PART B Webinar: Biogas CHP Systems in Wastewater Treatment Plants

U.S. DOE Midwest CHP Technical Assistance Partnership

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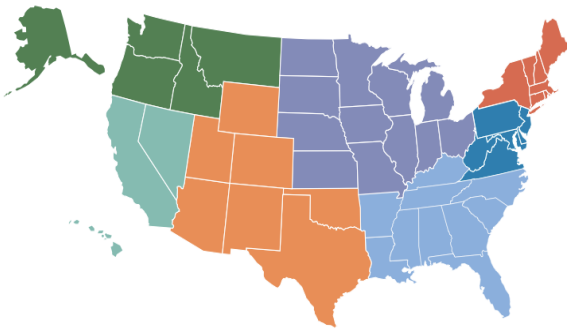
October 13, 2016

Presentation Overview

- DOE CHP TAP Technical Assistance
- Overview of Combined Heat & Power (CHP)
  - Concept
  - Benefits
  - Market
- Example CHP Projects
- Biogas Conditioning
- Working with the DOE CHP TAPs
- Next Steps and Questions

U.S. DOE CHP Deployment Program

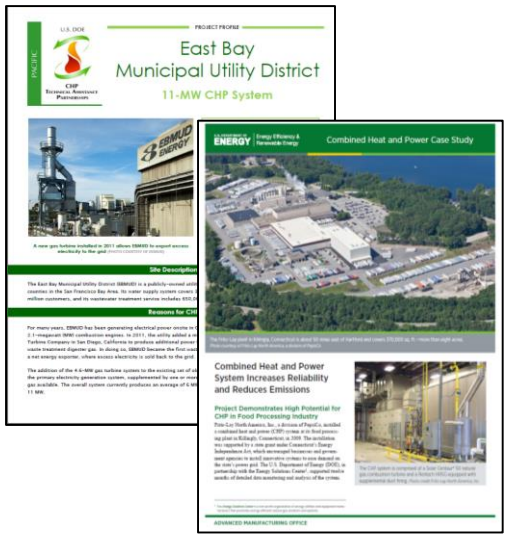
- Market Analysis and Tracking – Supporting analyses of CHP market opportunities in diverse markets including industrial, federal, institutional, and commercial sectors.



www.energy.gov/chp

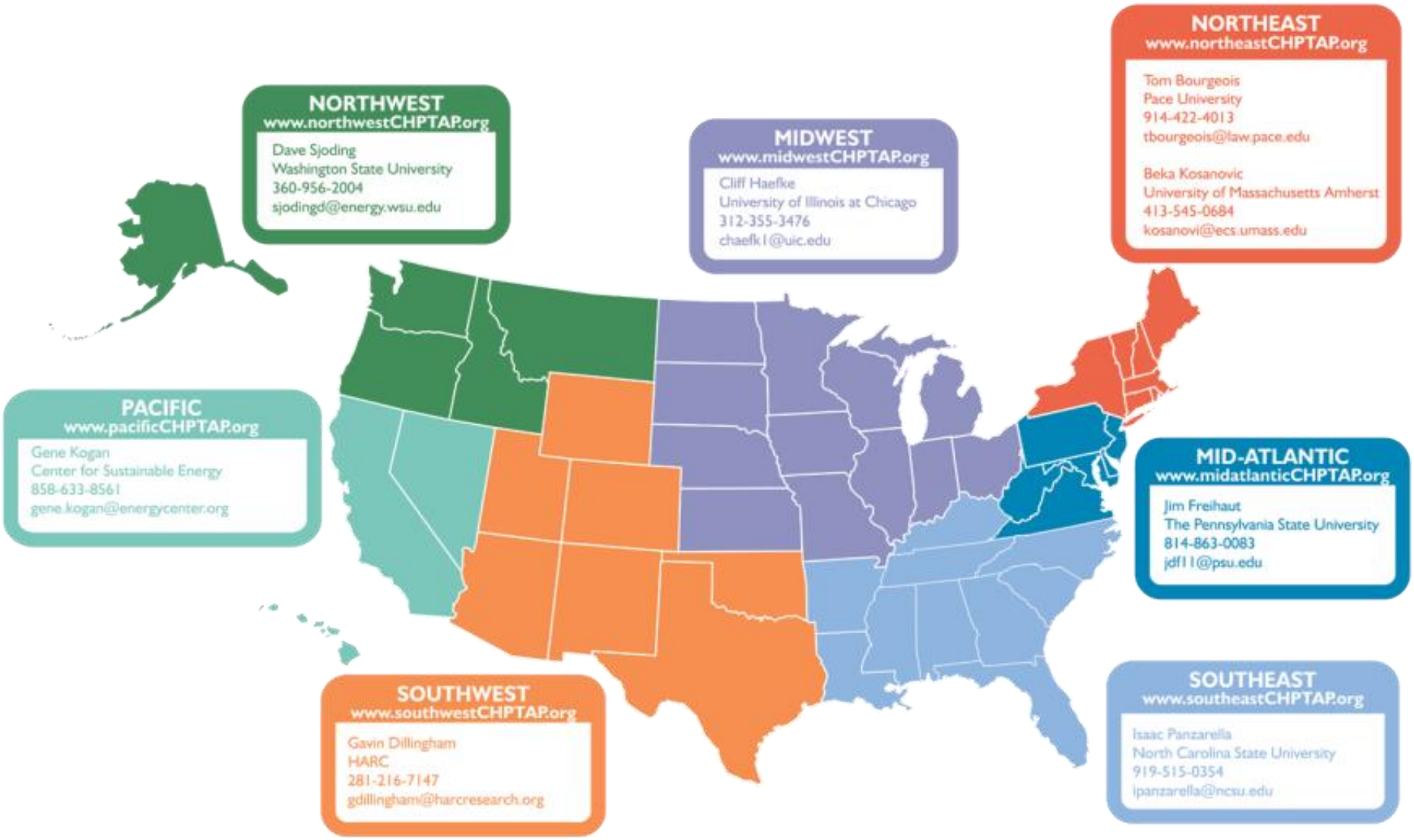
- Technical Assistance through DOE's CHP Technical Assistance Partnerships (CHP TAPs) – Promote and assist in transforming the market for CHP, waste heat to power, and district energy with CHP throughout the United States

- Just Launched Combined Heat and Power (CHP) for Resiliency Accelerator - Collaborating with Partners to support consideration of CHP and other distributed generation solutions for critical infrastructure resiliency planning at the state, local, and utility levels



- Packaged CHP System Challenge (under development) - Increase CHP deployment in underdeveloped markets with standardized, and warrantied packaged CHP systems driven by strong end-user engagement via Market Mover Partners, such as cities, states, and utilities

DOE CHP Technical Assistance Partnerships (CHP TAPs)



DOE CHP Technical Assistance Partnerships (CHP TAPs): Program Contacts

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CHP Technical Assistance Partnerships

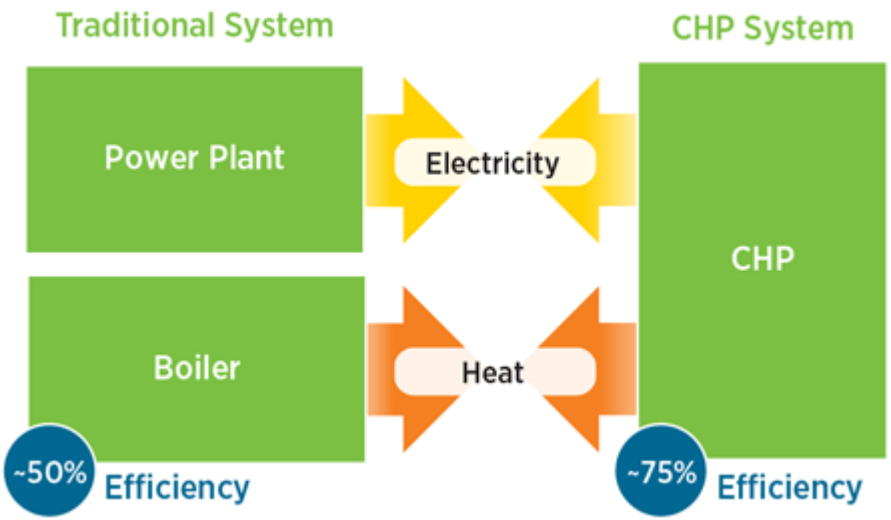
- **Technical Assistance**
  Providing technical assistance to end-users and stakeholders to help them consider CHP, waste heat to power, and/or district energy with CHP in their facility and to help them through the development process from initial CHP screening to installation.

- **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.

- **Market Opportunity Analysis**
  Supporting analyses of CHP market opportunities in diverse markets including industrial, federal, institutional, and commercial sectors

CHP: A Key Part of Our Energy Future

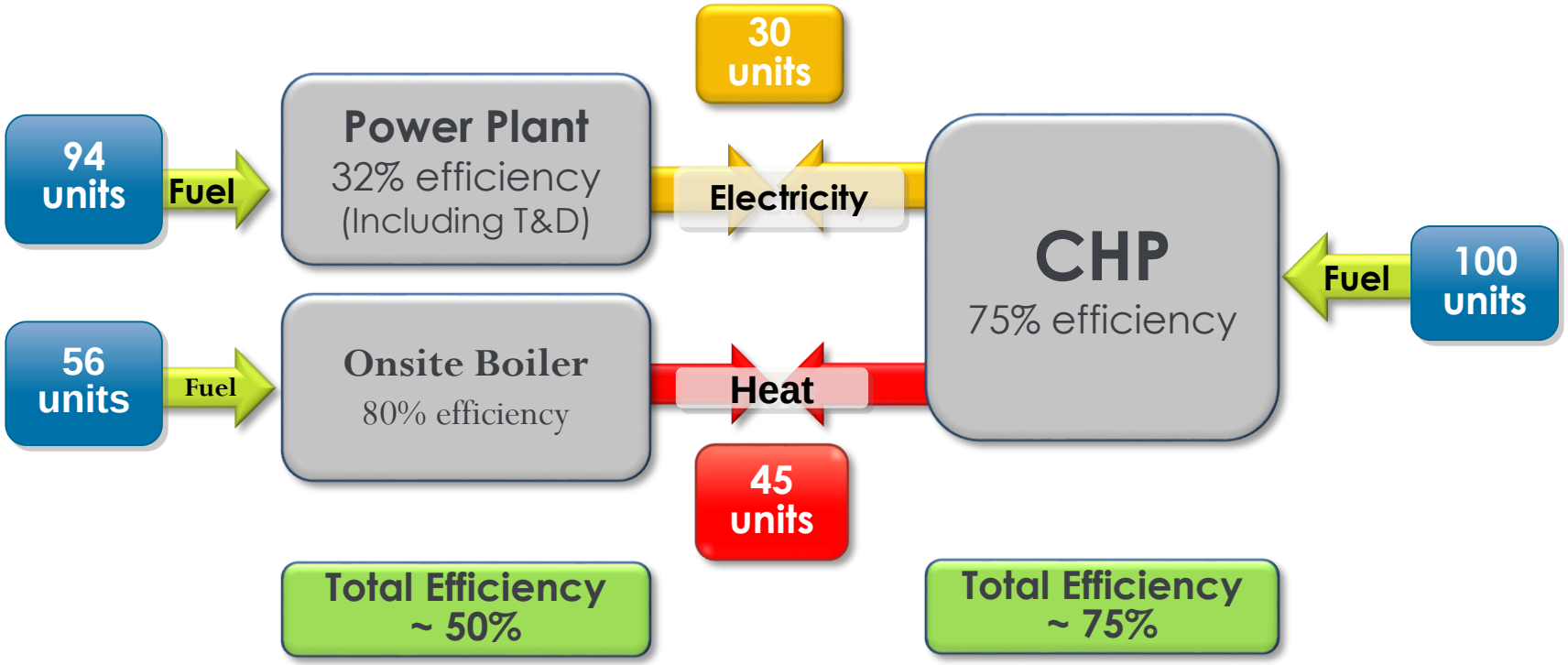
- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification



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

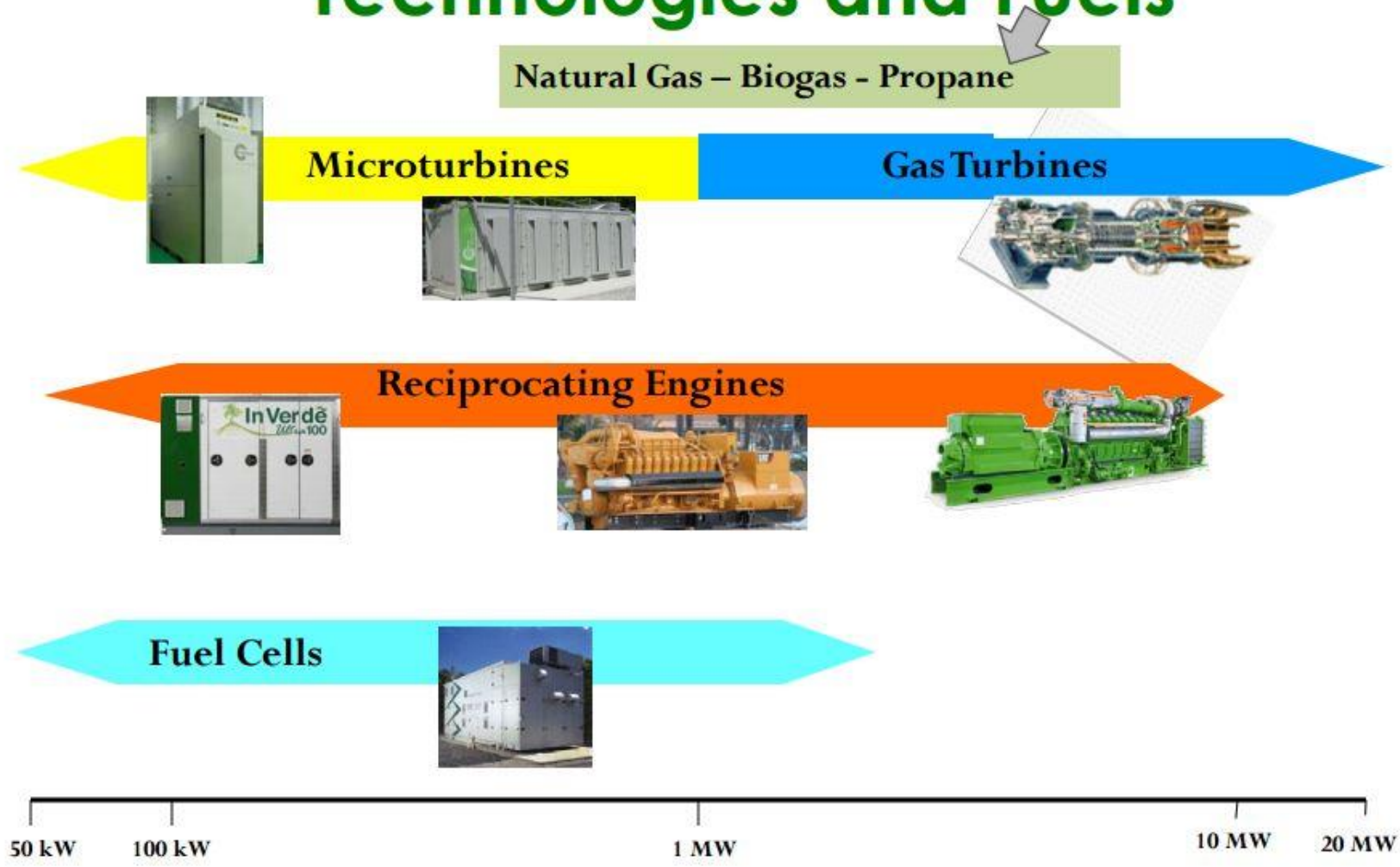
Source: www.energy.gov/chp

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

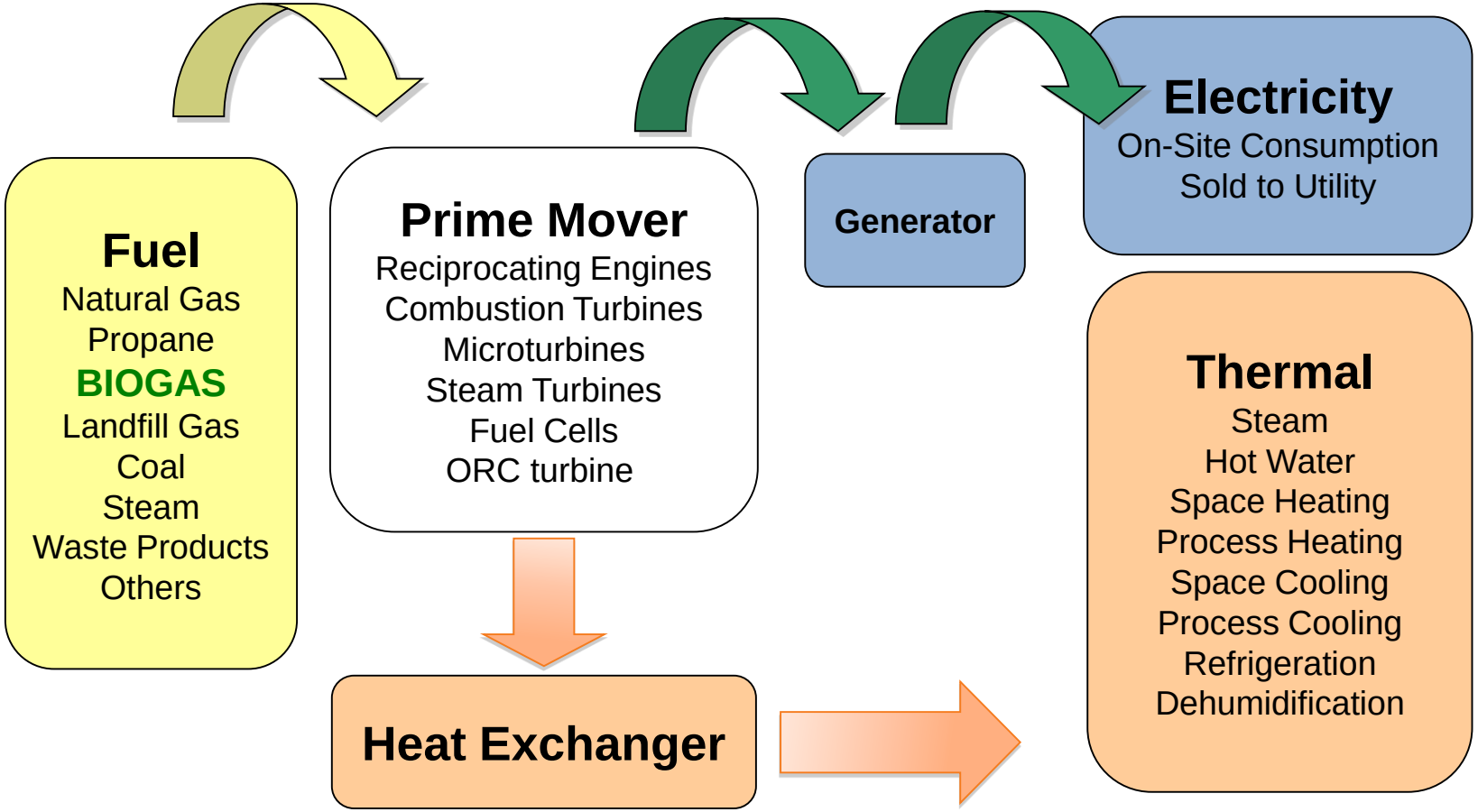


30 to 55% less greenhouse gas emissions

CHP can use a Variety of Technologies and Fuels



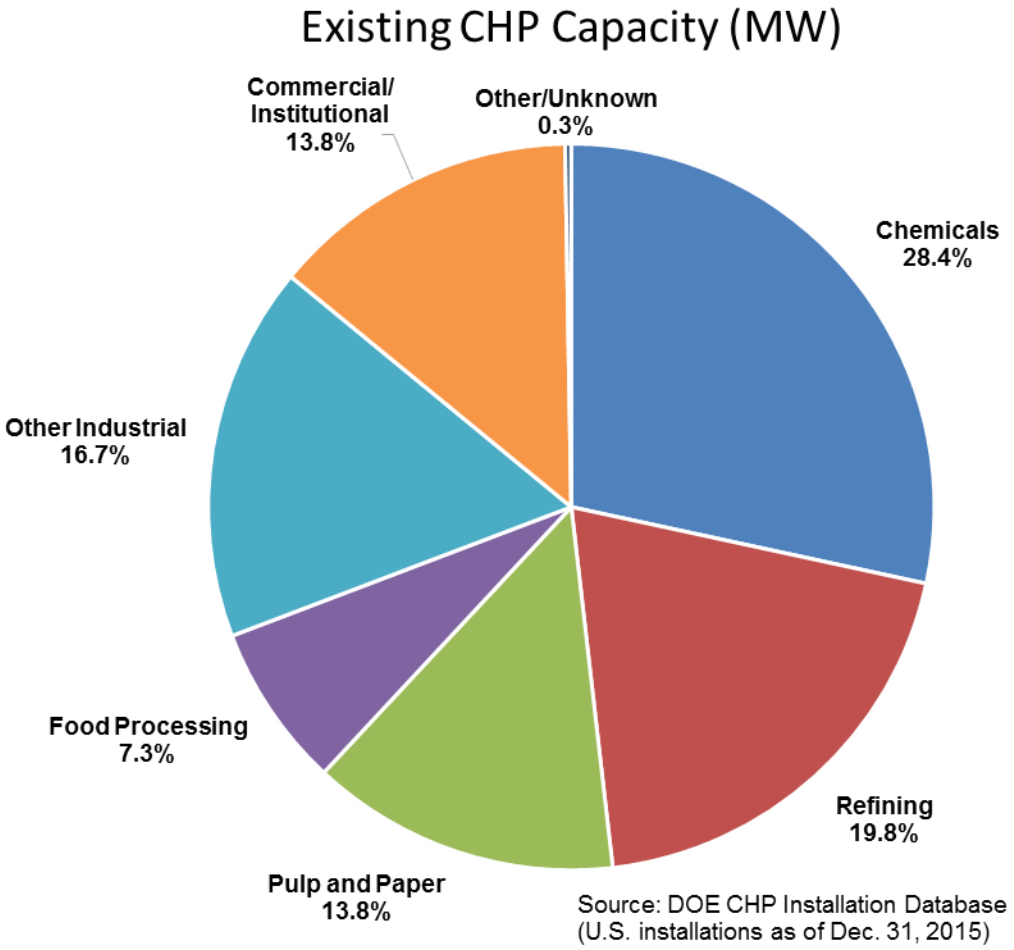
CHP System Schematic



What Are the Benefits of CHP?

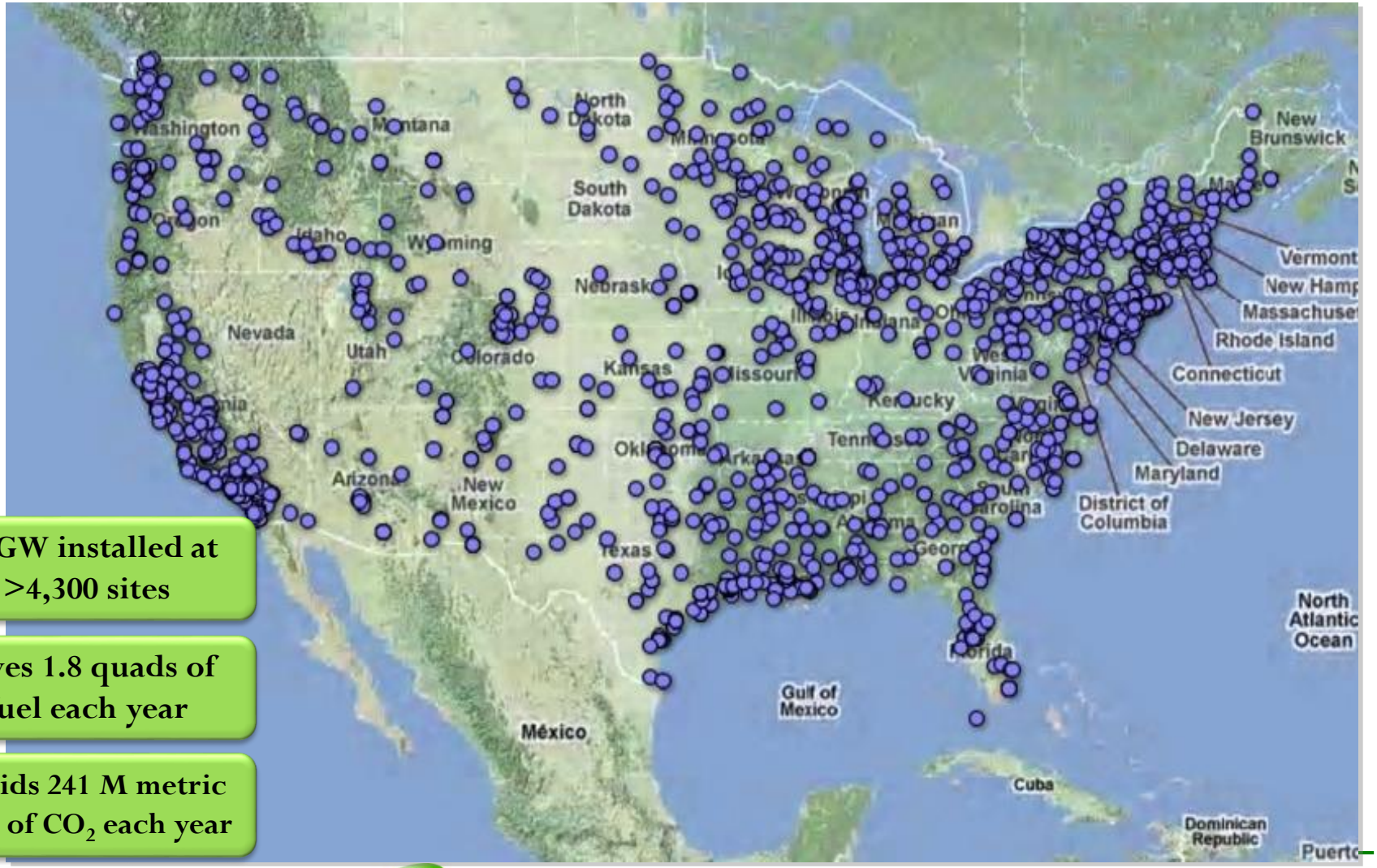
- CHP is **more efficient** than separate generation of electricity and heating/cooling
- Higher efficiency translates to **lower operating costs** (but requires capital investment)
- Higher efficiency **reduces emissions** of all pollutants
- CHP can also increase **energy reliability** and enhance power quality

CHP Today in the United States



- **81 GW** of installed CHP at over 4,300 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 Is Used Nationwide In Several Types of Buildings/Facilities



81 GW installed at >4,300 sites

Saves 1.8 quads of fuel each year

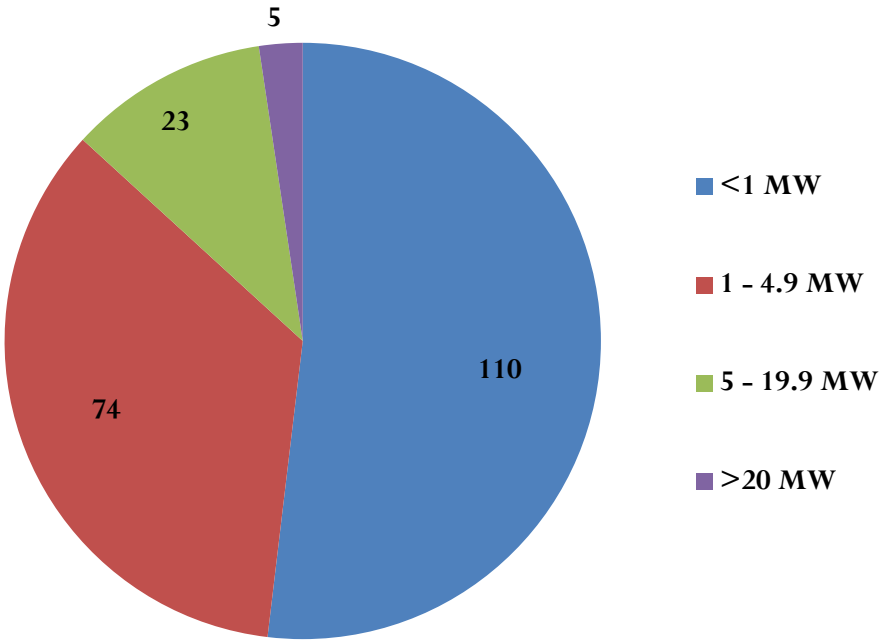
Avoids 241 M metric tons of CO_2 each year

U.S. Department of Energy
CHP Technical Assistance Partnerships

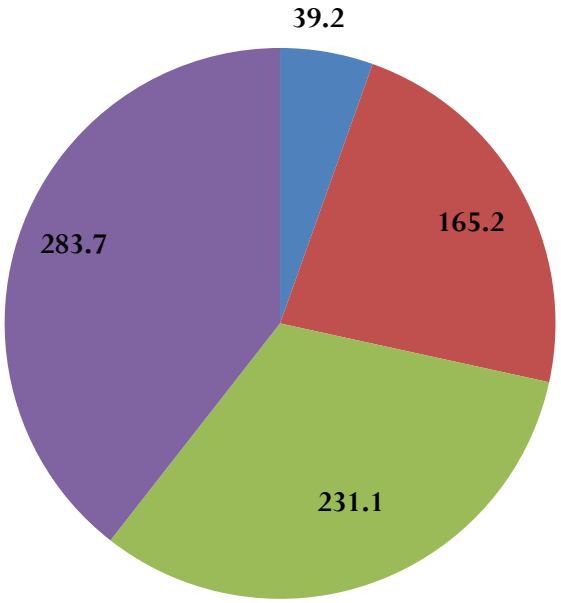
Source: U.S. DOE CHP Installation Database (U.S. installations as of Dec. 31, 2015)

CHP Today in WWTPs
(By CHP System Size)

Number of CHP Systems



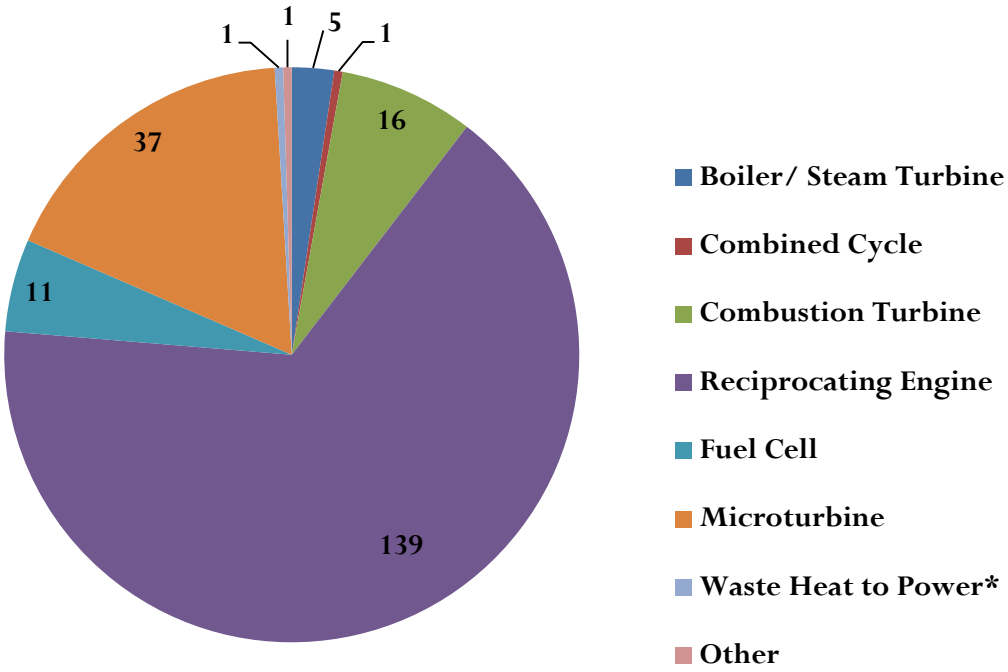
Installed CHP Generating Capacity, MW



Source: U.S. DOE CHP Installation Database
(U.S. installations as of Dec. 31, 2015)

CHP Today in WWTPs
(By Prime Mover Type)

Number of CHP Systems



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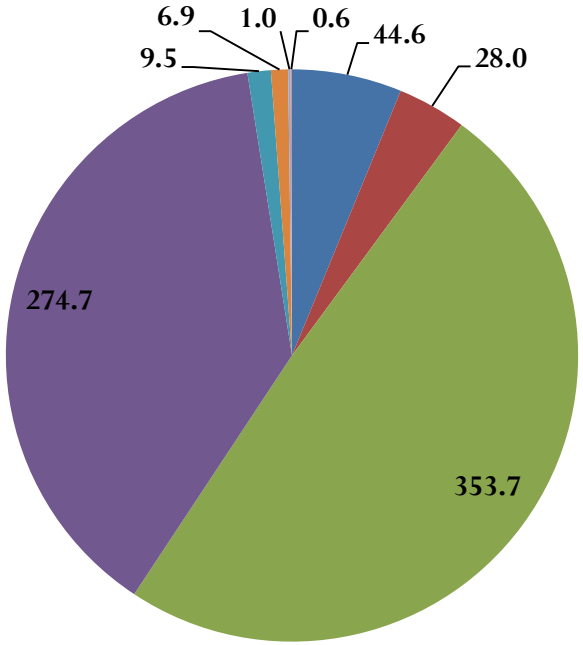
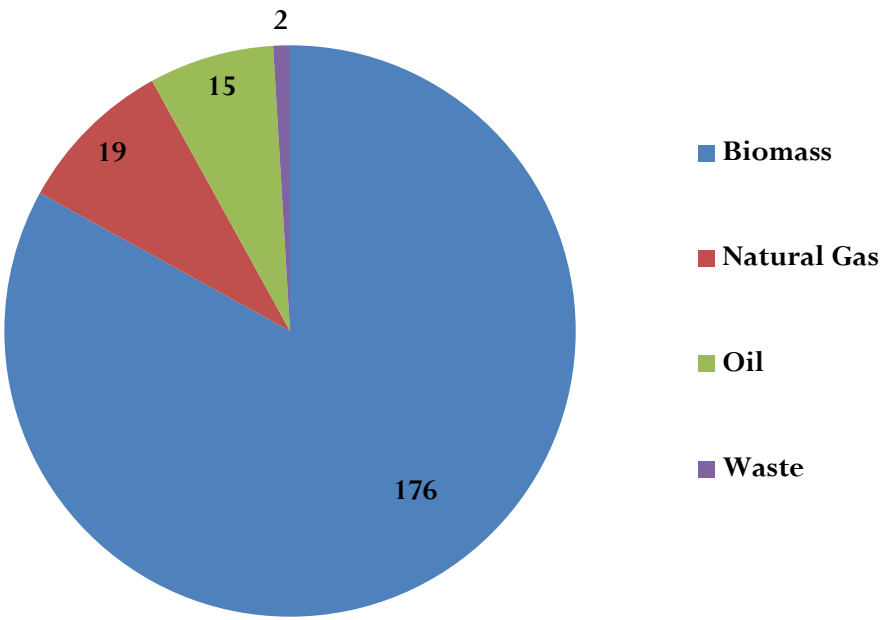


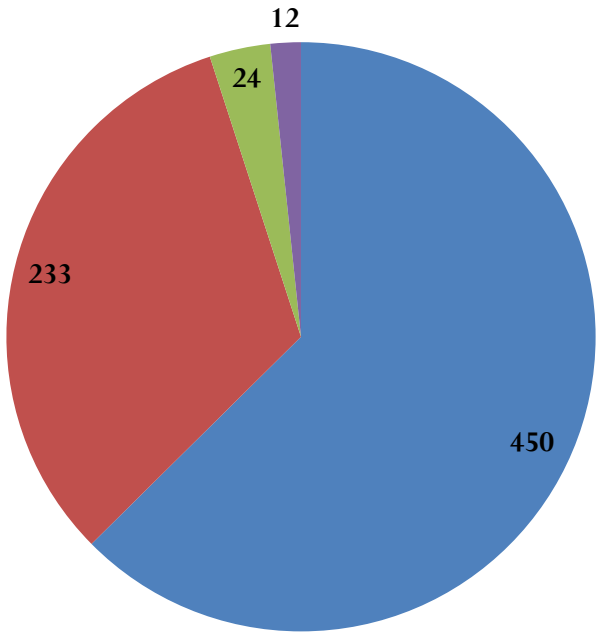
Source: U.S. DOE CHP Installation Database
(U.S. installations as of Dec. 31, 2015)

CHP Today in WWTPs
(By Fuel Type)

Number of CHP Systems



Installed CHP Generating Capacity, MW



Source: U.S. DOE CHP Installation Database
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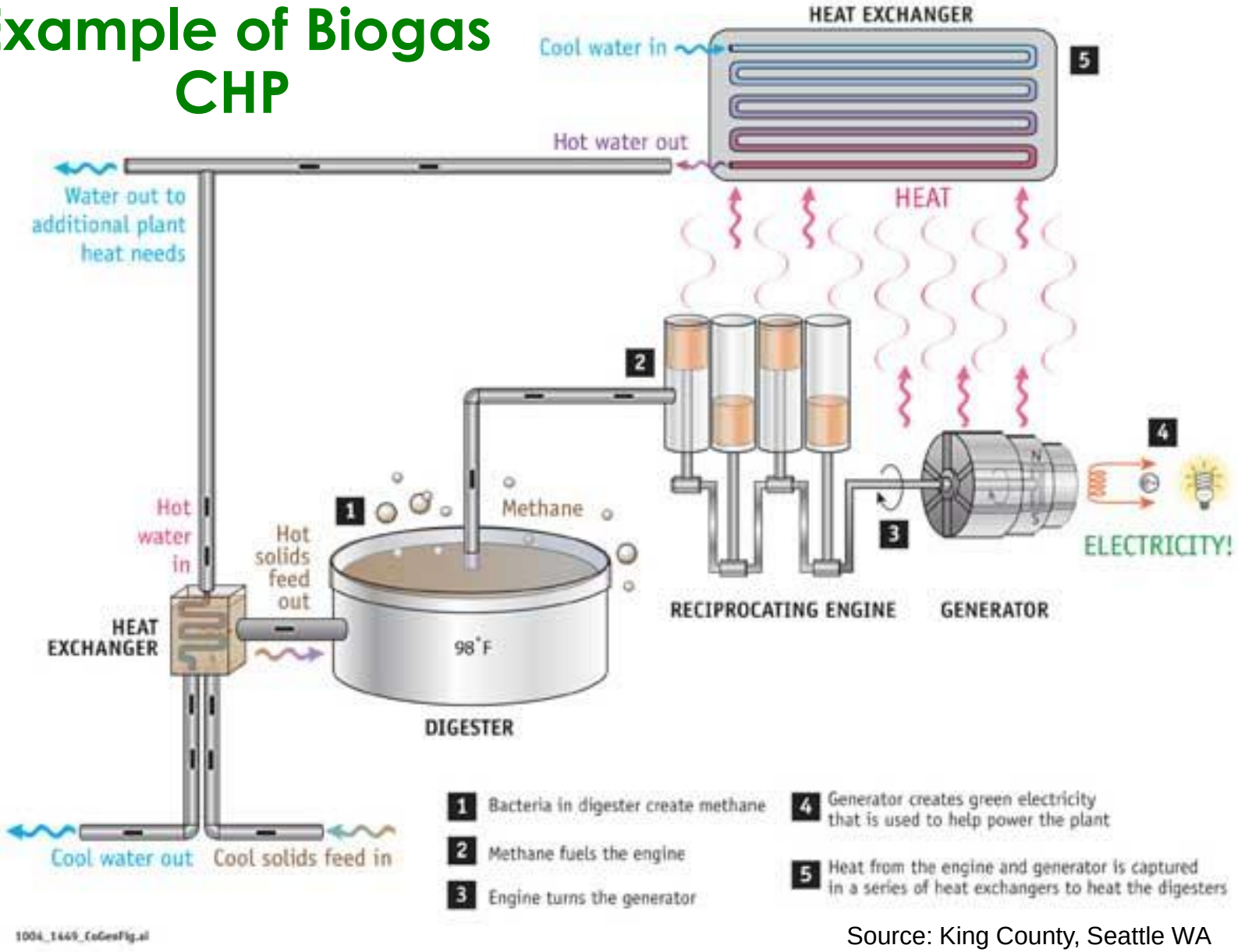
Example of Biogas CHP



Source: King County, Seattle WA

Best Candidates for CHP

- Consistent source of organic matter to produce biogas
- High and constant thermal load
- Favorable spark spread
- Need for high reliability
- Concern over future electricity prices
- Interest in reducing environmental impact
- Planned facility expansion or new construction; or equipment replacement within the next 3-5 years

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

Designing for Reliability

Two Generator Types

- Induction
  - Requires external power source to operate
  - When grid goes down, generator goes down
  - Less Complicated and Costly to Interconnect
- Synchronous
  - Self Excited (Does not need grid to operate)
  - Generator can operate thru Grid outages
  - More Complicated and Costly to Interconnect

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 grid power signal
- Ample Carrying Capacity
  - System size must match critical loads
- Parallel utility interconnection and switch gear controls
  - The system must be able to disconnect from the grid, support critical loads, and reconnect after an event

CHP Project Snapshot:

Hauled Waste Yields Significant Savings

Des Moines Wastewater Reclamation Authority

Des Moines, IA

Application/Industry: Wastewater Treatment

Capacity (MW): 4.6 MW

Prime Mover: 5 Reciprocating Engines

Fuel Type: Biogas

Thermal Use: Heat for the Digestion Process, Building Heat

Testimonial: DMWRA hauls in high strength waste, enough to account for 40% of their organic loading. This gas helps the facility produce around 1.6 million cu. ft. of biogas daily, which is enough to fuel 5 reciprocating engines with some supply leftover to sell to a neighboring manufacturing facility.

600 kW Engine. Source: Iowa Environmental Council

1.4 MW Engine. Source: Iowa Environmental Council

Source: energy.gov/chp-projects

Project Snapshot:
Waste gas produces large savings

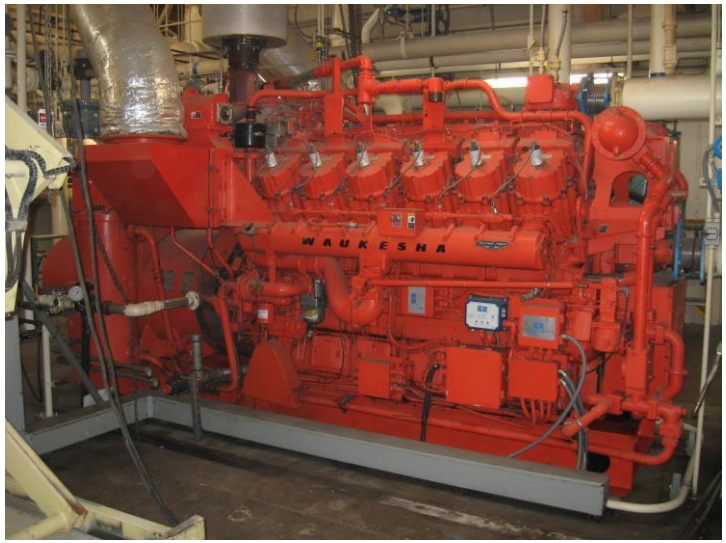
Rochester Wastewater Reclamation Plant
Rochester, MN

Application/Industry: Wastewater Treatment
Capacity (MW): 2 MW
Prime Mover: 2 Reciprocating Engines
Fuel Type: Biogas
Thermal Use: Heat for the Digestion Process, Feed Gas Preheat, Building Heat
Installation Year: 2008

Testimonial: "We are very pleased with the operation of the CHP system. It allows the city to utilize the renewable biogas produced at the plant for energy cost savings while also providing a source of emergency power. The system is also environmentally friendly because it eliminates flaring of the digester gas to the atmosphere."

- Chet Welle, Assistant Plant Manager

Aerial View of Rochester Wastewater Reclamation Plant



One of the two 1 MW engines

Source: energy.gov/chp-projects

Project Snapshot:
Moving towards net-zero

Danville Sanitary District

Danville, IL

Application/Industry: Wastewater Treatment

Capacity (MW): 150 kW

Prime Mover: Reciprocating Engine

Fuel Type: Biogas

Thermal Use: Heat for the Digestion Process, Building Heat

Installation Year: 2013

Testimonial: *"What's not to like about using sewage to generate heat and electricity while also reducing gas emissions into the atmosphere?"*

- Tom Stone, Engineer

150kW Reciprocating Engine

Gas Conditioning Equipment

Project Snapshot:

Increasing energy production with waste and moving towards net-zero

Downers Grove Sanitary District

Downers Grove, IL

Application/Industry: Wastewater Treatment

Capacity (MW): 280 kW

Prime Mover: Reciprocating Engine

Fuel Type: Biogas

Thermal Use: Heat for the Digestion Process, Absorption Chiller, Building Heat

Installation Year: 2014

Highlight: Waste grease from nearby restaurants helps increase biogas output allowing for greater energy production. The system offsets about 30% of the wastewater treatment plant's energy consumption. The district currently plans on installing a second engine.

Gas conditioning equipment: siloxane removal

Project Snapshot:
Opportunity Fuels

Lima Wastewater Treatment Plant
Lima, OH

Application/Industry: Wastewater Treatment

Capacity (MW): 130 kW

Prime Mover: 2 Microturbines

Fuel Type: Biogas

Thermal Use: Heat for the Digestion Process

Installation Year: 2012

Highlight: The CHP project was determined to provide:

- Best avenue for reductions of V.O.C.'s
- Best return of electrical energy
- Best capture of the heat for use in the WWTP

Source: http://www.puco.ohio.gov/puco/index.cfm/industry-information/industry-topics/combined-heat-and-power-in-ohio/chp-case-studies-voices-of-experience-workshop-june-20-2012/#sthash.MRLZAQNR.dpbs
http://gemenergycapstone.com/wp-content/uploads/chp-ohio-casestudies-120913.pdf

Lessons Learned: Biogas CHP Projects

Drivers and Benefits

- Energy cost savings
- Federal, state and local utility incentives
- Energy/sustainability plans and emissions reductions
- Green publicity/positive public relations
- Enhanced reliability
- Facility Upgrades
- Increased biogas production
- Enhanced biosolid management
- Utility load shedding

Fun Facts:

A typical WWTP processes 100 gal/day of wastewater for each person they serve

Each million gallons per day (MGD) of wastewater flow can produce enough biogas in an anaerobic digester to produce 30 kW of electric capacity

Lessons Learned: Biogas CHP Projects

- Technical Challenges
  - Biogas cleanup & cost considerations
  - Space constraints
  - Staff education/training with CHP operation and maintenance
  - Biogas production fluctuations
- Other Challenges
  - Utility issues
  - Permitting issues
  - Biogas supply/Food waste introduction
  - Project Financing

Co-digestion

- Co-digesting different organic wastes can increase biogas production, but care must be taken to understand the characteristics of the combined feedstock.
  - Can affect the quality of the effluents
  - Can impact permitting requirements
  - Is the feedstock you expected the feedstock you actually received
  - Not understanding the characteristics and/or volume added can severely damage the digester

Is Biogas Conditioning in WWTP really required?

- Hydrogen Sulfide (H_2S) and Siloxane concentrations are found in the biogas produced from all WWTP anaerobic digesters.
- H_2S oxidizes into sulfur dioxide in the combustion process, forming sulfuric acid when dissolved into water droplets. This can damage a prime mover exhaust system, heat exchangers, and stack liners.

Siloxane Removal is also Necessary

- Siloxanes are a family of organic silicon compounds that originate as additives to personal care products such as soaps, shampoos, sunscreens, lotions, hair sprays, deodorants, and shaving products.
- Siloxanes pass through the WWTP processes, accumulate in sludge and volatize to form a contaminant in anaerobic digester biogas.
- When combusted, the siloxanes form a glass-like deposit that is harmful to reciprocating engines, gas turbines, microturbines, and fuel cells.

Siloxane Deposits Result in:

- A decrease in CHP project efficiency
- An increase in heat rate
- A reduction in power output
- Formation of “hot spots”
- Premature equipment failure

Microturbine Recuperator

A Piston Head

WWTP Biogas Conditioning Conclusions

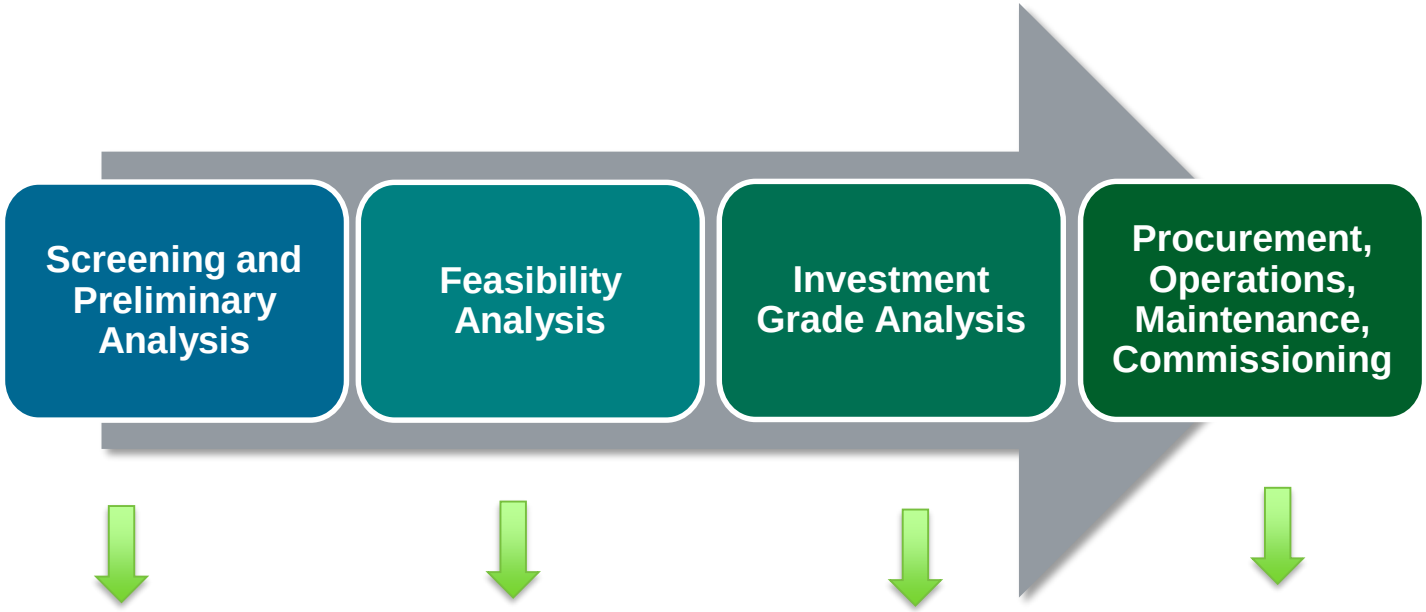
- Gas conditioning costs show a considerable “economy of scale”
- Biogas conditioning is essential to ensure that the biogas is of acceptable quality for use in biogas-fueled electrical generating equipment
- Biogas conditioning systems are custom engineered (with the removal efficiency based upon an inlet gas analysis and concentration limits for biogas utilization set by the equipment manufacturers)
- Without proper gas conditioning, maintenance costs will increase dramatically; system efficiency will deteriorate; and increased downtime will result in reduced annual energy generation.

Parameters for Success

- CHP Champion on site
- Interaction and Relationship with local utility
- System design
  - Collaborate with DOE CHP TAPs
  - Experienced project developer preferred
  - Biogas conditioning a key balance of plant (BOP) component
  - Visit DOE CHP Deployment website for project profiles www.energy.gov/chp-projects
- Operation and Maintenance
  - Requires personnel or 3rd party with appropriate CHP O&M training
  - Specific experience with biogas conditioning issues and maintenance important

Source: Oct 2011 EPA/CHP Partnership Report: Opp. For CHP at WWTF: Market Analysis and Lessons

CHP Technical Assistance



US DOE CHP TAP Services:

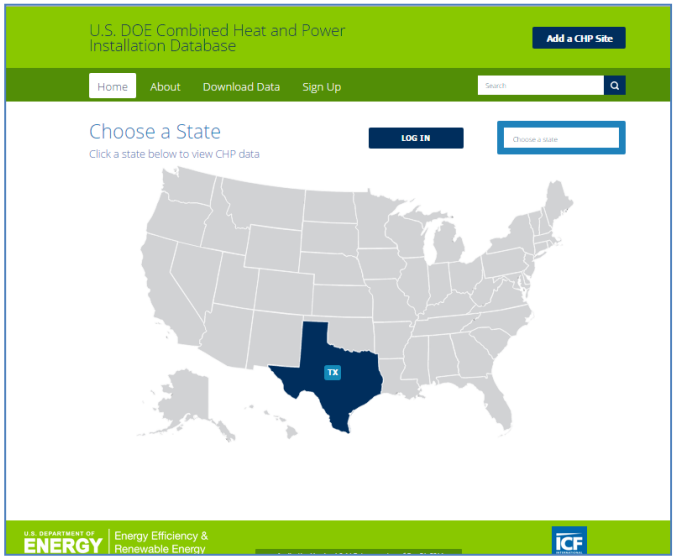
Screening and Preliminary Analysis	Feasibility Analysis	Investment Grade Analysis	Procurement, Operations, Maintenance, Commissioning
Quick screening questions with spreadsheet payback calculator.	Estimate - annual energy savings, installation costs, simple paybacks, equipment sizing and prime mover type.	3rd Party review of Engineering Analysis. Review equipment sizing and choices.	Review RFP bids and Specifications Limited operational analysis

CHP Project Resources

Combined Heat and Power Technology Fact Sheet Series (published June 2016)

www.energy.gov/chp-technologies

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



www.energy.gov/chp-installs

CHP Project Resources

DOE Project Profile Database (150+ case studies)

energy.gov/chp-projects

DOE Database of Incentives & Policies (DSIRE)

www.dsireusa.org

Next Steps and Questions?

Contact DOE CHP TAPs 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

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A program sponsored by

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