



# **Combined Heat and Power: A Cost-Effective, Flexible, and Environmentally-Friendly Technology**

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**U.S. EPA CHP Partnership**

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# EPA & Combined Heat and Power

- The EPA CHP Partnership is a voluntary program that seeks to reduce the environmental impact of power generation by **fostering the use of highly-efficient CHP**
- Through 2006, the CHPP has helped Partners put into operation more than **250 CHP projects** representing **3,577 MW** of capacity, resulting in the emission reductions of over **10 million tons CO<sub>2</sub>**
- CHPP works with multiple CHP applications and with multiple fuel types

# What Is Combined Heat and Power?

CHP is a highly efficient energy system that:

- Is located at or near a building/facility
- Generates electrical and/or mechanical power
- Recovers waste heat for
  - heating
  - cooling
  - dehumidification
- Can utilize a variety of technologies and fuels





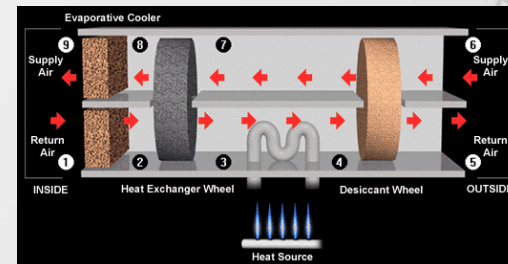
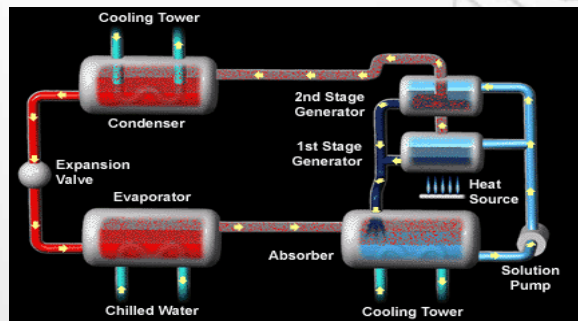
# CHP Is Proven Technology

- Generation Equipment
  - Reciprocating Engines
  - Gas Turbines
  - Microturbines



# CHP Is Heat Recovery

- Steam and Hot Water
- Absorption Cooling
- Desiccant Dehumidification



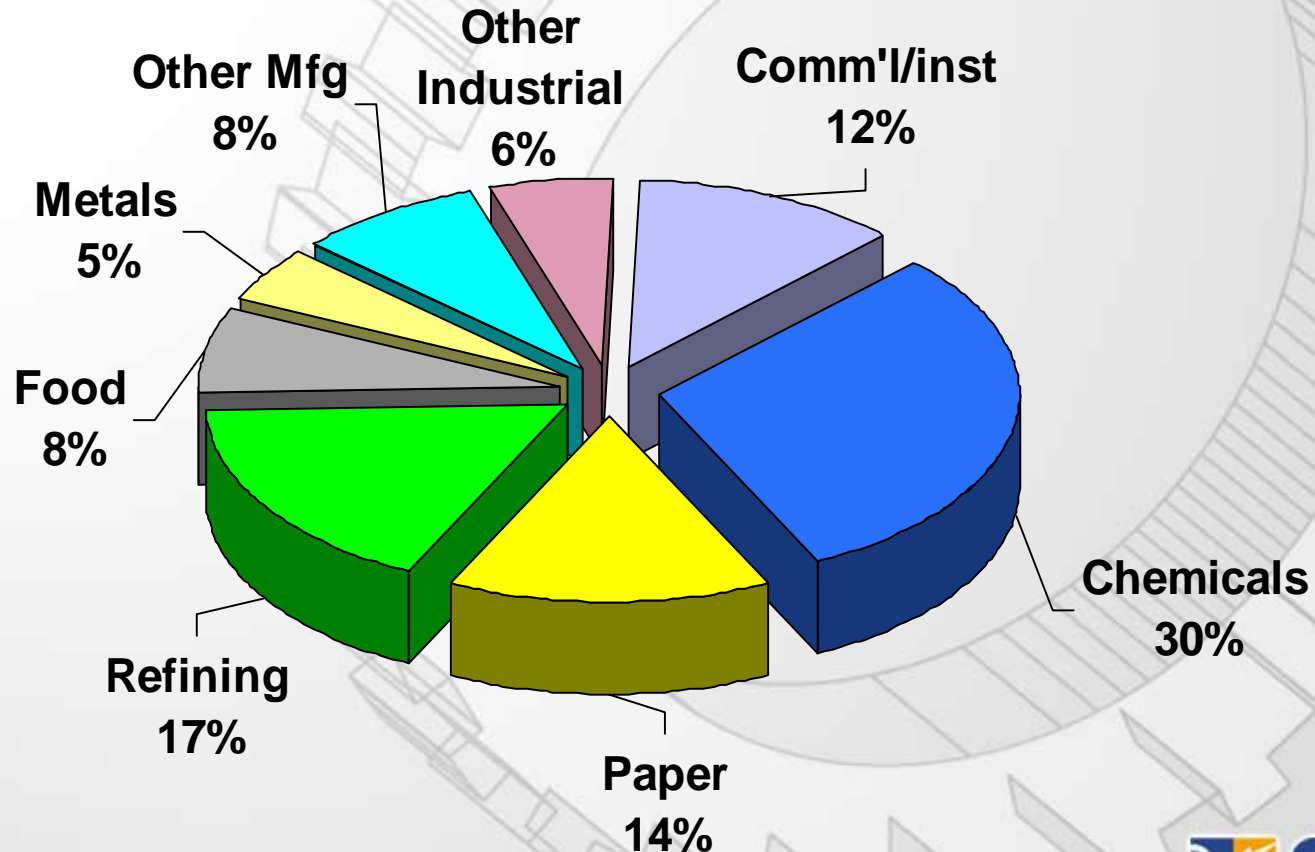
# CHP Is a Widely Used Technology

- 85,184 MW installed at over 3,364 sites (nationally)
- Represents 8% of total U.S. generating Capacity
- Saves an estimated 3 quads of fuel use per year
- Eliminates over 400 million tons of CO<sub>2</sub> emissions annually



# Where is CHP Used - Capacity

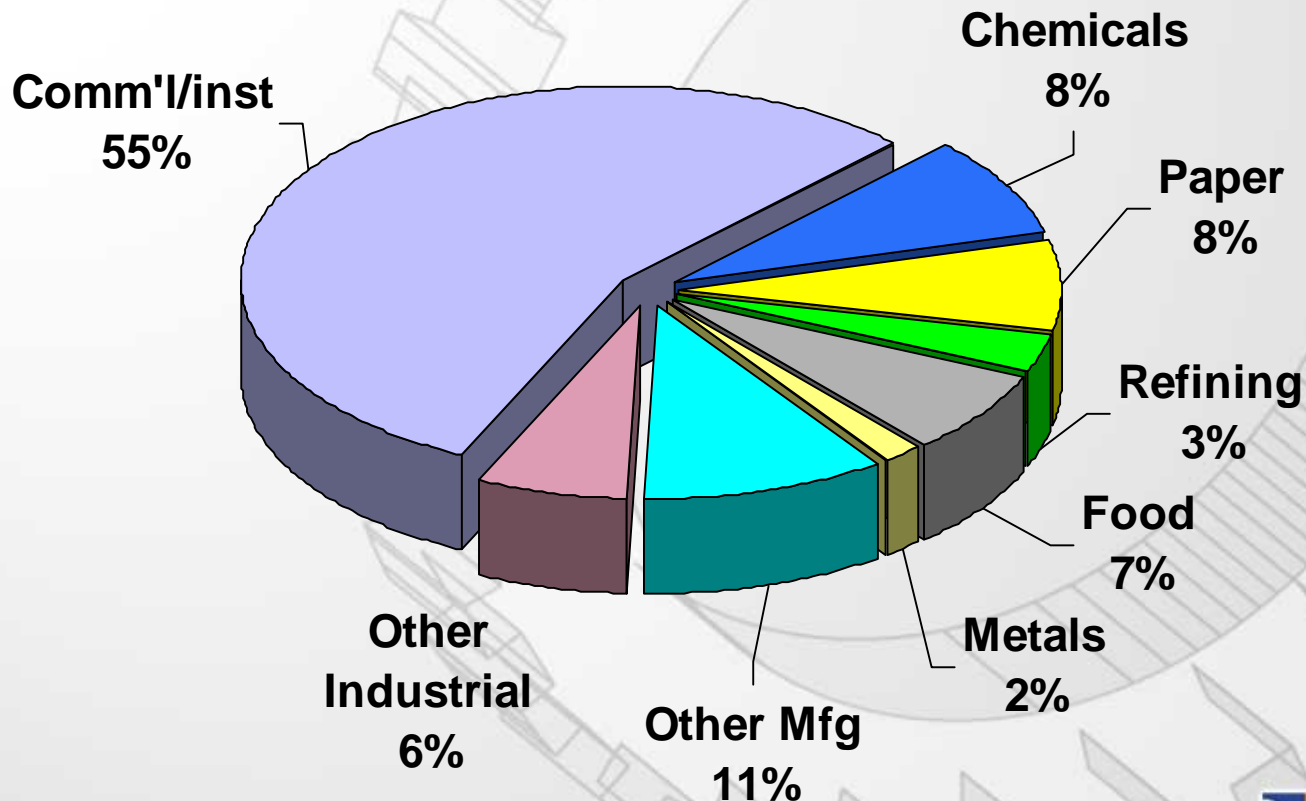
- **Existing CHP Capacity (2007) = 85,184 MW**



Source: EEA

# Where is CHP Used - Sites

- **Existing CHP Capacity (2007): 3,364 sites**

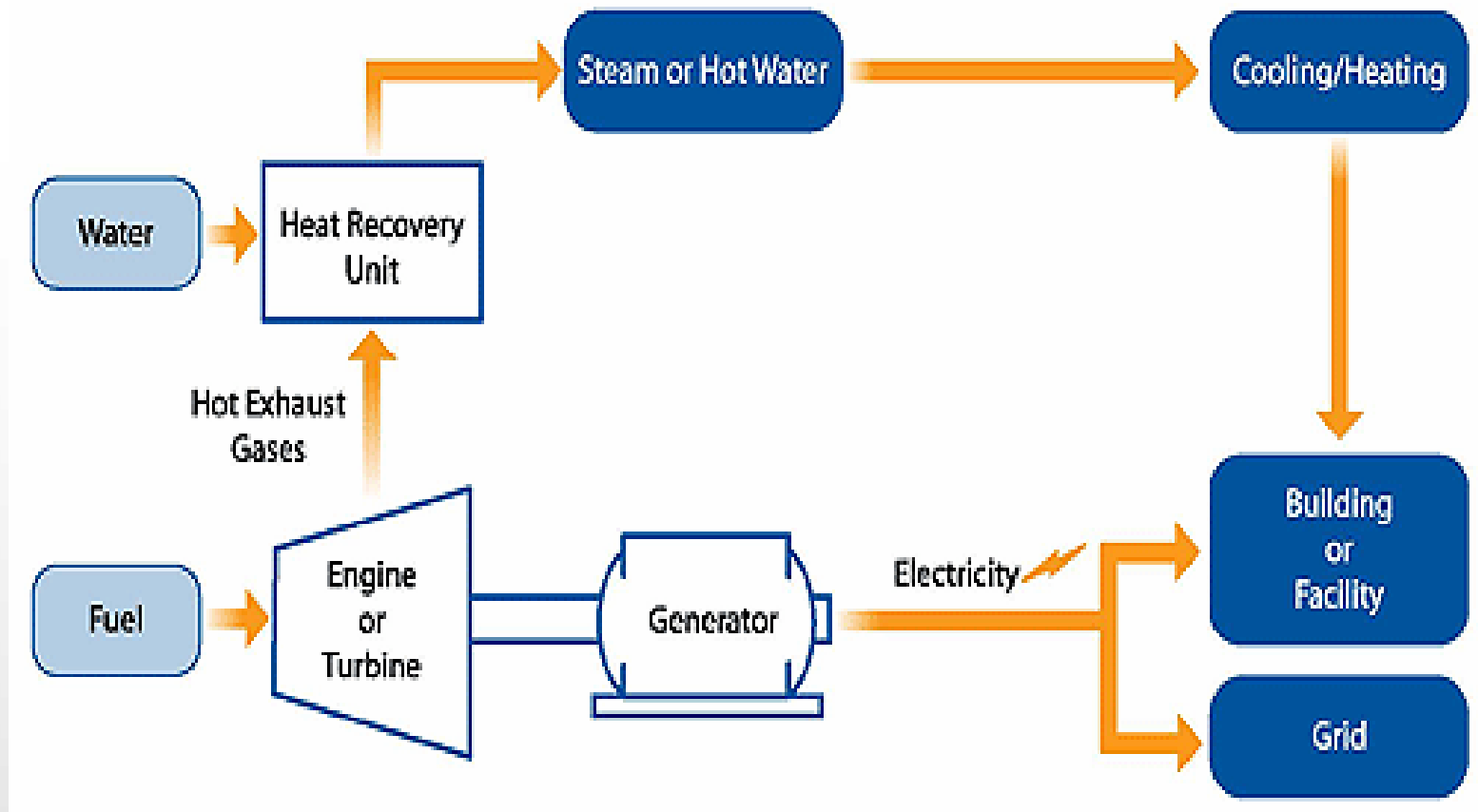


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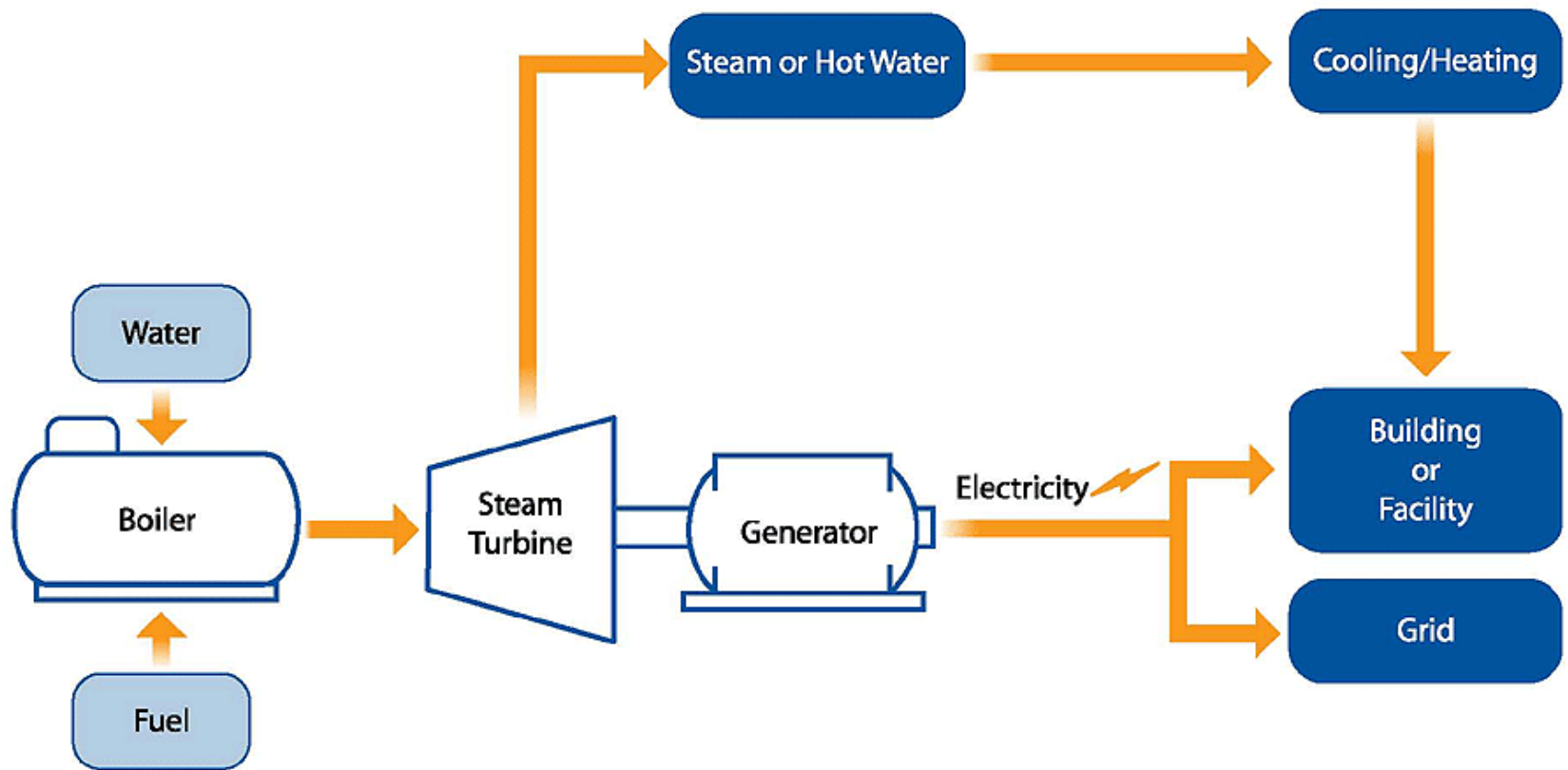
# Two Typical Configuration of CHP

## Engine or Turbine-Based CHP



# Two Typical Configuration of CHP *Cont.*

## Steam Boiler With Steam Turbine



# What Are the Benefits of CHP?

- CHP is more efficient than separate generation of electricity and thermal energy
- Higher efficiency translates to lower operating cost
- Higher efficiency reduces emissions of all pollutants, including CO<sub>2</sub>, NO<sub>x</sub> and SO<sub>2</sub>
- CHP can increase power reliability and enhance power quality
- On-site electric generation reduces grid congestion and avoids distribution costs

# Market Opportunities for CHP

- CHP application is determined by need for thermal energy
- Traditional applications
  - Industrial processes
  - Hospitals
  - Universities & Colleges
- Market opportunities
  - Biorefineries – ethanol production
  - Hotels and casinos
  - Municipal wastewater treatment
  - Utility-owned CHP
  - Data centers





# Market Opportunity: *Ethanol Industry*

- Energy is the second largest cost of production for dry mill ethanol plants
- Electric and steam demands are large and coincident
  - Typical power demand is 2 to 6 MW
  - Typical steam use is 40,000 to 150,000 lb/hr
- Electric and steam profiles are relatively flat
- Operating hours are continuous
- Energy costs are rising
- Potential for utility-ethanol facility partnerships

# Market Opportunity: *Hotels and Casinos*

- Number of hotels in U.S. that could use CHP technology: 10,000
- Number of hotels using CHP: approx.100 (2005)

## Benefits of CHP systems in hotels and casinos:

- Reduces operating costs.
- Ensures hot water is available for guests at all times.
- Provides reliable electricity for gaming venues, even during utility blackouts.
- Improves energy efficiency and overall environmental performance.
- Reduces future cost uncertainties by creating a hedge against fluctuating energy prices.

# Market Opportunity: *Waste Water Treatment Facilities (WWTF)*

- Total number of WWTF: >16,000
- Total number of WWTF >5 MGD: 1,066
- WWTF that have anaerobic digesters and utilize biogas: 106

A well-designed CHP system at a WWTF:

- Produce power at a cost below retail electricity.
- Displace fuels normally purchased for the facility's thermal needs.
- Qualify as a renewable fuel for green power programs.
- Offer an opportunity to reduce greenhouse gas and other air pollution emissions.
- Enhance power reliability for the treatment plant.

# Market Opportunity: *Data Centers*

- Data centers using CHP systems: 14 (2006)
- Data center system sizes: 5 kilowatts (kW) - approximately 11.5 megawatts (MW)

Benefits of CHP in data centers include:

- Reduced fuel and energy-related costs
  - Enhances economic competitiveness
  - Increases the company's profitability
- Increased electrical reliability
- Shortened timeline for facility expansion
- Improved local economy from company's increased profitability:
  - Increased worker wages
- Reduced emissions of greenhouse gases and criteria air pollutants



# CHP: Fossil and Renewably Fueled

## CHP

Efficient  
Clean  
Reliable

### Fossil Fueled

#### Additional Drivers:

- Expanded Renewable Portfolio Standards
- Energy Efficiency Credits (EEC)
- Federal/State grants, tax incentives

### Renewably Fueled

#### Additional Drivers:

- Renewable Portfolio Standards (RPS)
- Renewable Energy Credits (REC)
- State grants, loans, tax credits

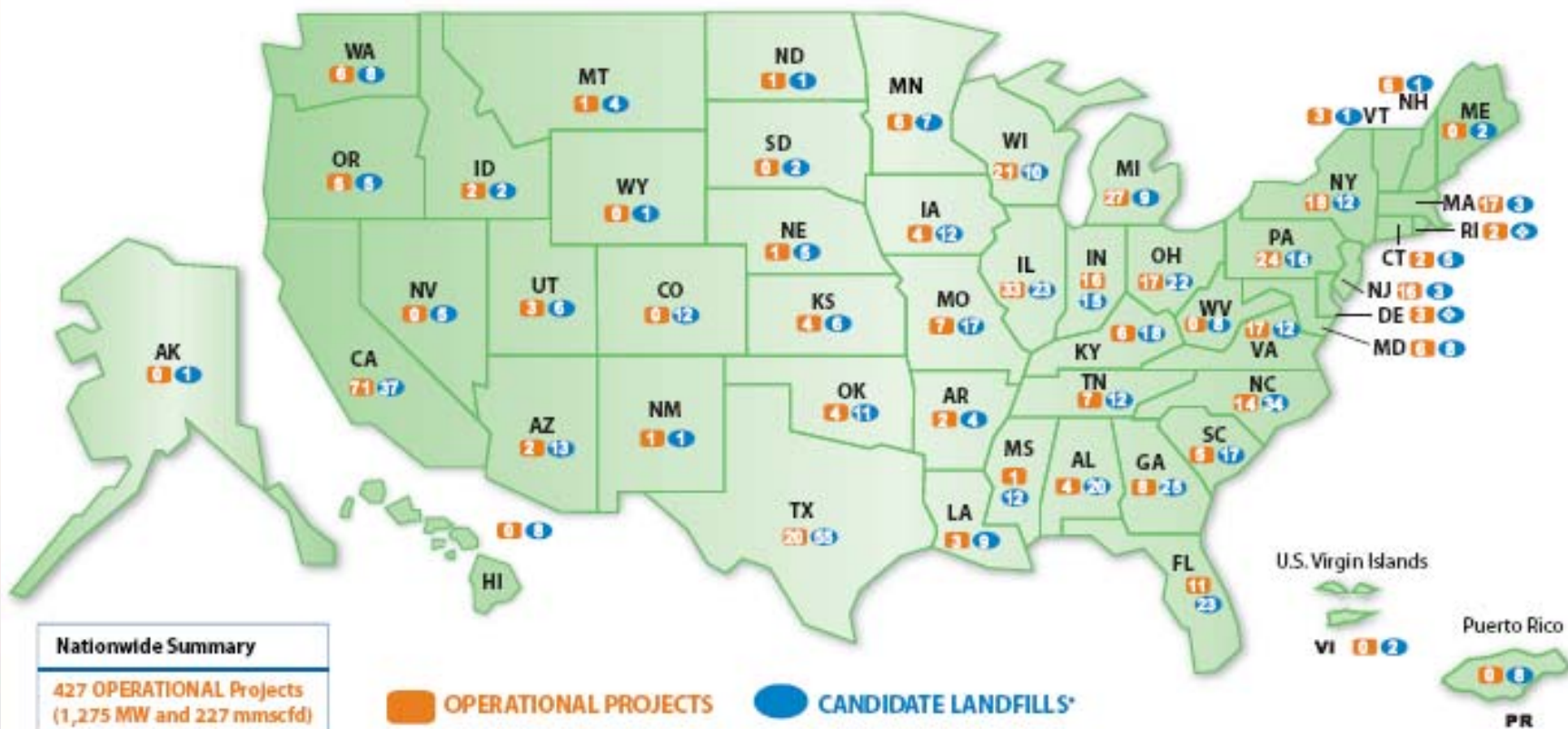
# Renewably Fueled CHP

- Biomass fuels
  - Wood waste
  - Switch grass
  - Bagasse
  - Corn stover
  - Biogas
- CHP Applications
  - Landfills
  - Wastewater treatment facilities (anaerobic digesters)
  - Farms
  - Biomass/Industrial applications

# Biogas 101

- Biogas is a by-product of the anaerobic decomposition of MSW in landfills, manure from farms, or sludges at wastewater treatment facilities
- If uncontrolled, biogas contributes to smog and the risk of global climate change, and may cause health and safety concerns
- Biogas
  - Landfill Gas
    - ~ 50% methane ( $\text{CH}_4$ ), ~ 50% carbon dioxide ( $\text{CO}_2$ ), <1% non-methane organic compounds (NMOCs)
  - Manure and WWTF Biogas
    - ~ 60% methane ( $\text{CH}_4$ ), ~ 30% carbon dioxide ( $\text{CO}_2$ ), other inert gases

# Status of LFGE Project Development and Candidate Landfills by State



## Nationwide Summary

427 OPERATIONAL Projects  
(1,275 MW and 227 mmscfd)

~ 550 CANDIDATE Landfills  
(1,320 MW or 680 mmscfd,  
15 MMTCE Potential)

OPERATIONAL PROJECTS

CANDIDATE LANDFILLS\*

\* Landfill is accepting waste or has been closed for 5 years or less and has at least 1 mmtons of waste and does not have an operational/under construction LFGE project or is designated based on actual interest/planning.

These data are from LMOP's database as of October 10, 2007.  
 ↗ LMOP does not have any information on candidate landfills in this state.

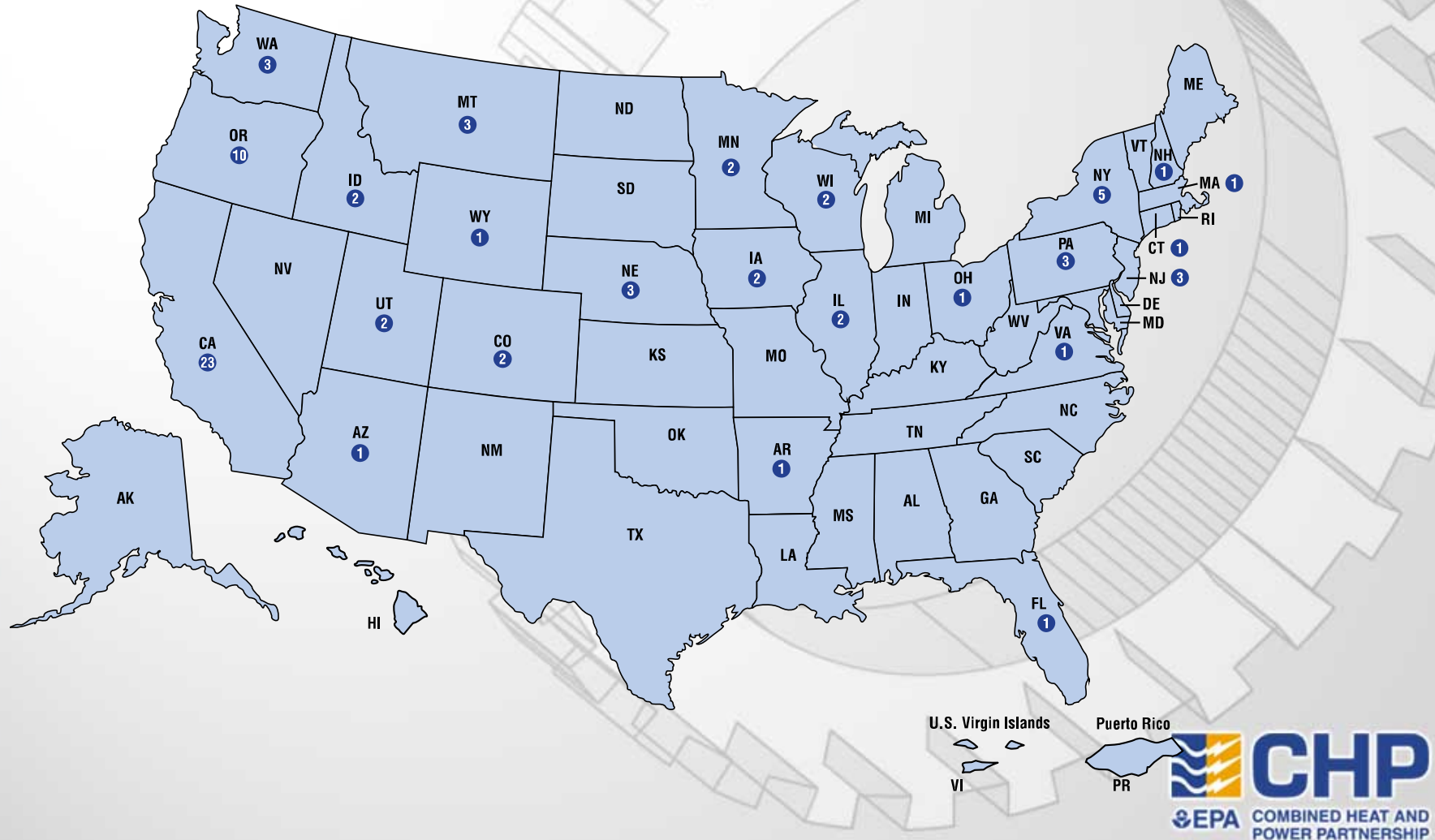


# Benefits of Landfill Gas CHP

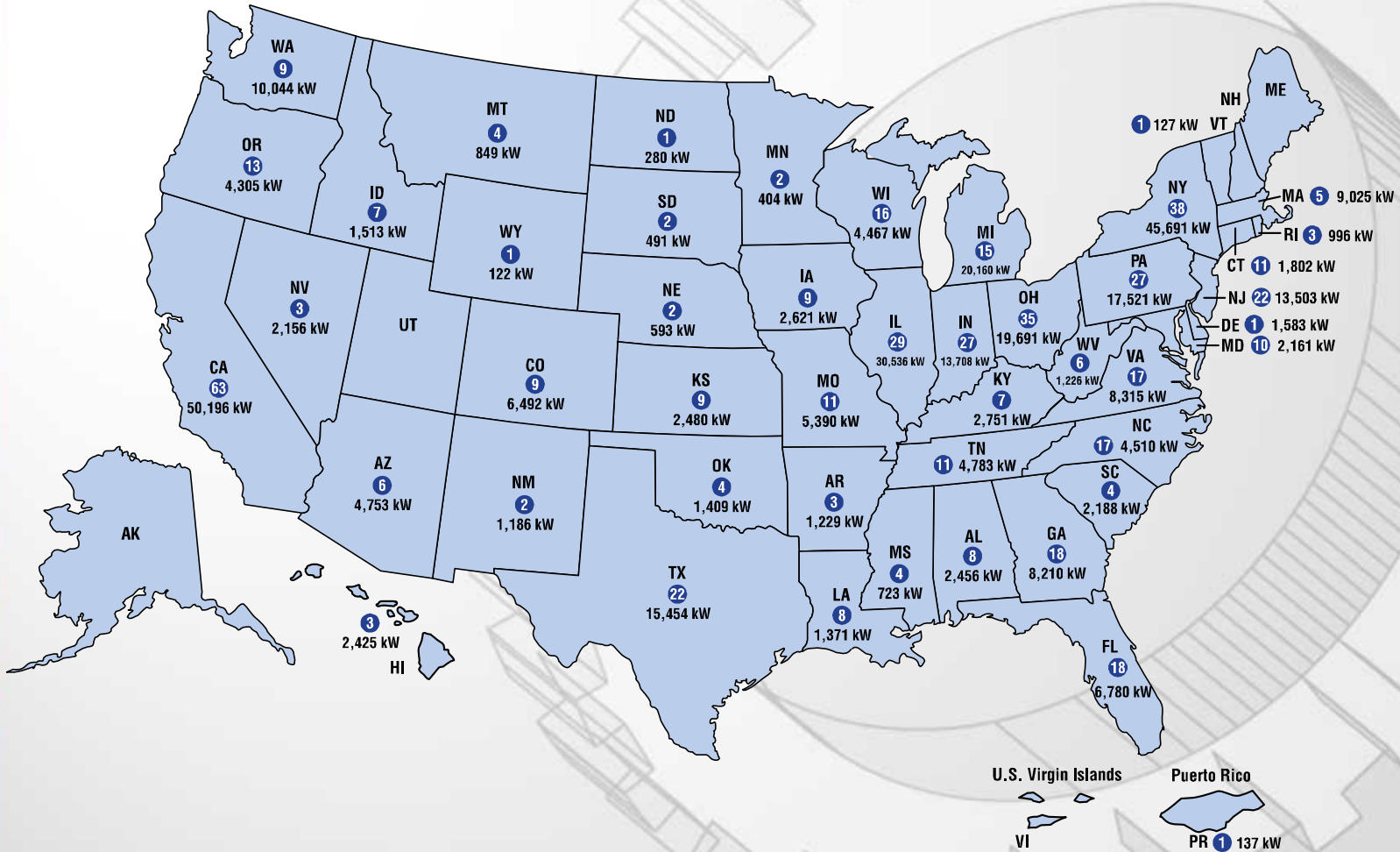
- LFG is a recognized renewable energy resource
  - Green-e, EPA Green Power Partnership, Sierra Club
- LFG is generated 24/7 and projects have online reliability over 90 percent
- Serves as the “baseload renewable” for many green power programs (RPS, RECs, tax credits)
  - Over 50 green power programs currently have LFG in portfolio
- Levelized cost of 4-6 cents per kWh for new electricity projects
- LFG CHP can act as a long-term price and volatility hedge against fossil fuels
- Co-ops, munis, and utilities are already using LFG

# CHP Applications at Wastewater Treatment Facilities (WWTF)

Biogas CHP applications – 220 MW at 76 sites



# WWTFs >5 MGD and Electric Generating Potential



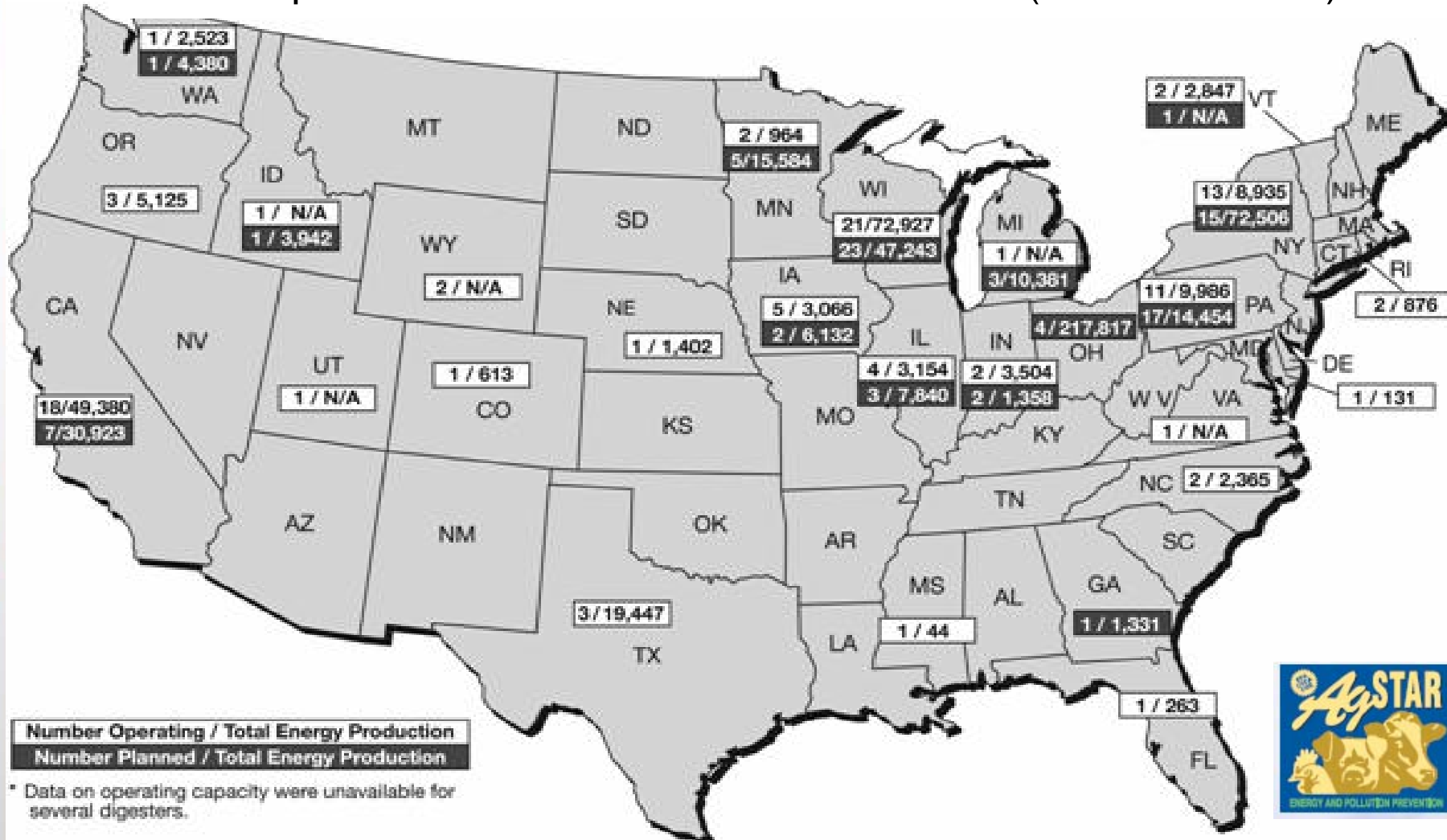
# Benefits of CHP to Wastewater Treatment Plants

- Produces power at a cost below retail electricity
- Displaces purchased fuels for thermal needs
- Qualifies as a renewable fuel for green power programs
- Enhances power reliability for the plant – serves as an additional back-up supply
- Can act as a long-term price and volatility hedge against purchased fuels and electricity
- Offers an opportunity to reduce GHG and other emissions



# Farm-based CHP applications

- 101 livestock-based anaerobic digestion systems - many w/ CHP
- GHG potential = 1.3 million tons of methane (4.7 million cars)



# Solid Fuel Biomass and CHP

Harvest / Collection → Transport → Prep Yard  
→ Conversion

Biomass Conversion for CHP			
Conversion Technology	Generator Type(s)	Typical Electric. Output	Typical Thermal Output
Direct-fired	Steam Turbine	1 – 100 MW	10 – 300 MMBtu/hr steam
Cofiring	Steam Turbine	50 MW – 100 MW	200 – 500 MMBtu/hr steam
Gasification*	Reciprocating Engine	~100 kW–3 MW	0.5 – 15 MMBtu/hr hot water
	Gas Turbine	~500 kW–20 MW	10 – 100 MMBtu/hr steam

\*Gasification is an emerging technology.

# Solid Fuel Biomass and CHP: *Applications*

- 1 to 100 MMBtu/hr steam or hot water
- Wood products industries, schools, colleges, hospitals, local government facilities, other commercial and institutional buildings
- Long practiced in wood products industries; growing practice for buildings in areas with wood waste



Source: Ecomatters, New Zealand

# Solid Fuel Biomass and CHP: *Co-firing Applications*

- 50 to 100 MW
- Large industrial, college campus, utility power plant
- University of Iowa
  - 25 MW coal boiler/steam turbine CHP system (500,000 lb/hr – 5 boilers)
  - Cofiring one boiler with 49% oat hulls from nearby Quaker Oats plant





# CHPP Tools/Support Available

- For states
  - Identify opportunities for strategic sector developments (ethanol production, wastewater treatment plants, hotels, and casinos) to encourage energy efficiency through CHP
  - Identify opportunities for policy developments (energy, environmental, and economic) to encourage energy efficiency through CHP

# CHPP Tools/Support Available

- For projects
  - Provide project-specific technical assistance, including identifying opportunities, quantifying economic, environmental and efficiency benefits.
  - Maintain database of state and federal CHP incentives and beneficial policies/ regulations
  - Facilitate peer-to-peer marketing and networking
  - Administer ENERGY STAR CHP Awards for exceptionally efficient projects.
  - Perform technical and market analysis, profile CHP potential, provide outreach in strategic market sectors.

# For More Information

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