Combined Heat and Power for Tribal Facilities

USDOE Office of Indian Energy Policy and Programs
Western Area Power Administration

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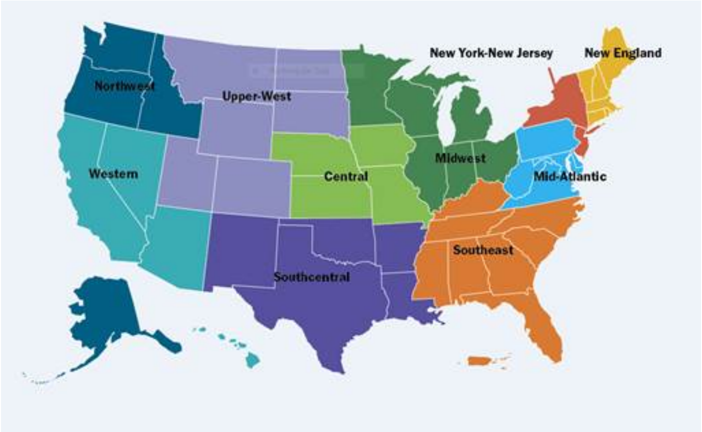
U.S. Department of Energy
CHP Technical Assistance Partnerships
NORTHWEST

Outline of Presentation

- US DOE’s CHP Technical Assistance Partnerships: Who we are and what we do
- CHP Overview
- CHP Technologies: Performance, Applications, and Costs
- Project Snapshots
- Developing CHP projects with CHP TAP resources

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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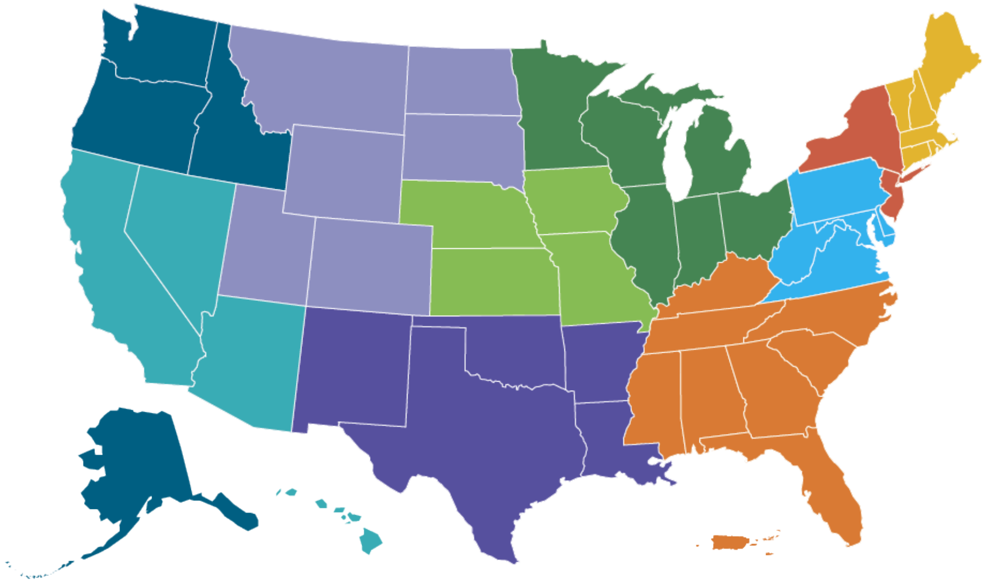

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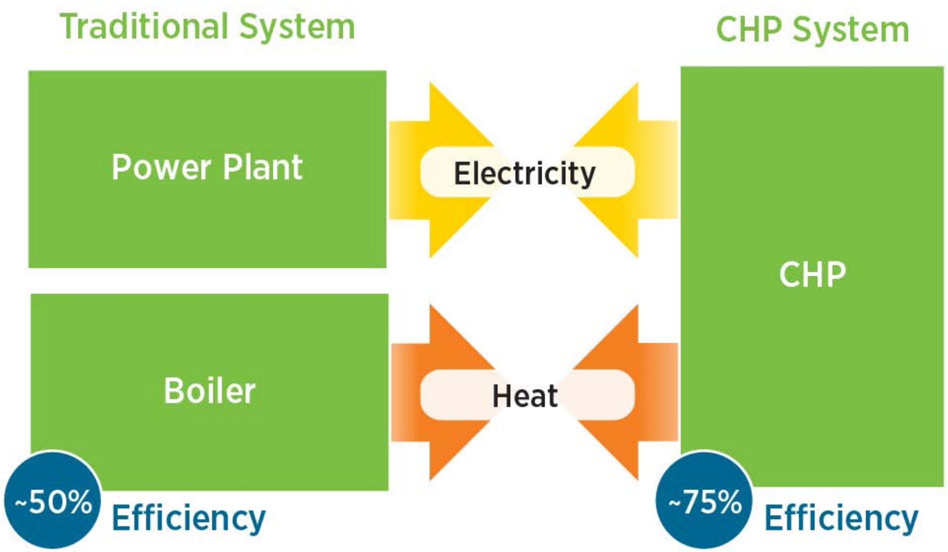
CHP Overview

CHP: A Key Part of Our Energy Future

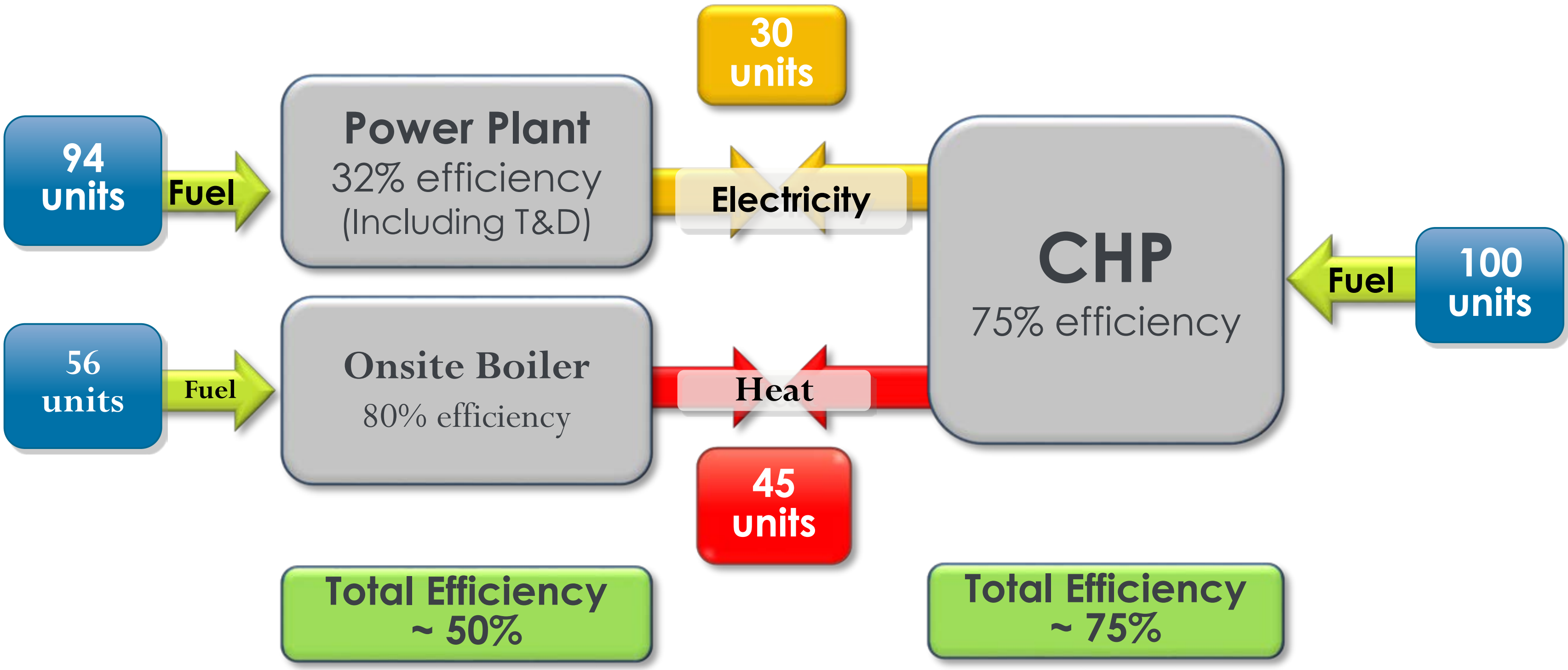
- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification



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

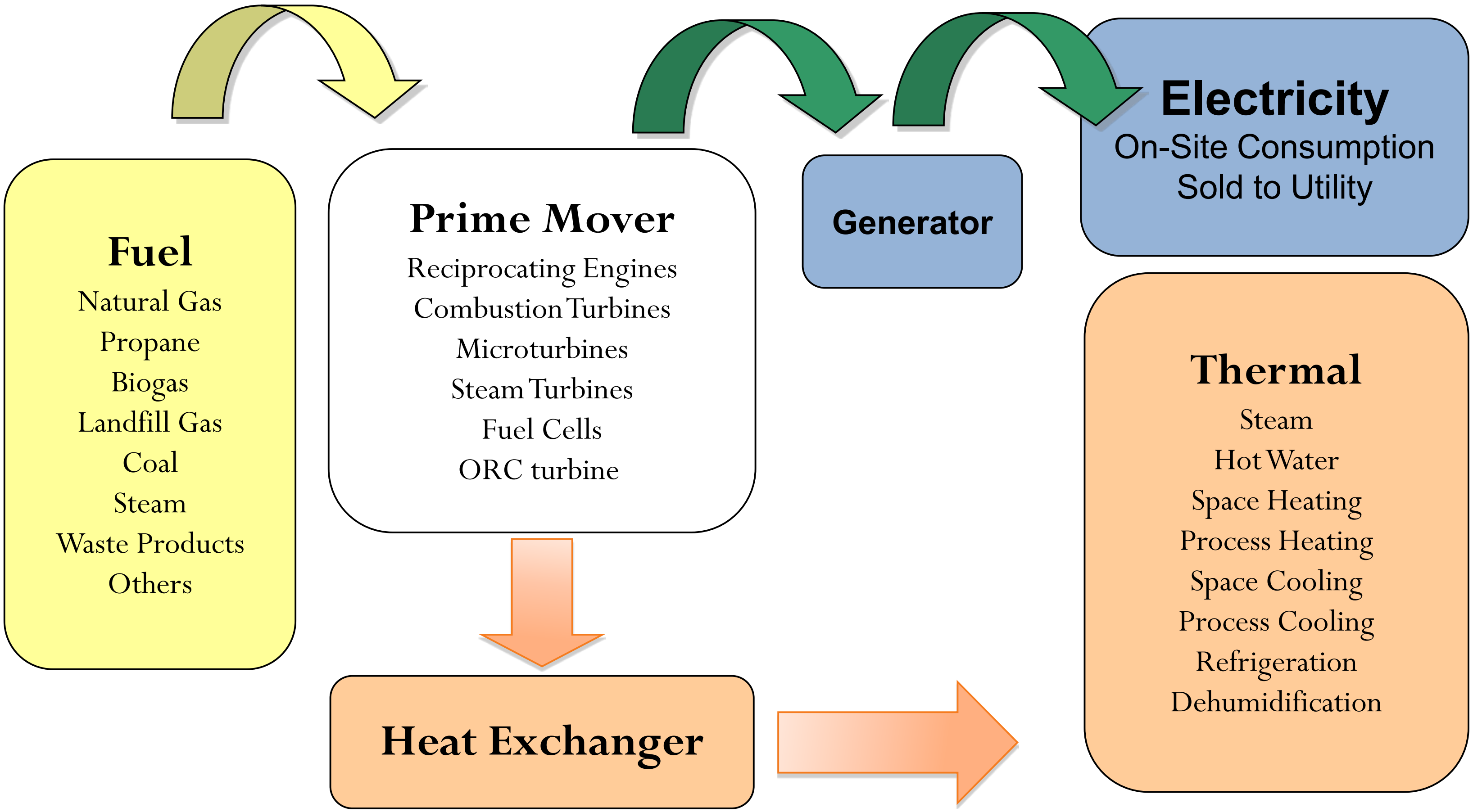
Source: www.energy.gov/chp

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



30 to 55% less greenhouse gas emissions

CHP 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 pollutants
- CHP can also increase **energy reliability** and enhance power quality
- On-site electric generation can **reduce grid congestion** and avoid distribution costs.

Common Uses for Thermal Energy Recovered

- Space heating at a single facility, district or campus
  - "District heating"
- Domestic water heating
- Process hot water or steam at an industrial facility
- Hospitals: Steam for space and water heating, humidification and sterilization
- Pool or spa heating at hotels, schools, rec centers, casinos
- Absorption chilling for space cooling & refrigeration

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

CHP Technologies

Common CHP Prime Movers

Gas Combustion Turbine

https://www.wotol.com/1-solar-titan-130-gas-turbine-genset/second-hand-machinery/prod_id/468134

Reciprocating Engine

Steam Turbine

Microturbine

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

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: 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

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]	$1,430 – $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…*

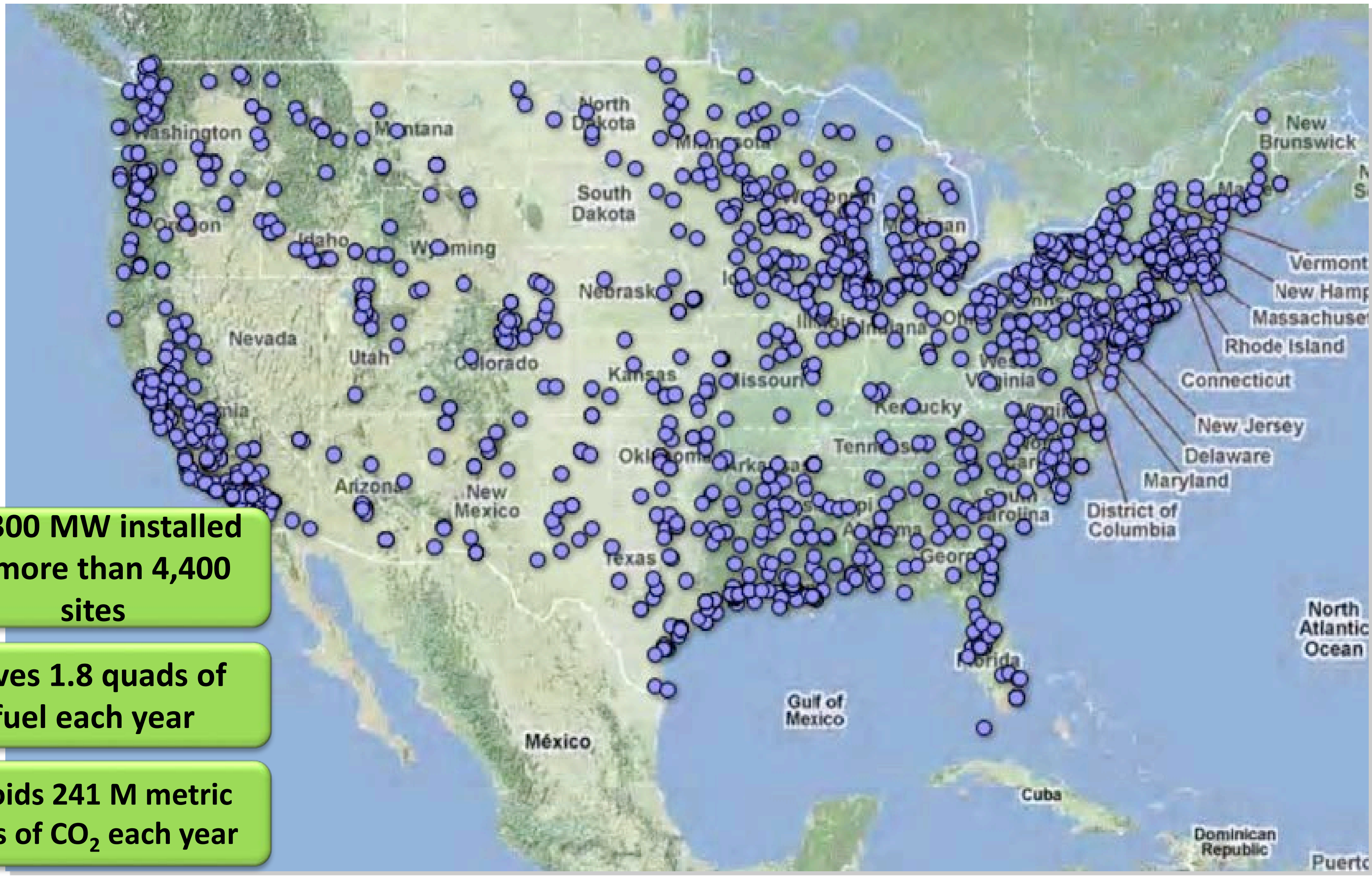
Characteristic	Technology				
	Reciprocating Engine	Gas Turbine	Microturbine	Fuel Cell	Steam Turbine
Fuel Pressure (psig) [1]	1-75	100-500 (may require fuel compressor)	50-140 (may require fuel compressor)	0.5-45	n/a
Part Load Efficiency	Good at both part-load and full-load	Better at full-load	Better 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.

Economy of Scale Advantages

- Total Installed Cost, $/kW
- Heat Rate, Btu/kWh
- Efficiency for electrical generation, %
- Maintenance costs, $/kWh
- Transport Gas Availability and Cost
- Possibly in Permitting and Project Financing

CHP Is Used Nationwide In Many Types of Buildings/Facilities



81,300 MW 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)

Slide prepared on 7-3-18

Project Snapshots

Project Snapshot:
Utilities Expansion

Northwest Community Hospital
Arlington Heights, IL

Capacity: 4.6 MW
Fuel: Natural gas
Prime Mover: Recip engines
Installed: 1997/2005

Testimonial: *"We said, 'Well, if we're going to centralize it all, doesn't it make sense to do a CHP—and generate our own electricity, to reduce our demand load, and then capture the heat of those engines and utilize all that for heating and/or cooling?' "*
- Charlie Stevenson, Director of Plant Operations, Northwest Community Hospital

Project Snapshot:
Addressing Sustainability

Oregon Health Science University
Center for Health and Healing
Portland, OR

Application/Industry: Healthcare
Capacity (MW): 300 kW
Prime Mover: 5 Microturbines
Fuel Type: Natural Gas
Thermal Uses: Heating
Installation Year: 2006

Testimonial: "The CHP turbines achieve 78% efficiency of fuel conversion vs. typical electric power generation efficiency of 32% contributing to the 55 LEED scorecard points out of a possible 69. Oregon Health & Science University Center for Health & Healing is one of only 50 buildings in the country to have been awarded U.S. Green Building Council (USGBC) LEED Platinum certification and the largest and most complex building in the country to have achieved it."
Source: High Performance Building Magazine Dennis Wilde
http://www.hpbmagazine.org/attachments/article/11972/09W-OHSU-Center-for-Health-and-Healing-Portland-OR.pdf

Photo Courtesy of Regatta Solutions: http://regattasp.com/case-studies/healthcareeducation-oregon-health-science-university/

Project Snapshot:
Hospitality/Hotels

The Westin Princeville Ocean Resort Villas

Kauai, Hawaii

Application/Industry: Hospitality/Hotels

Capacity: 1 MW

Prime Mover: 5 x 200 kW microturbines

Fuel Type: Propane

Thermal Use: Absorption cooling and pool heating

Testimonial: *"We recognize that the vitality of the resort is directly linked to the vitality of the community where it operates…In addition to doing the right thing for the environment, Westin Princeville Ocean Resort Villas is proud of the economic benefits that our project provided to Kaua'i's local contractors and vendors."*
– Denise Wardlow, General Manager, Westin Princeville Ocean Resort Villas

Source: The Westin Princeville Ocean Resort and Villas

Source: Hawaii Business Magazine issued April 2015 "More Efficient Power" By Chris Oliver

Project Snapshot:
Food Waste to Energy

FOREST COUNTY POTAWATOMI
Keeper of the Fire

Forest Country Potawatomi Community Renewable Generation

Milwaukee, WI

Application/Industry: Casino

Capacity: 2 MW

Prime Mover: Reciprocating engine

Fuel Type: Biomass

Thermal Use: Heating, hot water

Installation Year: 2013

Energy Savings: Unknown

Highlights: Waste from a variety of local food producers fuels the 2 MW CHP plant on Potawatomi tribal land. Power is sold to We Energies. The system also provides heat and hot water to the nearby Potawatomi Bingo Casino.

School Project Snapshot:
Biomass Boiler with Backpressure Steam Turbine

Alaska Gateway School District, Tok School

Tok, Alaska

Facility Peak Generation: 120 kW

Facility Size: 80,000 square feet

Equipment: Elliot Steam Turbine/ Hurst Biomass Boiler

Fuel Type: Wood grinds

Thermal Uses: School and greenhouse heating

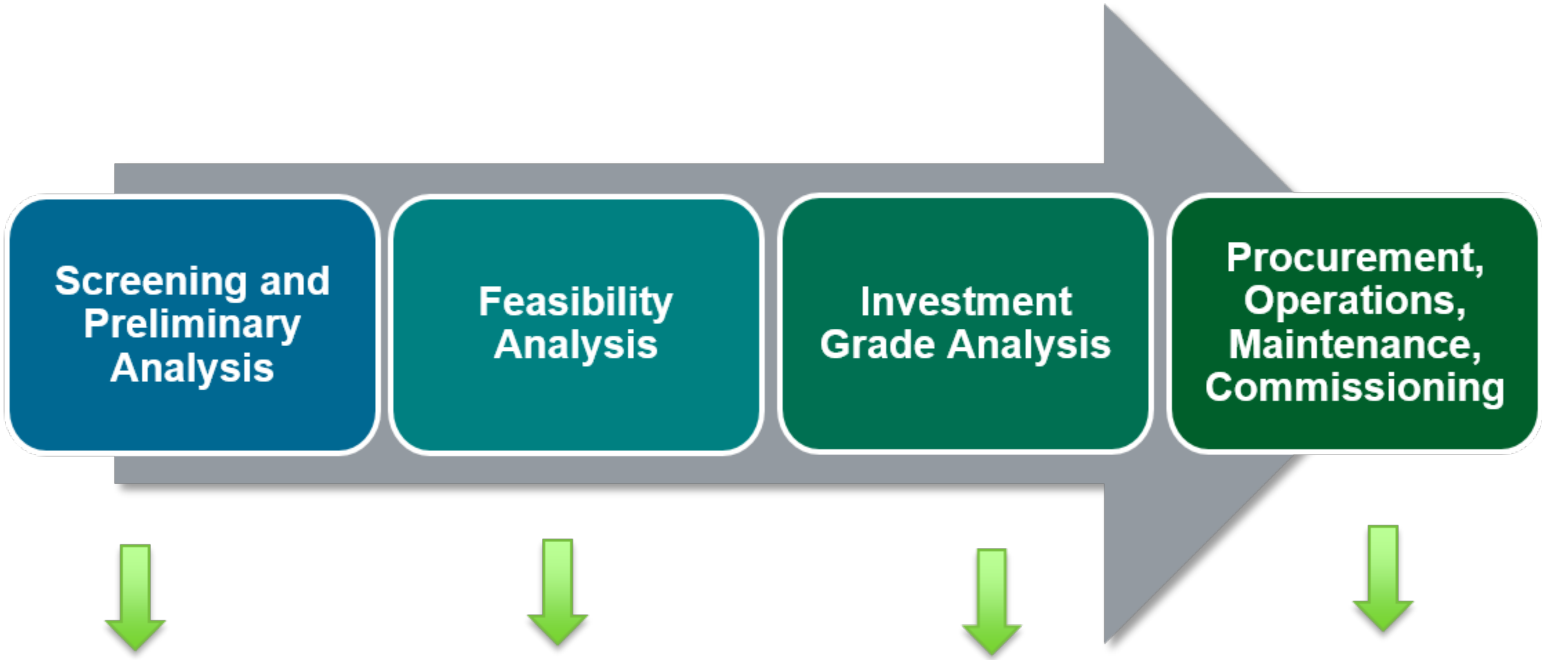
CHP in Operation Since: 2013

Simple Payback: 8 years

Environmental Benefits: GHG emissions reductions, wildfire danger reduction. Annual realized diesel fuel offset of 59,000 gallons. Greenhouse produces 20,000 pounds of fresh vegetables.

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

CHP TAP Role: Technical Assistance



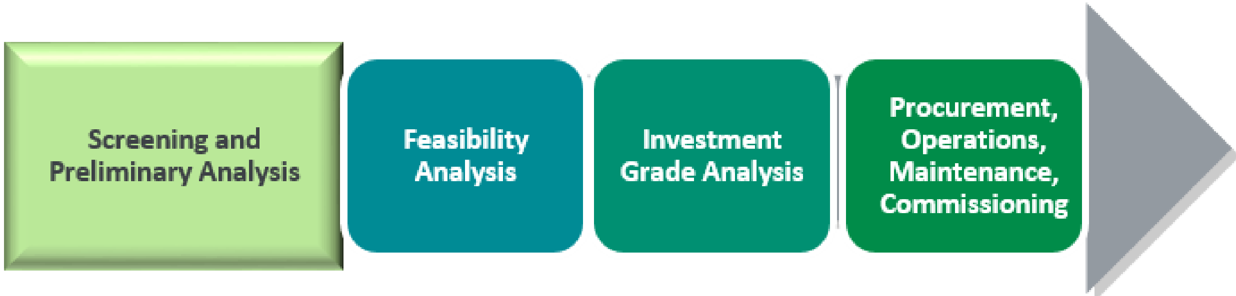
Quick screening questions with spreadsheet payback calculator; Advanced technical assistance to explore equipment or operational scenarios.

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.)

DOE TAP CHP Screening Analysis

- High level assessment to determine if site shows potential for a CHP project
  - Quantitative Analysis
    - Energy Consumption & Costs
    - Estimated Energy Savings & Payback
    - CHP System Sizing
  - Qualitative 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**

DOE CHP TAP
Advanced Technical Assistance

For qualified projects, the DOE Northwest CHP TAP can provide additional analyses customized to the site, end-user and their specific needs:

- Emissions analysis
- Electrical load profiling
- Thermal load profiling
- Thermal use determination (what to do with the heat)
- Installation cost estimates
- Financial calculations (simple payback, return on investment, etc.)
- Cost/savings information compared to what your facility would pay if the CHP system were not installed
- Review of existing CHP proposals

Finding the Best Candidates: Some or All of These Characteristics

- High and constant thermal load
- Favorable spark spread
  - High electricity rates *relative* to fuel prices
  - both expressed in $ per MMBtu
- 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

Involve the Electric Utility

- Contact your local electric utility to gain an early understanding of retail rates, net metering possibilities, avoided costs, and interconnection requirements.
- Identifying win/win solutions
  - Utilities co-locating their generating facilities at load centers
  - Constructing district heating thermal distribution loops
  - Add waste heat recovery to existing reciprocating engines

Summary

- CHP is a proven technology providing energy savings, reduced emissions, and opportunities for improved resiliency
- Utility renewables mandates are creating a market for RECs
- Opportunities exist to learn about facilities that have incorporated CHP
- Engage with the DOE Northwest CHP TAP to learn more about the technical assistance offerings in evaluating CHP opportunities at your site

Next Steps

Resources are available to assist in developing CHP Projects at your site

Contact the Northwest CHP TAP to:

- Perform CHP Qualification Screening for a particular facility
- Identify existing CHP sites for Project Profiles
- Additional Technical Assistance

Thank You!

Northwest CHP TAP

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