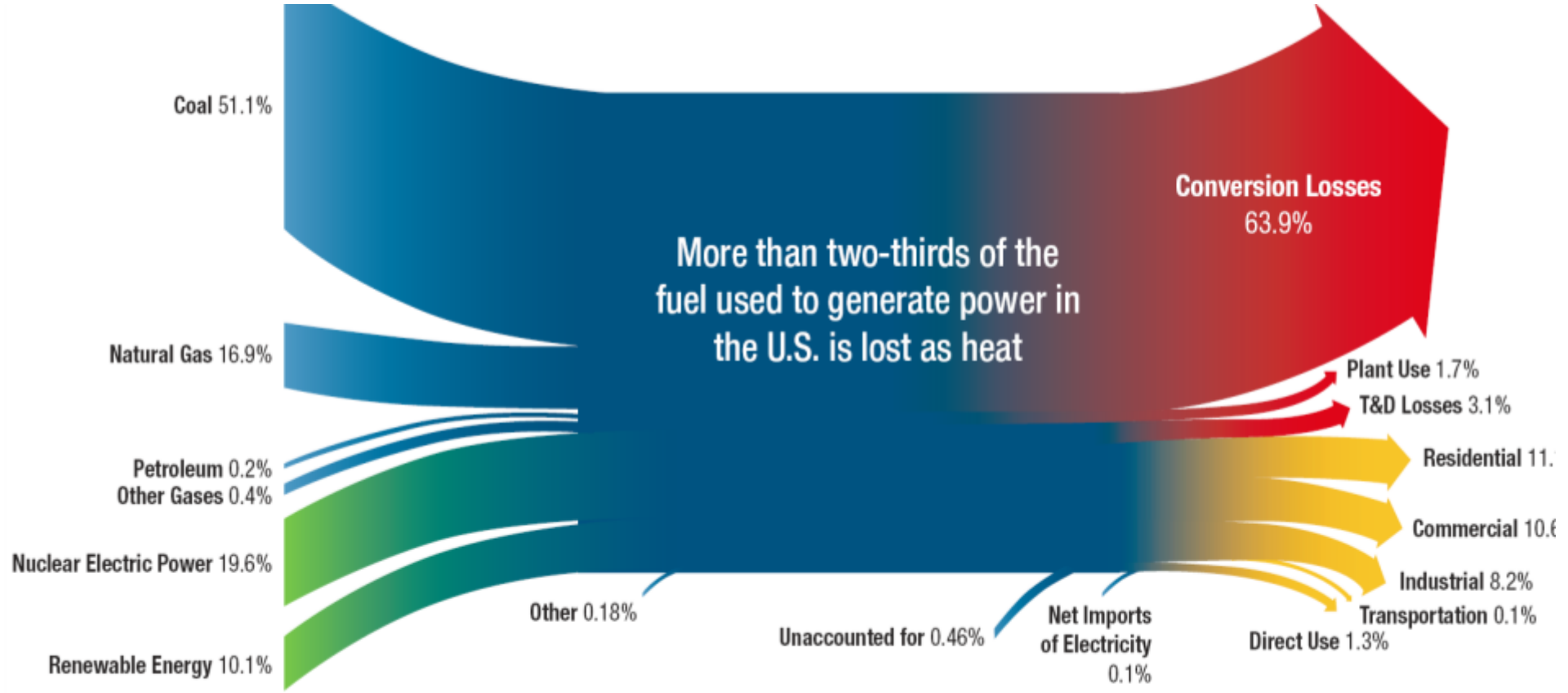
CHP the Concept

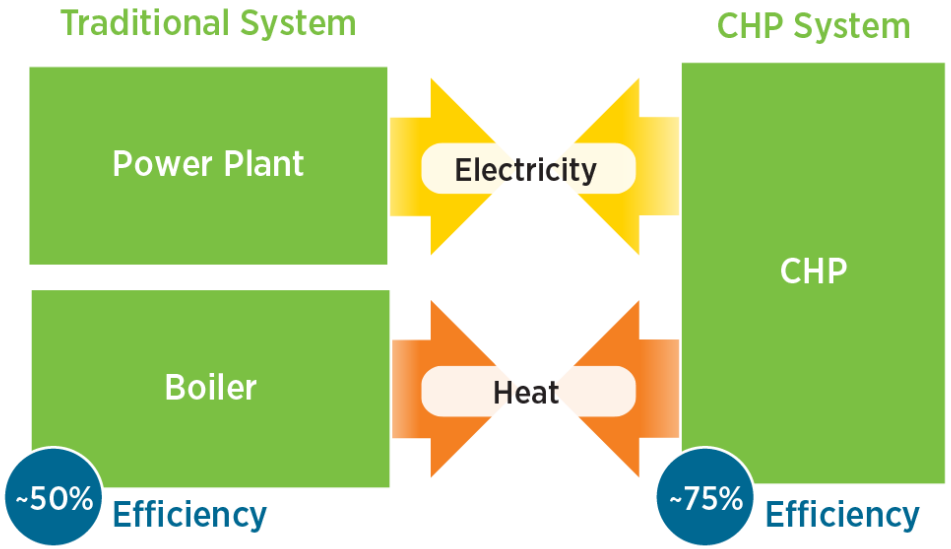
Fuel Utilization by U.S. Utility Sector



Source: http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_report_12-08.pdf

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.

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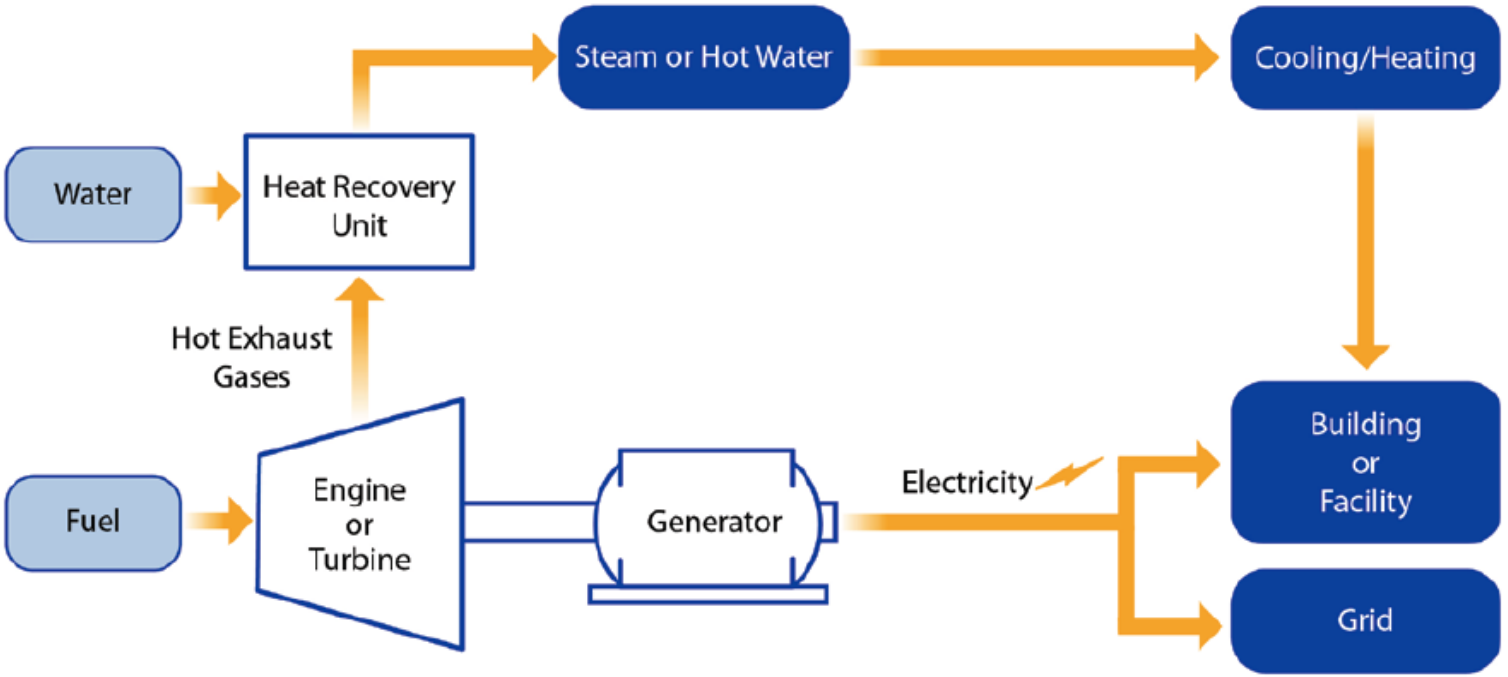
Source: http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_clean_energy_solution.pdf

Defining Combined Heat & Power (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 – 32%**
- **Thermal generation - 80%**
- **Combined efficiency – 45% to 55%**

CHP Energy Efficiency (combined heat and power)
70% to 85%
Reducing greenhouse gas emissions by 30-55%

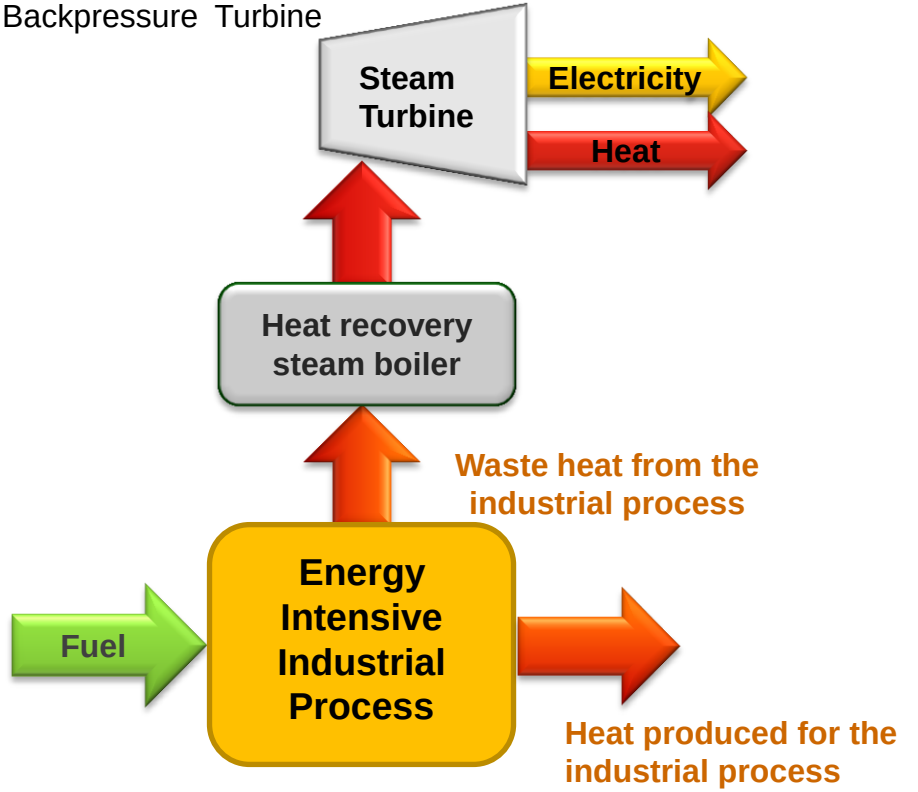
Defining Combined Heat & Power (CHP)

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)*

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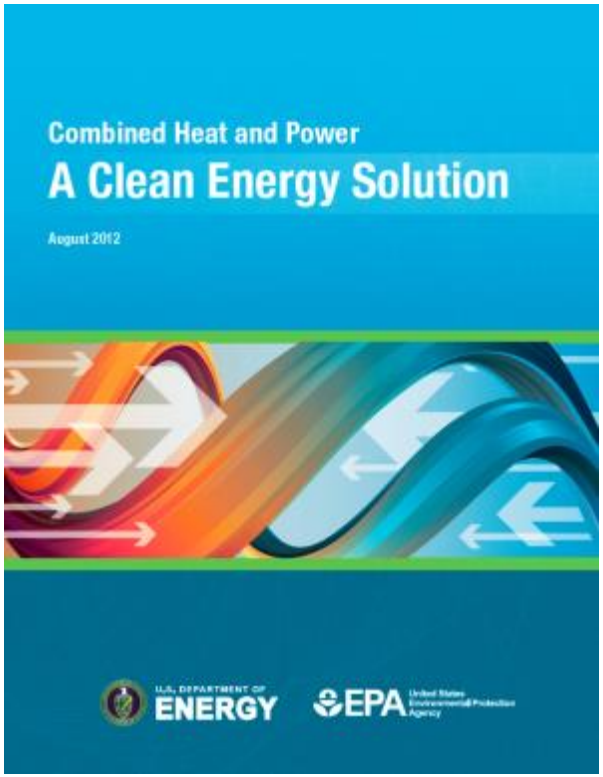
What Are the Benefits of CHP?

- 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*

Emerging Drivers for CHP

- Benefits of CHP recognized by policymakers
  - President Obama signed an Executive Order to accelerate investments in industrial EE and CHP on 8/30/12 that sets national goal of 40 GW of new CHP installation over the next decade
  - State Portfolio Standards (RPS, EEPS, Tax Incentives, Grants, standby rates, etc.)
- Favorable outlook for natural gas supply and price in North America
- Opportunities created by environmental drivers
- Utilities finding economic value
- Energy resiliency and critical infrastructure

DOE / EPA CHP Report (8/2012)



Executive Order: http://www.whitehouse.gov/the-press-office/2012/08/30/executive-order-accelerating-investment-industrial-energy-efficiency
Report: http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_clean_energy_solution.pdf

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

What Site Characteristics are Favorable for Future CHP Projects?

- Concern about energy costs
- Concern about power reliability
- Concern about sustainability and environmental impacts
- Long hours of operation
- Existing thermal loads
- Central heating and cooling plant
- Future central plant replacement and/or upgrades
- Future facility expansion or new construction projects
- EE measures already implemented
- Access to nearby renewable fuels
- Facility energy champion

What market sectors make sense for CHP?

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

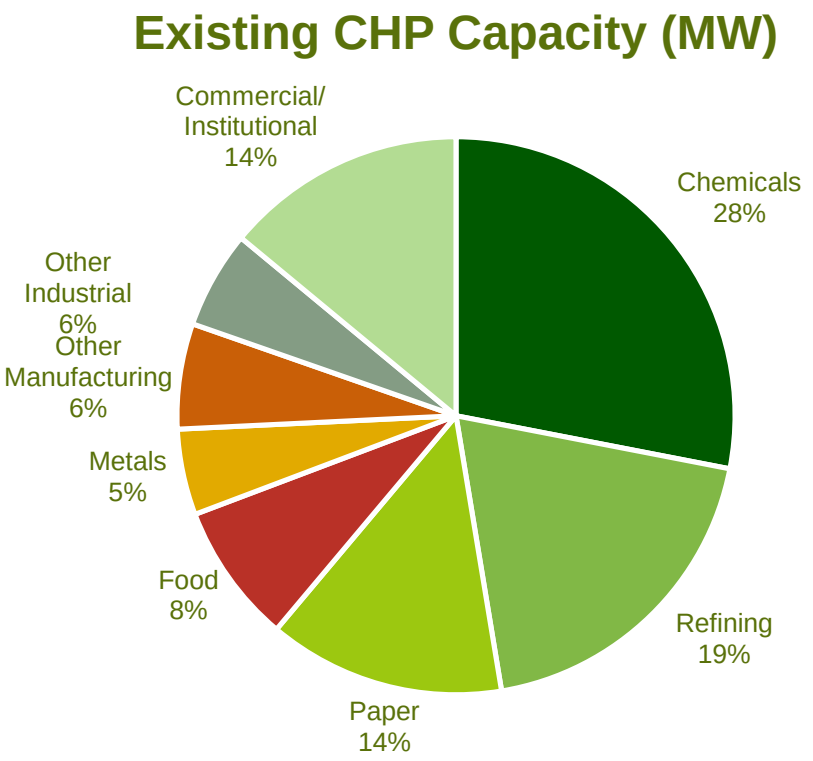
Institutional

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

Agricultural

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

CHP Today in the United States



Sources: DOE/ICF CHP Installation Database (U.S. installations as of December 31, 2014);
EIA http://www.eia.gov/todayinenergy/detail.cfm?id=8250
Energetics, "US Manufacturing Energy Use and Greenhouse Gas Emissions Analysis, November 2012"

- **82.7 GW** of installed CHP at over 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

CHP Installations Summary in Minnesota

Market Sector	Sites	MW
Commercial	21	238.8
Industrial	23	669.2
Other	8	53.5
Total	52	961.5

Technology	Sites	MW
Boiler/Steam Turbine	27	674.7
Combined Cycle	2	264.0
Combustion Turbine	2	6.5
Reciprocating Engine	10	10.9
Fuel Cell	-	-
Microturbine	6	0.5
Waste Heat to Power	5	5.0
Other	-	-
Total	52	961.5

Fuel Type	Sites	MW
Biomass	15	147.4
Coal	11	330.4
Natural Gas	14	361.0
Oil	1	3.9
Waste	8	68.7
Wood	3	50.2
Other	-	-
Total	52	961.5

Source: U.S. DOE CHP Installation Database (as of December 2013)
https://doe.icfwebservices.com/chpdb/

CHP Installations in Minnesota

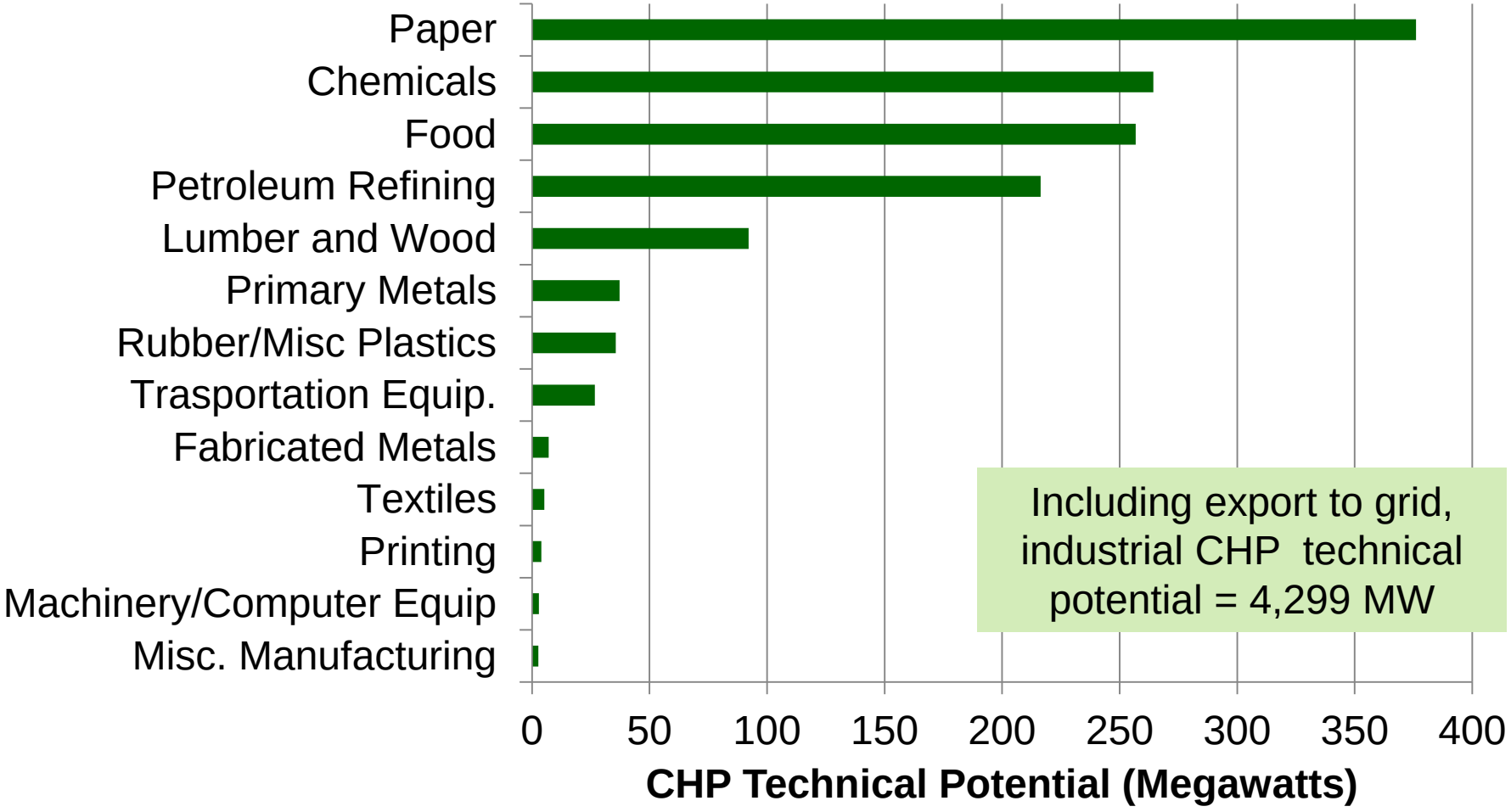
City	Facility Name
Albert Lea	Albert Lea Wastewater Treatment Plant
Alexandria	Pope-Douglas Resource Recovery Facility
Altura	Diamond K Dairy / Ponderosa Dairy
Bemidji	Potlatch Corporation
Brainerd	Potlatch Corporation
Brooten	Jer-Lindy Farms
Burnsville	Fairview Ridges Hospital
Cloquet	Sappi Fine Papers (Potlatch Corp)
Cloquet	Fond du Lac Tribal and Community College
Coon Rapids	YMCA Coon Rapids
Cottage Grove	3M Plant
Crookston	American Crystal Sugar Co
Duluth	Lake Superior Paper Co
East Grand Forks	American Crystal Sugar Co
Grand Rapids	Blandin Paper Company
Hancock	District 45 Dairy
Hibbing	Hibbing Public Utilities Comm
International Falls	Boise Cascade Corporation
Lake Crystal	Poet Biorefining - Ethanol
Little Falls	Central Minnesota Ethanol Cooperative
Mankato	Archer Daniels Midland Company
Maplewood	Ramsey County Correctional Facility
Minneapolis	Dakota Station
Minneapolis	Foster Wheeler Twin Cities, Inc.
Minneapolis	FMC
Minneapolis	U.S. Navy / FMC

City	Facility Name
Moorhead	American Crystal Sugar Co
Morris	Riverview Farms (site #1)
Morris	Riverview Farms (site #2)
New Ulm	New Ulm Public Utilities Comm
Ottawa	Center Point Energy
Perham	Tuffy's Pet Foods
Princeton	Haubenschild Dairy
Rochester	Southern Minnesota Beet Sugar
Rochester	Rochester WWTP
Rochester	County Of Olmsted
Rochester	Franklin Heating Station
Rochester	St. Mary's Hospital
Rochester	Mayo Clinic
Shakopee	Koda Energy LLC
Sherburne	Liberty Paper
Silver Bay	Northshore Mining Corporation
Spring Valley	Spring Valley Pub Utils Comm
St. Paul	Rock Tenn St. Paul Facility
St. Paul	Metropolitan Council / Von Roll Inc.
St. Paul	St. Paul Cogeneration Plant
St. Paul	District Energy St. Paul
St. Peter	Northern Plains Dairy
Virginia	City of Virginia
West Duluth	ML Hibbard
Willmar	Willmar Municipal Utils Comm
Winona	Winona Wastewater Treatment Facility

Source: U.S. DOE CHP Installation Database (as of December 2014)
https://doe.icfwebservices.com/chpdb/

CHP Opportunities in Minnesota

"Industrial" CHP Technical Potential = 1,327 Megawatts



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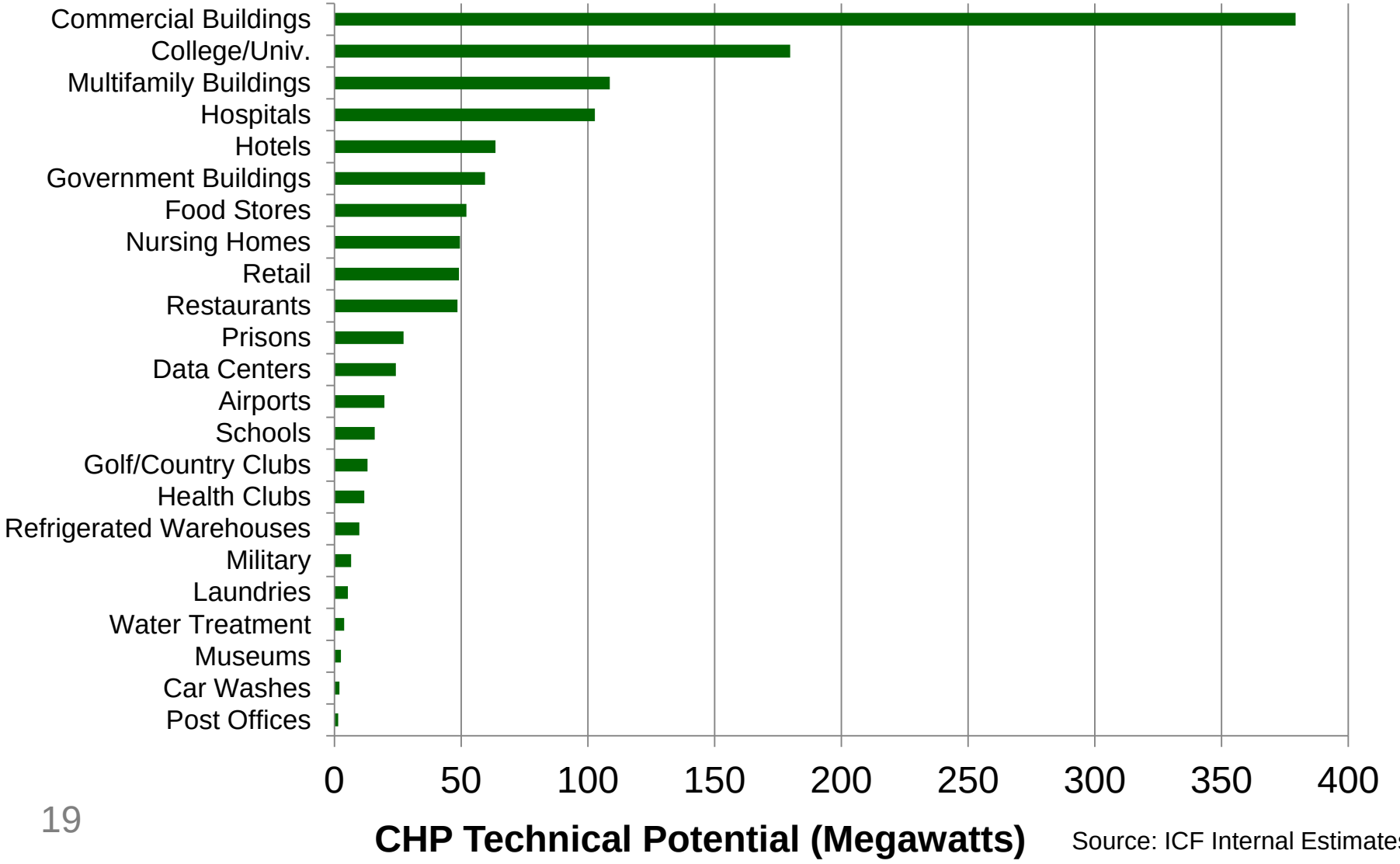
Source: ICF Internal Estimates

CHP Opportunities in Minnesota

"Commercial/Institutional" CHP Technical Potential = 1,236 Megawatts



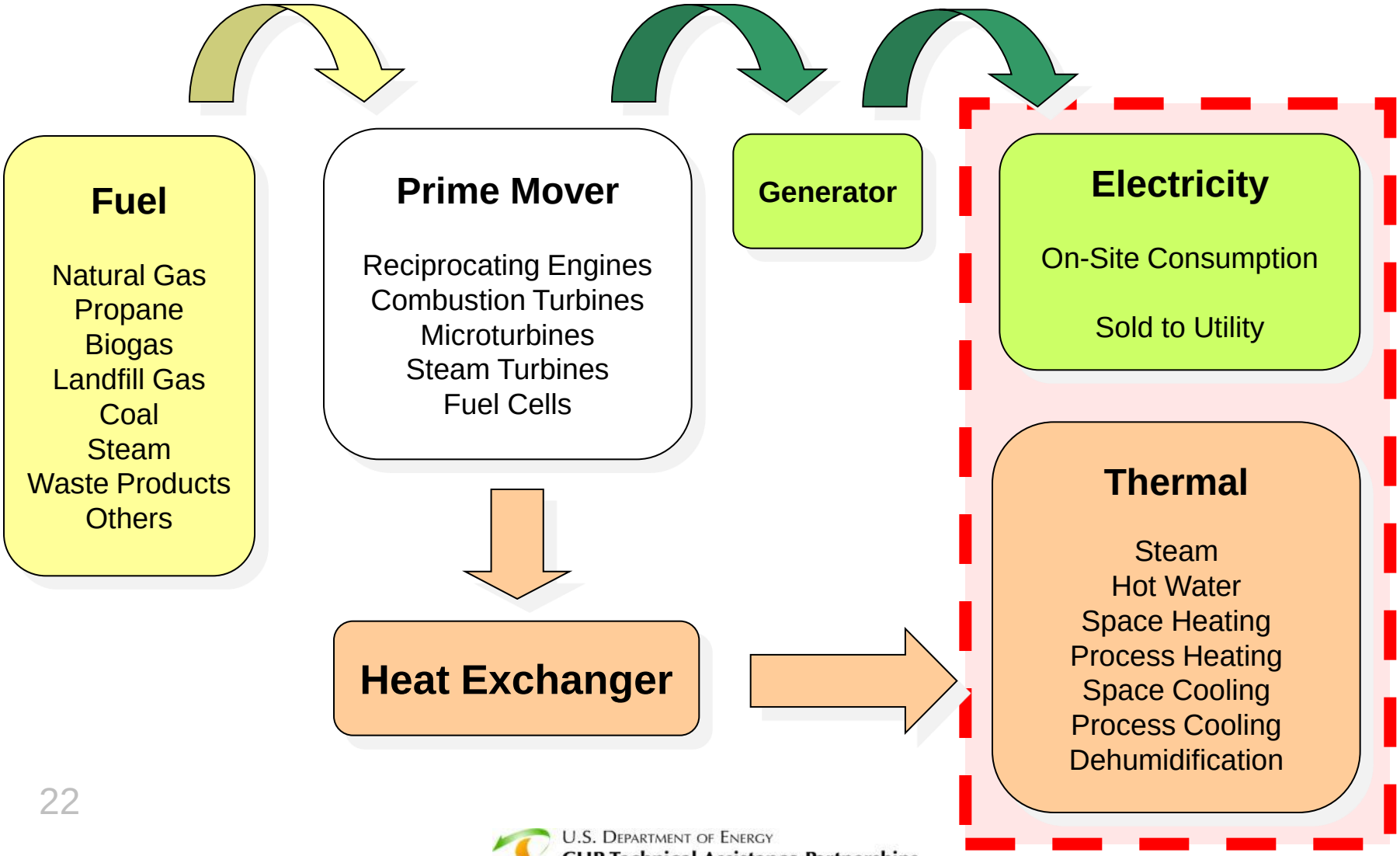
Source: ICF Internal Estimates

CHP Activities in Minnesota

- Minnesota CHP State Action Plan to be Issued by Minnesota Department of Commerce (COMM) later this year
  - Funded by DOE SEP Competitive Grant
  - Included Stakeholder Meetings and Comment Periods in 2014 & 2015
  - Included studies on CHP barriers, standby rates, and policy recommendations
- Minnesota Department of Commerce targeting wastewater treatment sector for energy efficiency and CHP (funded under DOE SEP Competitive Grant)
- Minnesota Public Utility Commission Generic Docket on Standby Rates (expected Fall 2015)
- University of Minnesota CHP Barriers Study (funded by Institute for Advanced Studies)
- For more information on Minnesota COMM activities, contact Jessica Burdette (Jessica.Burdette@state.mn.us, 651-539-1871) or Adam Zoet (Adam.Zoet@state.mn.us, 651-539-1798)

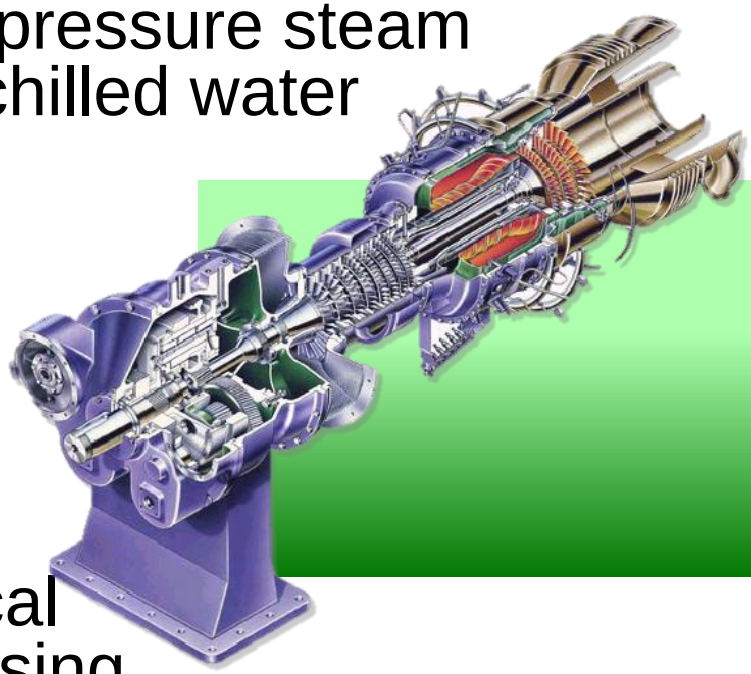
CHP Technologies

CHP Technology Components



Prime Mover: Combustion Gas Turbine

- Size Range: 500 kW 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)
  - Efficiency at part load can be be substantially less than at full load.
- Example Applications:
  - hospitals, universities, chemical plants, refineries, food processing, paper, military bases



Source: DOE/EPA Catalog of CHP Technologies

Prime Mover: Reciprocating Engines

- Size Range: 10 kW to 18 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:
  - food processing, office buildings, multifamily housing, nursing homes, hospitals, schools, universities, wastewater treatment

Source: DOE/EPA Catalog of CHP Technologies

Prime Mover: Microturbines

- Size Range: 30 kW to 330 kW
- 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

Source: DOE/EPA Catalog of CHP Technologies

Prime Mover: Steam Turbine

- 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 (coal and biomass fuels such wood, and waste products, and pellets).
  - Steam extracted or exhausted from steam turbine can be used for thermal application
  - Can operated over a wide range of steam pressures.
- Example Applications:
  - industrial applications, district heating and cooling systems; forest products, paper mills, chemicals, food processing, backpressure turbines in lieu of steam system pressure reducing valves

Source: DOE/EPA Catalog of CHP Technologies

Prime Mover: Fuel Cells

- Size Range: 3 kW to 2 MW
- Characteristics
  - Relatively high electrical efficiencies 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

Source: DOE/EPA Catalog of CHP Technologies

Two Types of Generators

Induction

- **Requires External Power Source to Operate (Grid)**
- Contributes to Poor PF
- **When Grid Goes Down, CHP System Goes Down**
- Less Complicated & Less Costly to Interconnect
- Preferred by Utilities

Synchronous

- **Self Excited (Does Not Need Grid to Operate)**
- Can Assist in PF Correction
- **CHP System can Continue to Operate thru Grid Outages**
- More Complicated & Costly to Interconnect (Safety)
- Preferred by CHP Customers

Operation Requirements and Highlighted CHP Examples Maintaining Facility Operations

Uninterrupted Operation Requirements

- **Black start capability**
  - allows the system to start up independently from the grid
- **Generators capable of grid-independent operation**
  - the system must be able to operate without the grid power signal
- **Ample carrying capacity**
  - system size must match critical loads
- **Parallel utility interconnection and switchgear controls**
  - the system must be able to disconnect from the grid, support critical loads, and reconnect after an event

CHP System Highlights	
Super-storm Sandy	Princeton University Princeton, NJ 5 MW gas turbine
Hurricane Katrina	Mississippi Baptist Medical Center Jackson, MS 4.2 MW gas turbine
Midwest Snow Storm	Presbyterian Homes Evanston, IL 2.4 MW recip engines
Operating CHP Since 1969	Brandonview Building St. Louis, MO 4.3 MW recip engines

Heat Capture: Converting Heat into Work

Heat Exchangers

- Recover exhaust gas generated by:
  - Gas turbine
  - Industrial processes
- Transfers exhaust gas into useful heat (e.g., steam) for downstream applications
- Heat recovery steam generator (HRSG) the most common

Heat Recovery Steam Generator (HRSG)

Heat Capture: Converting Heat into Work

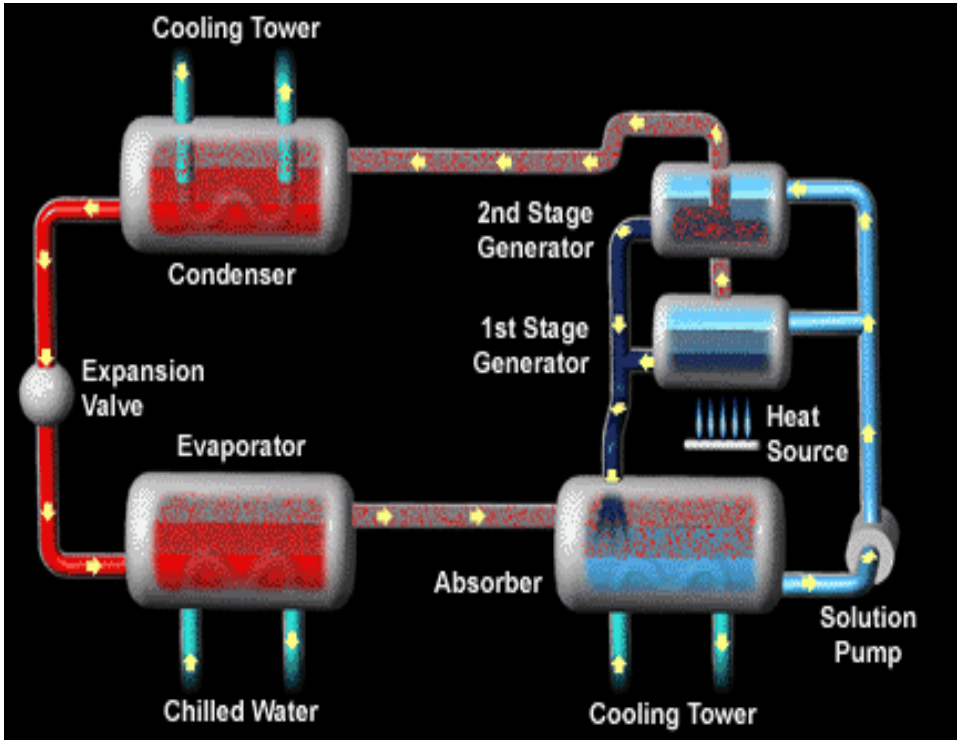
Heat-Driven Chillers (Absorption)

- Use "waste" heat to chill water for A/C, cooling machinery
- More efficient, fewer emissions vis-à-vis electric chillers

ABSORPTION CHILLERS

Use exhaust gas, hot water, or steam via thermal compressor to boil water vapor out of lithium bromide/ water solution and compress refrigerant to higher pressure; avoids CFCs/HCFCs

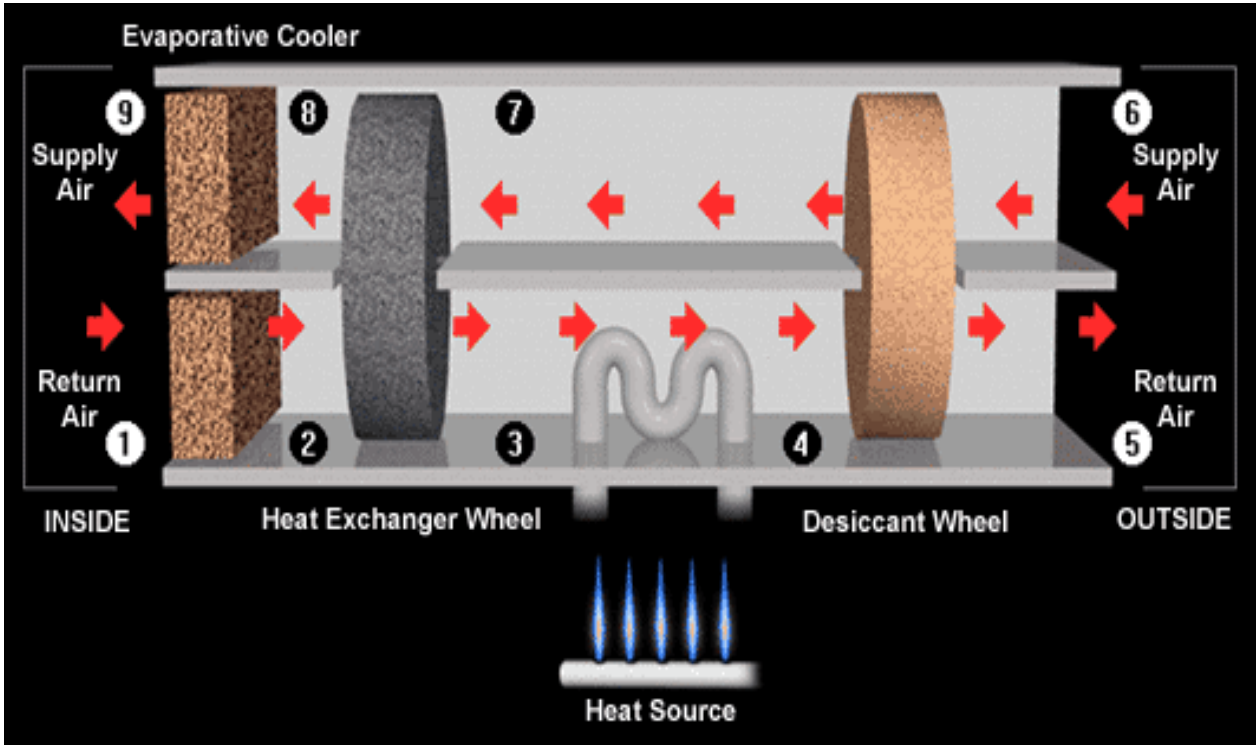
Range: 10-3,000 tons



Heat Capture: Converting Heat into Work

Desiccant Dehumidifiers

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

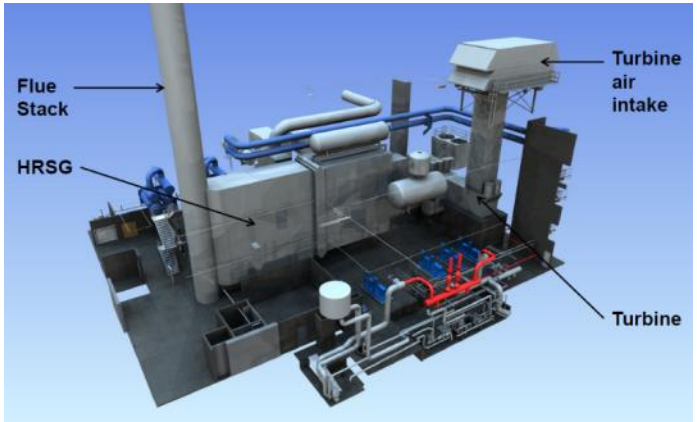


Example CHP System Highlights

CHP System Highlights:
CHP in Colleges/Universities

University of Minnesota
Minneapolis, MN

Status: **Under Development**
Capacity: **25 MW**
Fuel: **Natural Gas**
Prime Mover: **Combustion Turbine**
Expected Completion: **2016**



Rendering of Turbine and Heat Recovery Steam Generator


Minimal changes will need to be made to the existing building's exterior

8 Year Return on Investment

Decreases the Twin Cities Campus carbon footprint by 15%

Source: http://www1.umn.edu/regents//docket/2012/february/heatandpower.pdf

CHP System Highlights:
Microturbine Application in Lowertown Apartments

Schmidt Artists Lofts
(revamped Schmidt Brewery)
St. Paul, MN

Capacity: **65 kW**
Fuel: **Natural Gas**
Prime Mover: **Microturbine**
Installed: **2014**

The 65 kW "jet engine" produces electricity and thermal energy around the clock. Vergent Power's "Factory Protection Plan" is providing full maintenance coverage through 2024.

- Vergent Power Solutions

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Source: www.vergentpower.com
http://www.dominiumapartments.com/

CHP System Highlights:

Utility Partnering with Ethanol and Food Processing Plants

Great River Energy Spiritwood Station

Jamestown, ND

Capacity: **99 MW**
Fuel: **Natural Gas**
Prime Mover: **Steam Turbines**
Installed: **2014**

The CHP plant supplies steam to the Cargill Malt plant and the Dakota Spirit AgEnergy biorefinery.

In addition to utilizing beneficiated lignite, Spiritwood Station will use state-of-the-art control technologies to control emissions.

Source: http://www.greatriverenergy.com/makingelectricity/newprojects/spiritwood_fact_sheet.pdf

CHP System Highlights:
Municipal Utility Partnering with Greenhouse

City of Coldwater and Mastronardi Produce
Coldwater, MI

Capacity: **13 MW**
Fuel: **Natural Gas**
Prime Mover: **Recip. Engines**
Installed: **2015**

New CHP engines will meet the City's energy demand and provide Mastronardi with heat and CO_2, enabling the addition of 28.8 acres of greenhouses.

Source: http://www.inlandpowergroup.com/media_pdfs/doc_20140919114838.pdf

CHP System Highlights:

Utility Owned CHP System; Partnering with Paper Industry

Liberty Paper

(Xcel Energy – Sherburne County Generating Station)

Becker, MN

CHP Capacity: **100 MW**

CHP Fuel: **Coal**

CHP Prime Mover: **Boiler / Steam Turbine**

CHP Installed: **1994**

The steam from Sherburne County Generating Station is sold to Liberty Paper, a major employer in Becker, Minnesota.

Source: https://doe.icfwebservices.com/chpdb/state/MN; http://www.libertycarton.com
http://www.mncenter.org/Portals/0/5%20-%20legal/Xcel%20Initial%20Filing%201%20and%202%20Sherco%20Study%20smaller.pdf
http://www.xcelenergy.com/Company/Operations/Sherburne_County_(Sherco)_Generating_Station

US DOE CHP TAP
Services and Resources

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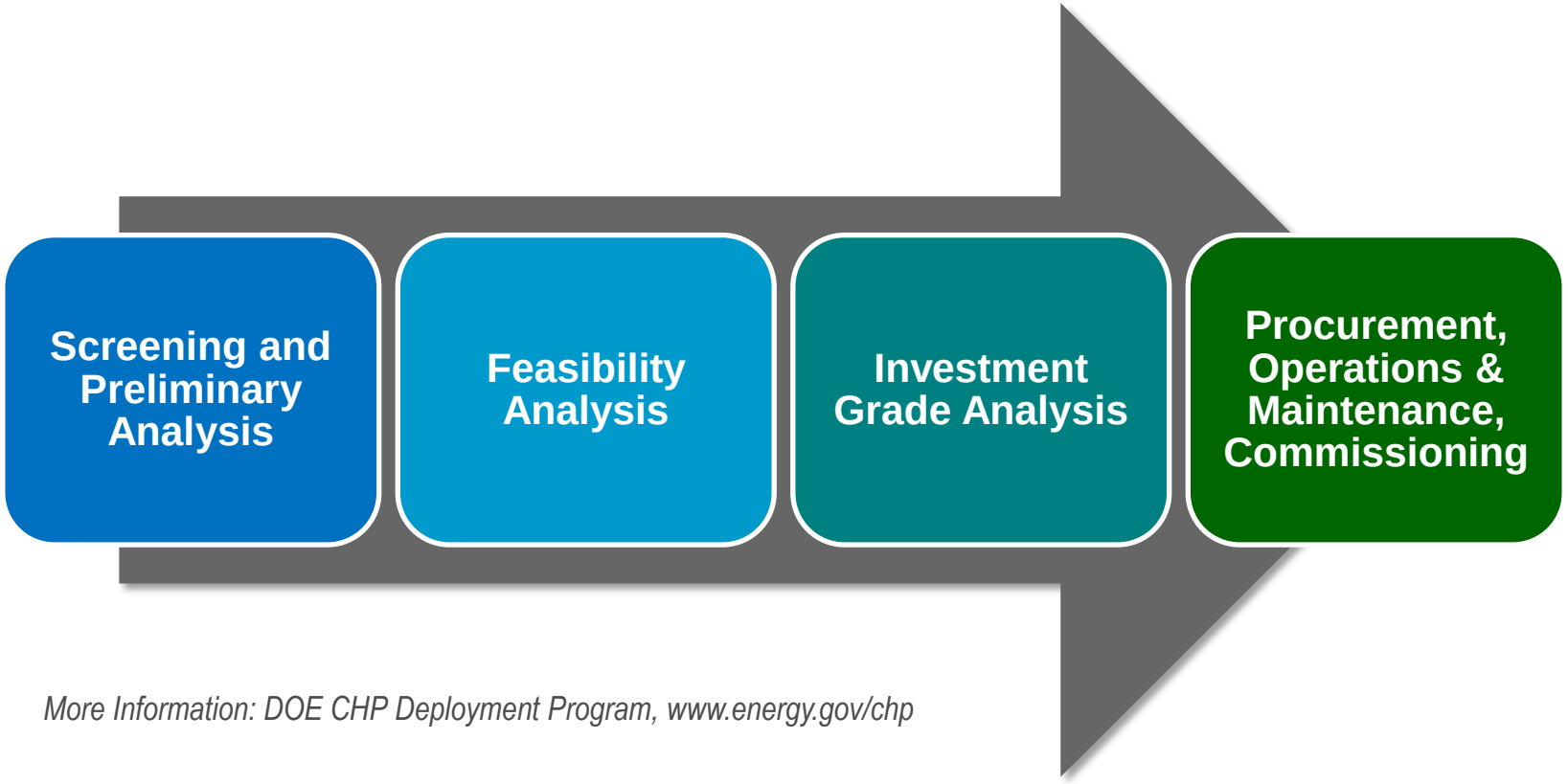
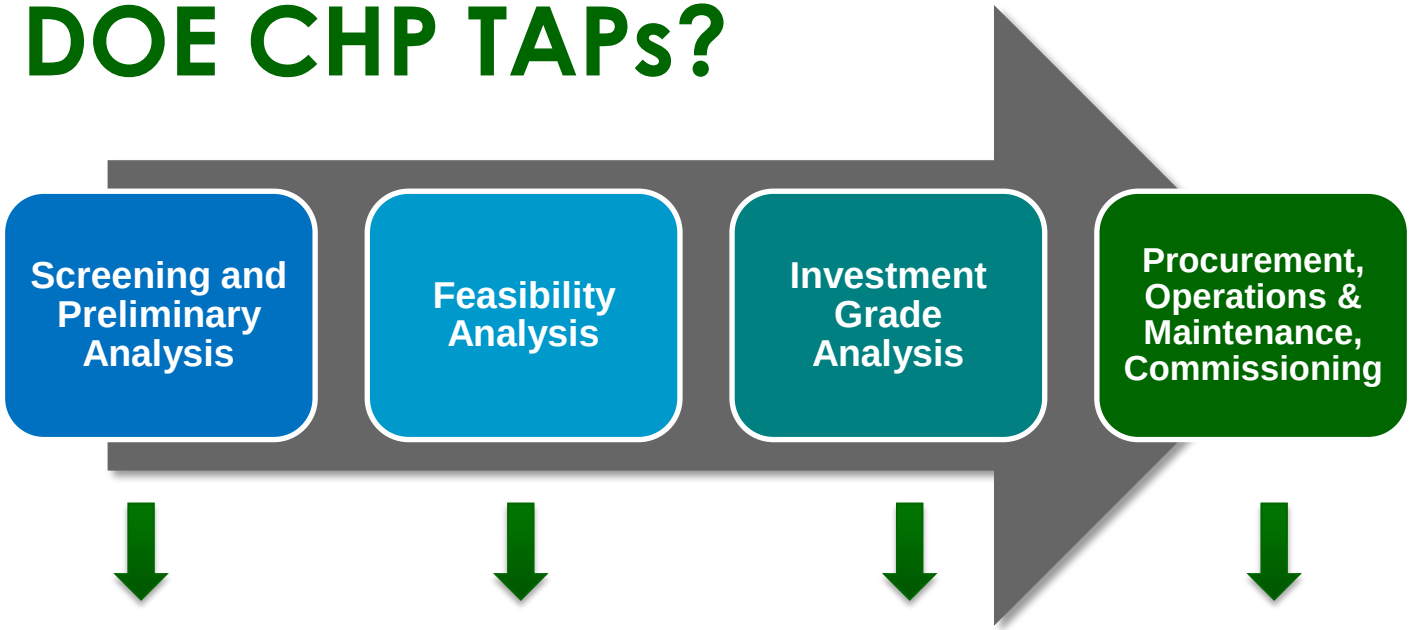
What is the Project Development Process for a CHP Project?



More Information: DOE CHP Deployment Program, www.energy.gov/chp

Following the Project Development process can help reduce risk later down the road.

What type of Technical Assistance is available through the U.S. DOE CHP TAPs?



US DOE CHP TAP Services:			
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 choices.	Review specifications and bids, Limited operational analysis

CHP Project Resources

- **U.S. DOE CHP Installation Database**
  - Comprehensive data collection listing CHP installations through the country
  - Data includes site location, type of prime mover, system size, fuel type, year installed
  - New format published Spring 2015 (includes downloadable spreadsheets)
  - https://doe.icfwebservices.com/chpdb/
- **U.S. DOE CHP TAP Project Profiles**
  - 2 page fact sheets providing information and lessons learned of operating CHP systems (100+ available)
  - http://www1.eere.energy.gov/manufacturing/distributedenergy/chp_projects.html

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

Summary and Next Steps

- CHP is a proven technology with numerous benefits, market factors are coming together to create an emerging opportunity for CHP, and many opportunities exist in Minnesota
- Next steps…
  - For Gas Utilities – consider partnering with DOE Midwest CHP TAP to educate key accounts on benefits of CHP for their application
  - For Prospective End Users – contact the DOE Midwest CHP TAP for a quick no-cost qualification screening to see if CHP works for your facility

Thank You

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