

# Combined Heat and Power (CHP): Applications of Distributed Power

## *Overview of Opportunities and Market Prospects*

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# Seminar Outline

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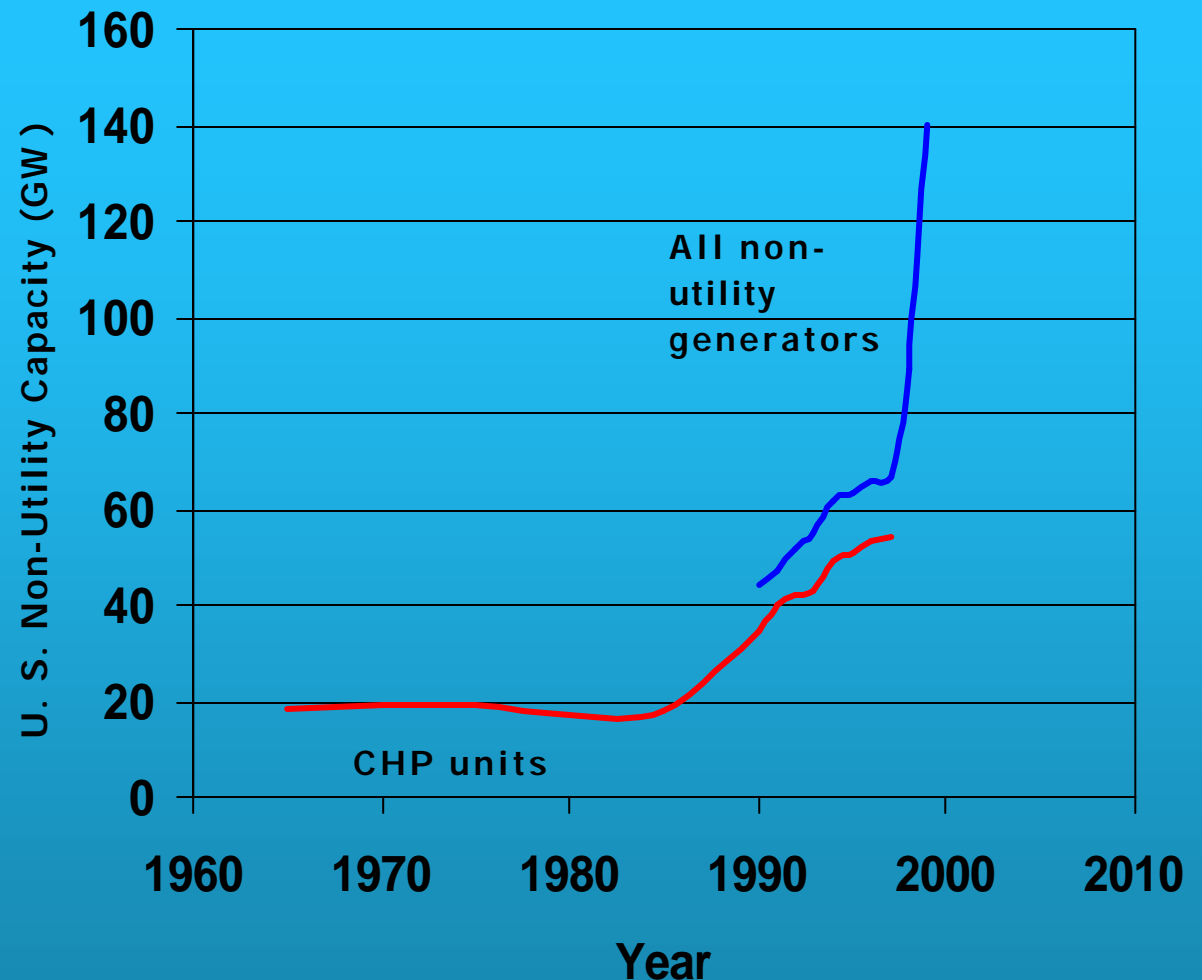
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# Markets for Distributed Power

- Primary Power Markets
  - » Electric Only
  - » CHP
- Other Markets
  - » Backup/Emergency
  - » Peak Shaving
  - » Shaft Drive
- New Niche Markets
  - » Premium Power
  - » Green Power

# History of CHP in the U. S.

- Turn of the century: CHP most common electric generators
- Pre-1970: CHP loses favor to central station
- Late 1970s: energy crises renewed interest in CHP
- 1978: Public Utilities Regulatory Policies Act (PURPA) removed many barriers, including sale of CHP excess power
- 1992: Energy Policy Act signaled the onset of restructuring
- 1997: Kyoto Protocol placed emphasis on efficient use of fuel
- 1998: restructuring emerges in CA and other states and DOE issues CHP Challenge



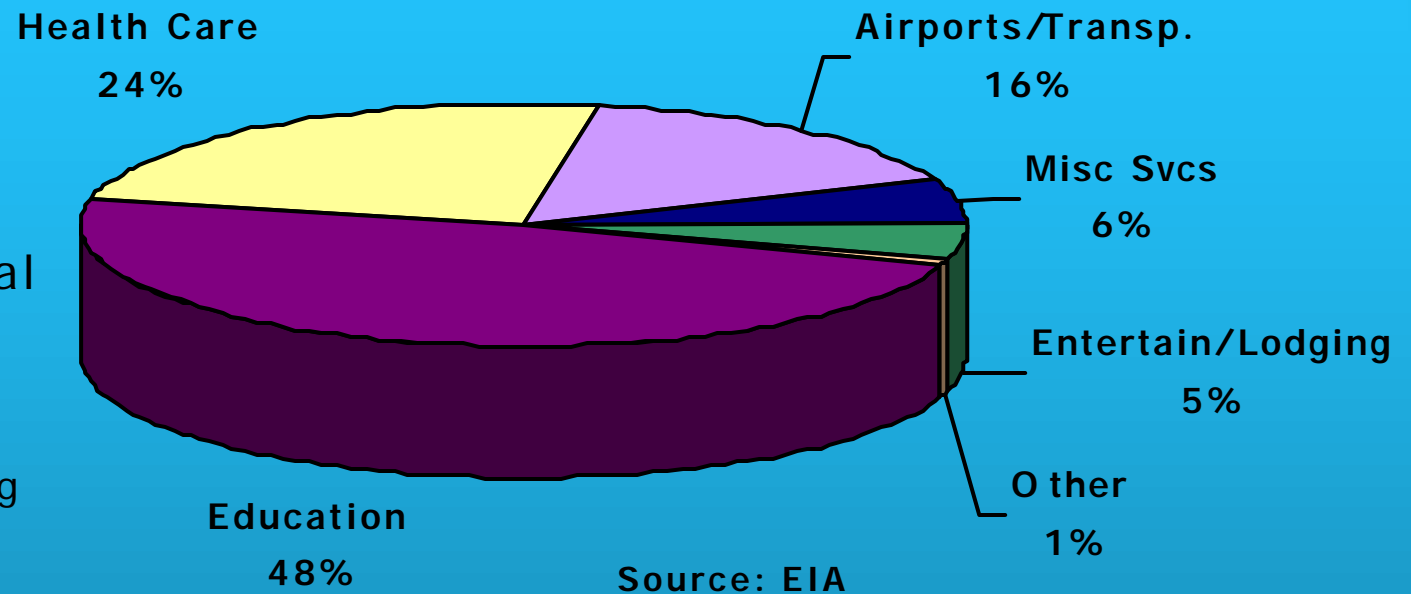
Source: EEI (CHP units),  
EIA (non-utility  
generators)

# What's the CHP Buzz About?

- Restructuring promises opportunities for CHP
  - » Capacity shortages in CA, TX, and other areas
  - » Merchant plants taking hold, some with CHP
  - » Exit fees and standby charges being contested
- Environmental concerns add complexity
  - » High price regions overlap with non-attainment areas
  - » NOx control cost burdens smaller units
  - » CHP seen as environmentally sound, but not "green"
  - » Output-based standards could give CHP a leg up
- Plethora of CHP options
  - » New technologies being commercialized
  - » Ambitious improvements slated for old standbys
- Interconnection debate continues

# CHP Use in Buildings

- Educational and health care sectors stand out
- Other sectors with limited installations and significant potential
  - » Offices
  - » Retail
  - » Multifamily housing
  - » Lodging



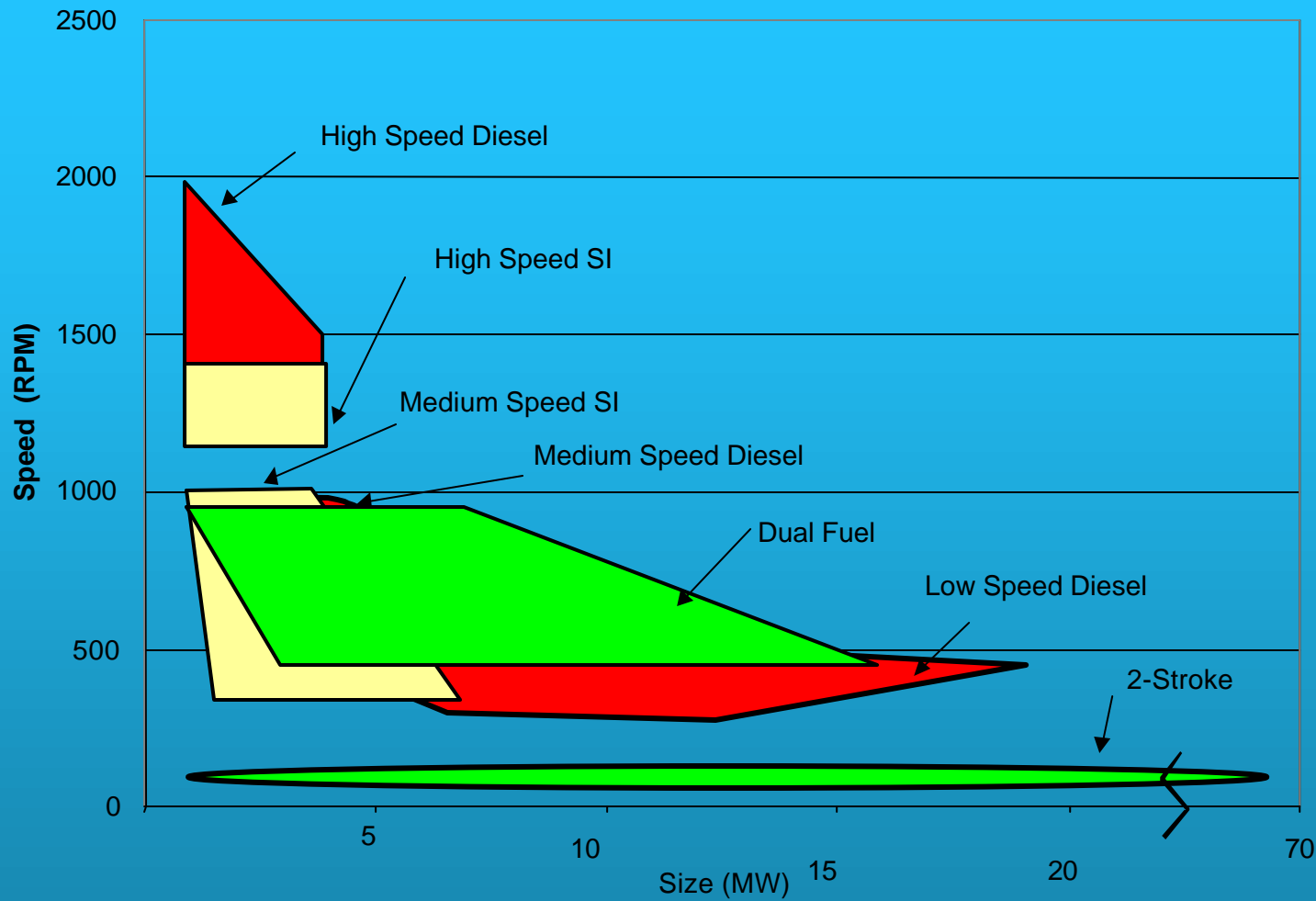
- GRI/AGA/Gas utilities instrumental in market development
- Long operating hours, longer paybacks acceptable, focus on cost reduction, and active energy managers are “intangible” driver

# CHP Technology Options

# CHP Technology Options

Technology Option	Size Range (MW )	Outlook
Boiler/Steam Turbines	30+ MW	Largest installed base, no longer CHP technology of choice. Aging industrial boiler population in need of replacement.
Reciprocating Engines	0-10+ MW	Limited use for CHP due to maintenance requirements and low quality thermal output. Common within educational segment due to in-house maintainability.
Industrial Turbines	1-40+ MW	Technology of choice for size range.
Microturbines	30-300 kW	Emerging option, but little focus on CHP by manufacturers thus far
Fuel Cells	0-3 MW	Promising option if costs can be decreased. Residential CHP on the drawing board.
<u>Others</u> Stirling Engines Fuel Cell Hybrids	0-50 kW 300 kW – 25 MW	Residential CHP? May have some niche applications

# Recips Offer a Broad Range of Options



# Critical Price and Performance Issues

## ➤ Installed Costs

- » Engines typically have advantage
- » Interconnection and permitting can be a major adder (especially in smaller sizes)
- » Add on emissions controls can kill projects

## ➤ Efficiency

- » Fuel cells typically have highest efficiency, followed by engines
- » Better efficiency leads to lower fuel cost and CO<sub>2</sub> emissions

## ➤ Emissions

- » Engines, especially diesel, have high emissions of NO<sub>x</sub>, CO, and particulates and may be difficult to site
- » Fuel cells have virtually no emissions due to the lack of combustion process, though minor emissions from fuel reformer

## ➤ Useful Thermal Output

- » Turbines and fuel cells produce higher quality heat than engines and are better suited for cogeneration applications, especially where steam is required

## ➤ Maintenance

- » Turbines have an edge, reciprocating engines tend to require more frequent maintenance
- » Some users staff trained reciprocating mechanics, and favor their user serviceability
- » Fuel cells and microturbines require demonstrations to show maintenance requirements

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# Market Potential for U.S. CHP

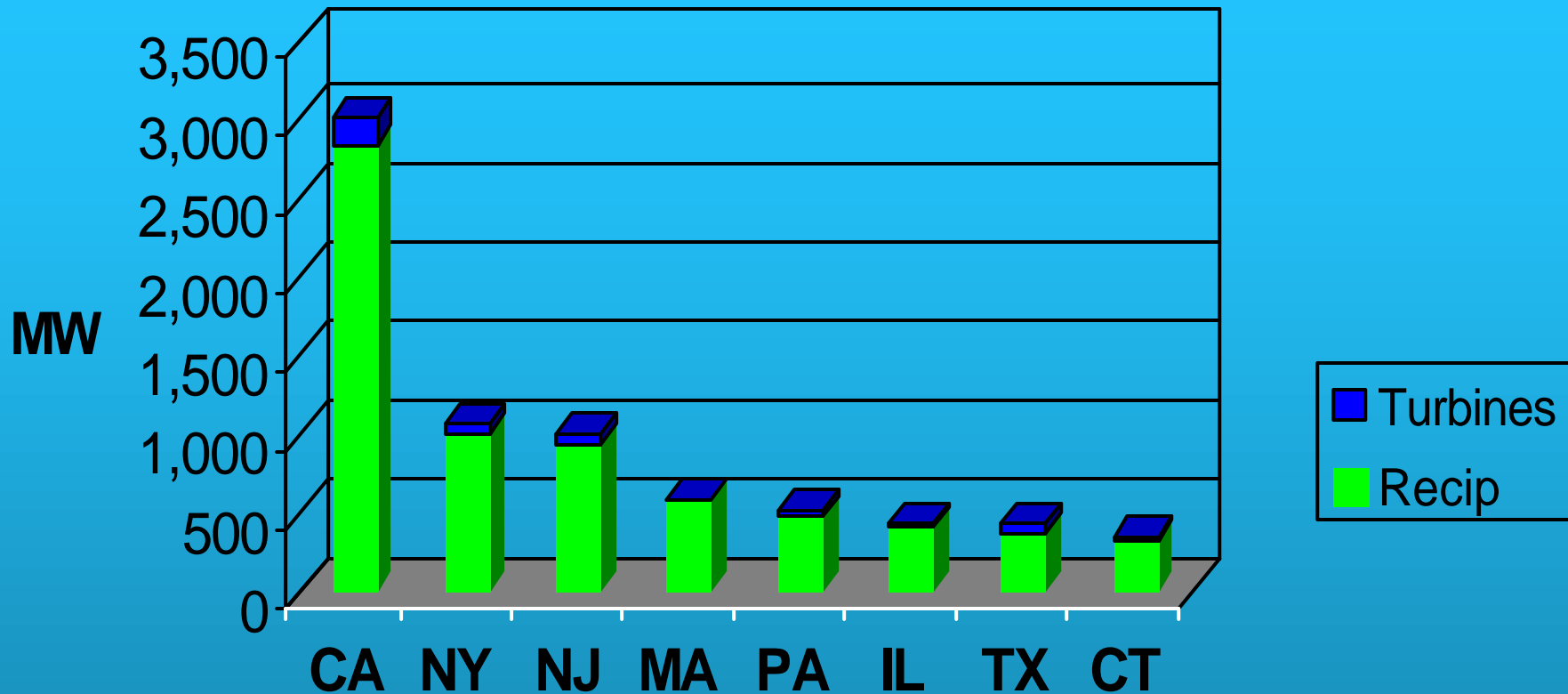
# Recent CHP Studies

- Industrial Applications for Micropower: A Market Assessment
  - » Study objective was to assess the market impact of future R&D aimed at improving cost and efficiency micropower (under 1MW ) options
- CHP Analysis for Scenarios for Clean Energy Futures
  - » Objective of effort was to determine carbon reduction impact of aggressive policies designed to lower barriers to CHP
- Buildings Cooling, Heating and Power
  - » Goal was to determine size of market for CHP in buildings, examining a wide range of CHP/cooling options

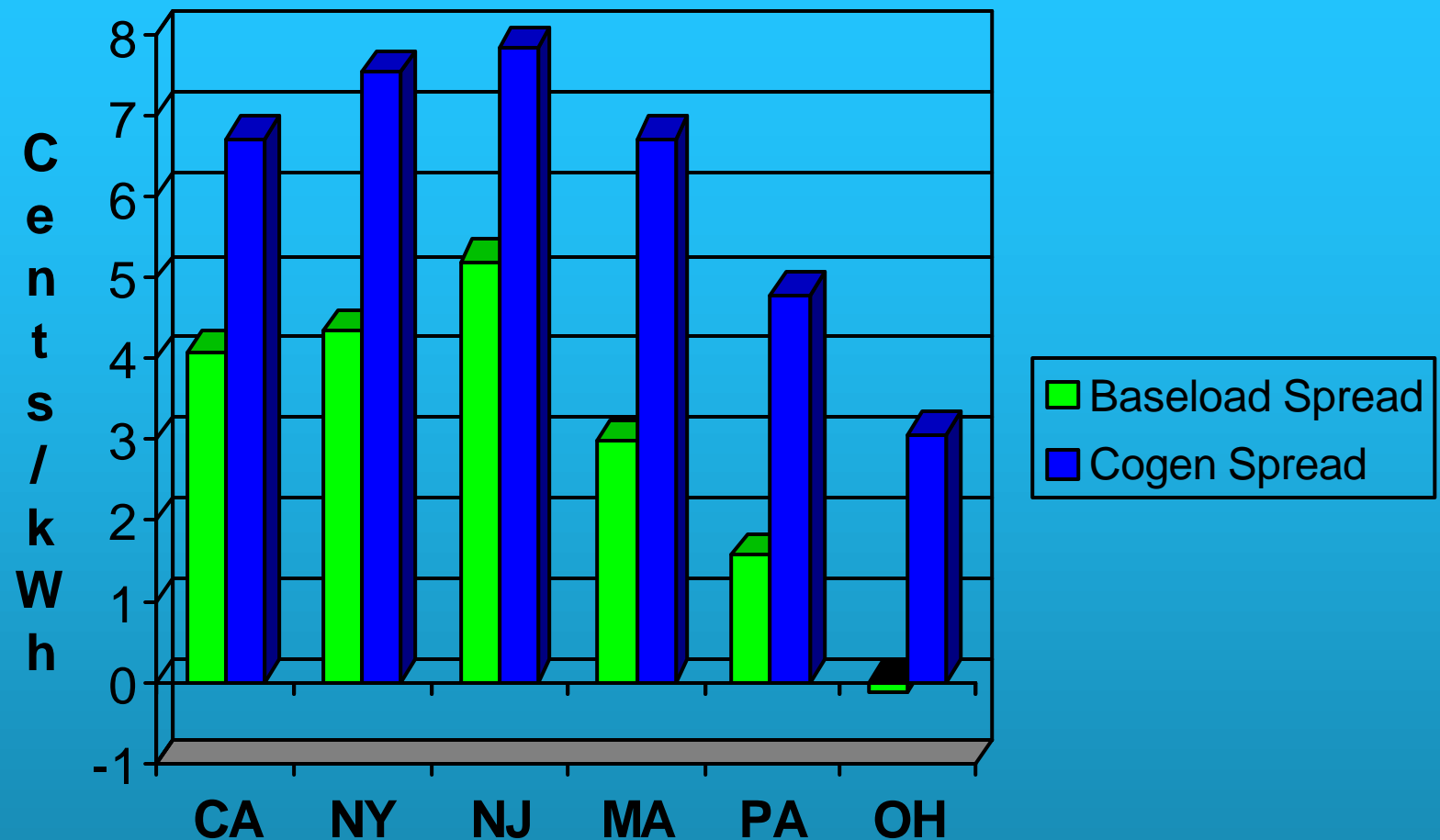
# Economics of Continuous Power/CHP Applications

- High competing grid price, as well as installed cost of unit drives applications
- Operating cost (mainly fuel), power quality, and reliability of grid power are contributing factors
- Emission regulations and permitting can be strong barriers
- Restructuring fees/uncertainty can also be a formidable barrier

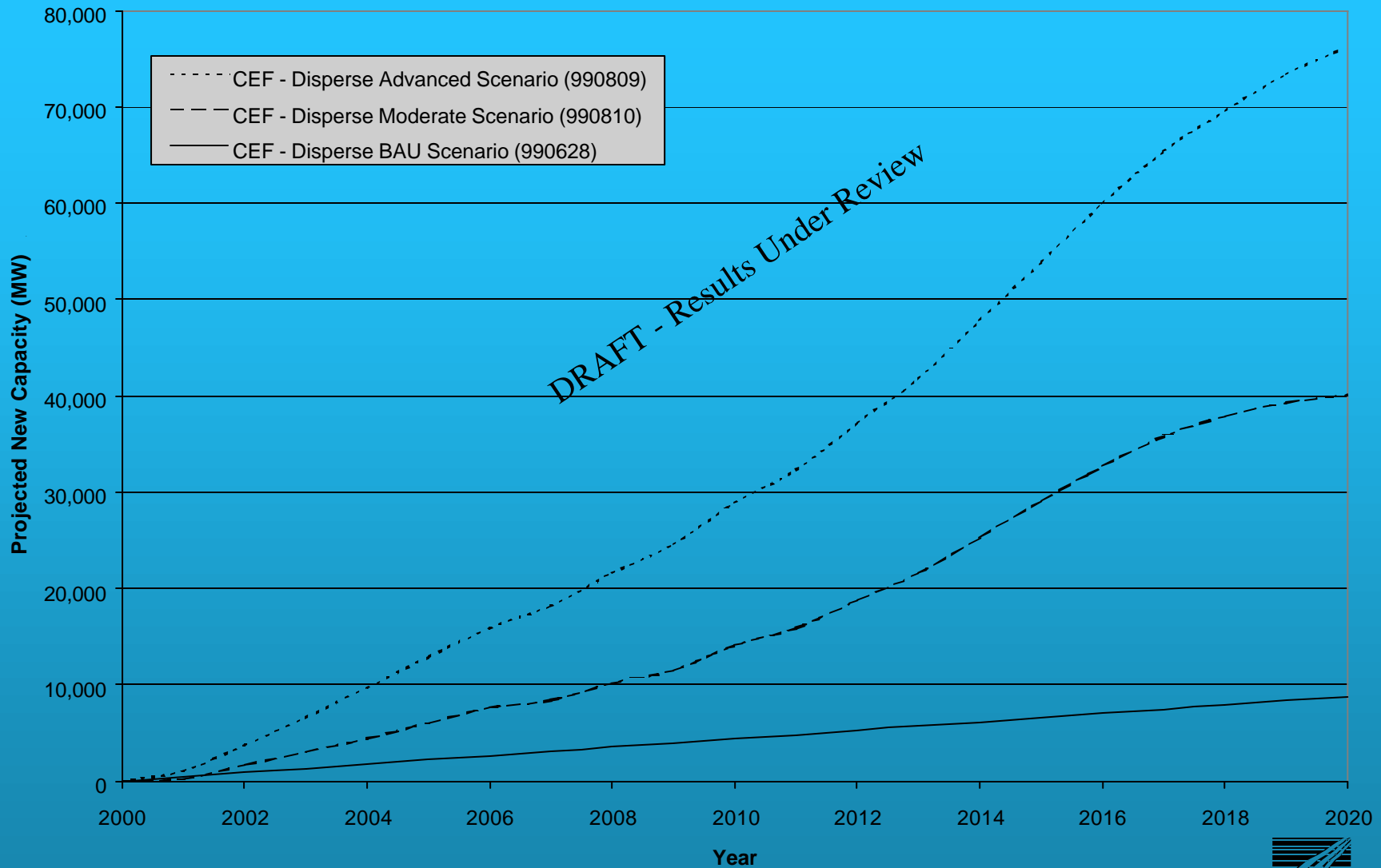
# Continuous Power CHP: Regional Market Potential for Industrial



# Spark Spreads Illustrate Economic Drivers



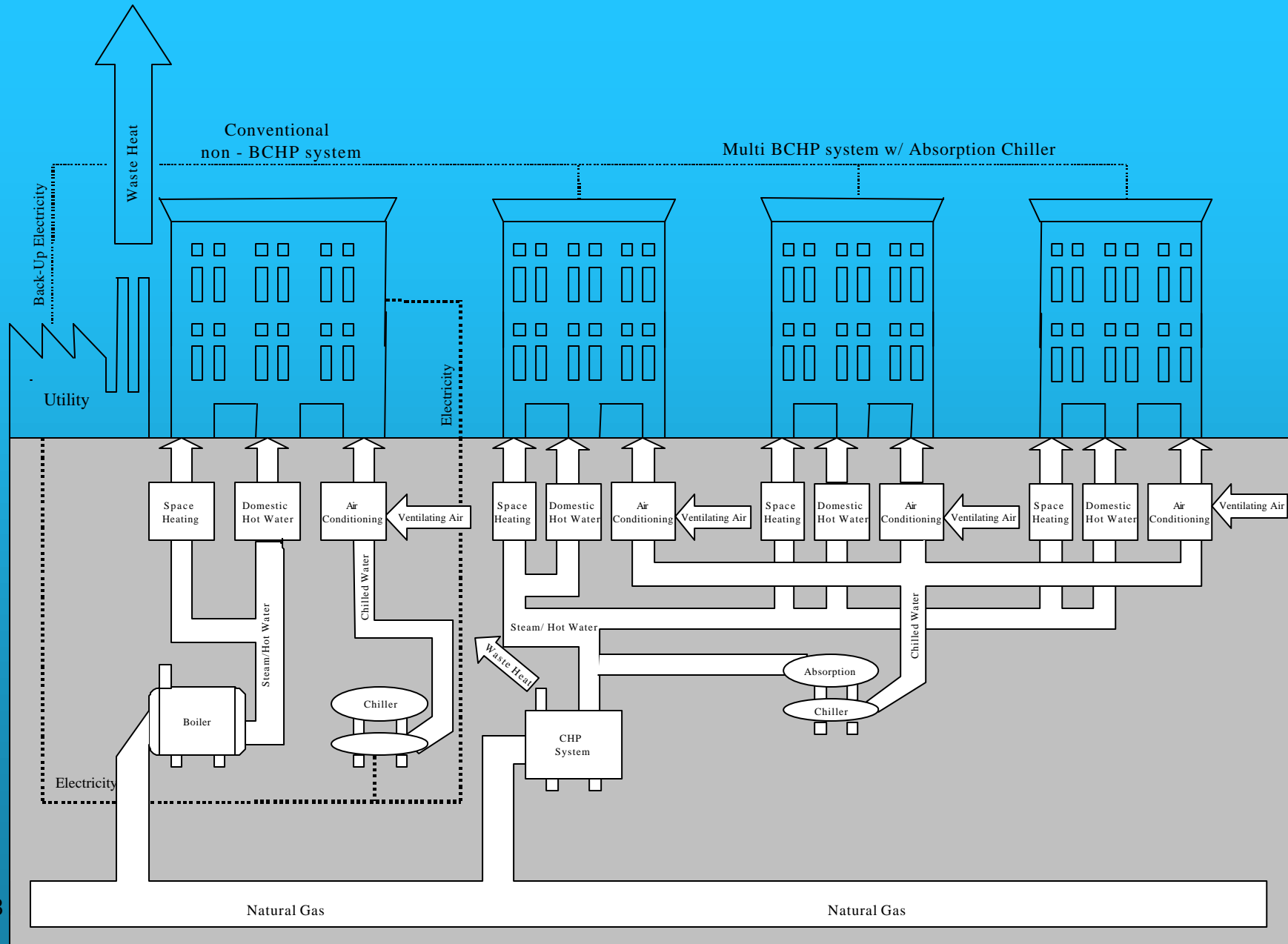
# CHP Impacts



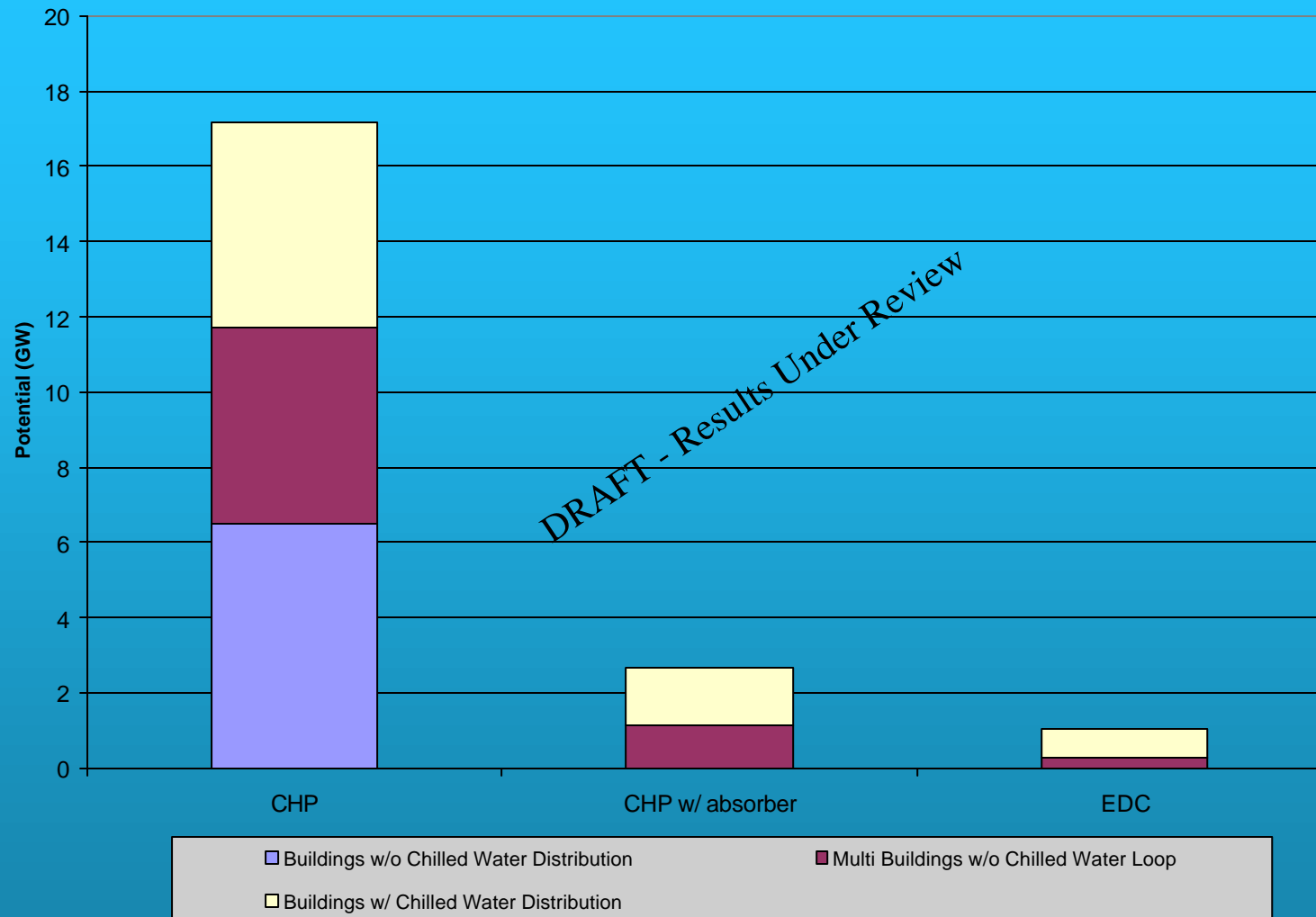
# Building Cooling, Heating, and Power (BCHP)

- Building applications of CHP limited by insufficient use of thermal energy during summer months
- New thermally-driven cooling technologies are being developed which can use CHP thermal energy effectively
- Other factors which favor BCHP include multi-building facilities, which are:
  - » Under common ownership, favoring aggregation of loads
  - » Closely located, so that connecting buildings with distribution piping is not cost prohibitive
  - » More commonly owner occupied, so that comfort is more of an issue
  - » Generally more highly occupied, so that expensive systems can be more quickly amortized

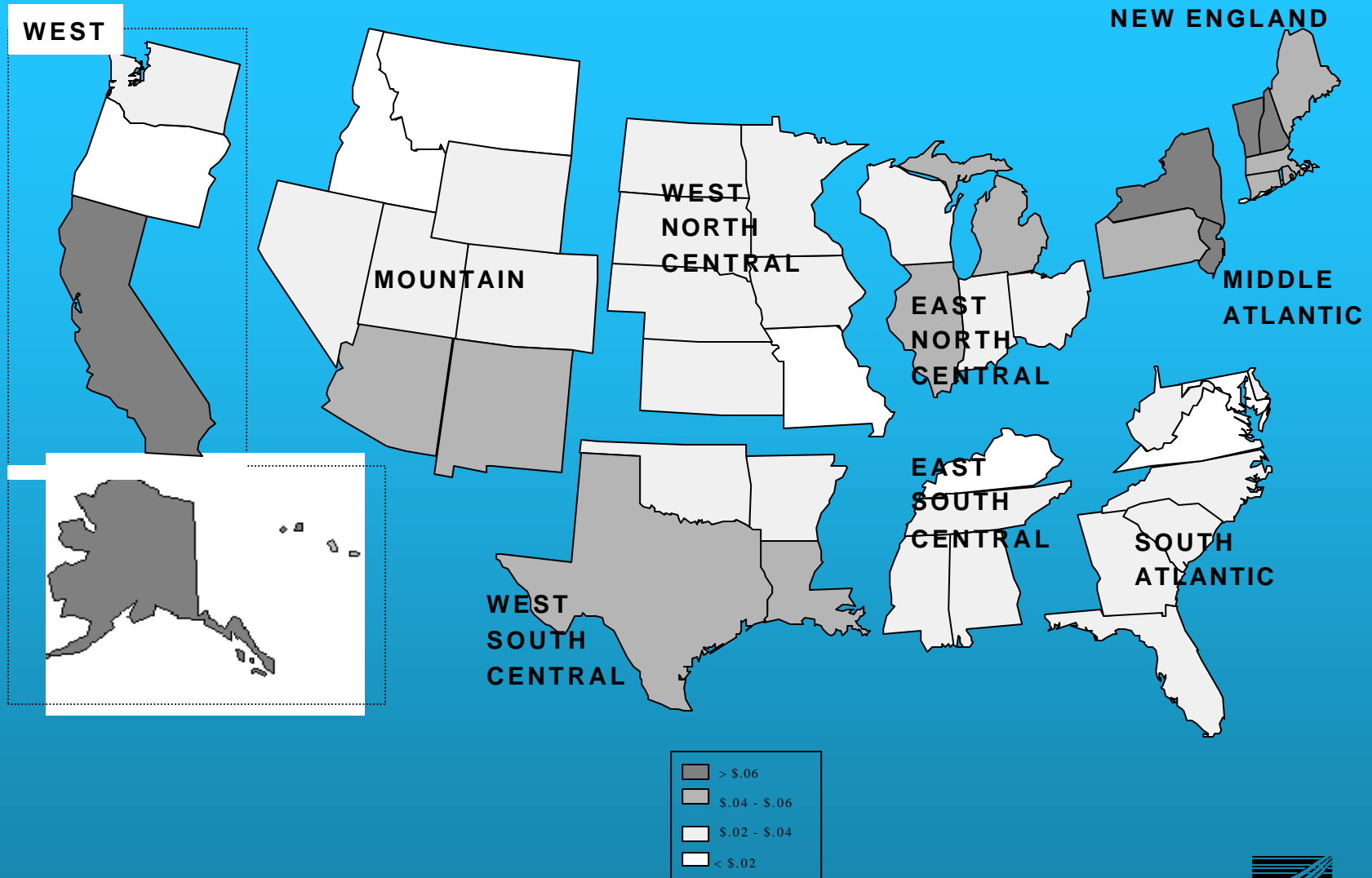
# BCHP Systems



# Potential by Type of BCHP System



# BCHP "Spark Spreads"



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# Barriers to Continued Growth in CHP

# Technical and Market Barriers Hinder More CHP

- Economics and Tax Treatment
- Product Performance
- Awareness and Education
- Utility Policies and Regulations
- Planning, Zoning, and Codes
- Environmental Regulation
- Supporting Market Infrastructure

# Current Economics and Tax Treatment Reduces CHP Incentives

- CHP systems are expensive, and require more up-front capital than boiler/grid purchase option
- Long asset life minimizes up-front depreciation and may outlive system useful life
- Accelerated depreciation and tax credits no longer in place
- Solutions:
  - » Tax credits have been proposed by current Administration
  - » Shorter asset life would improve tax treatment
  - » Continue/boost R&D funding levels to develop more efficient and less costly options
  - » Encourage third party ownership, which may welcome capital investment and lower returns

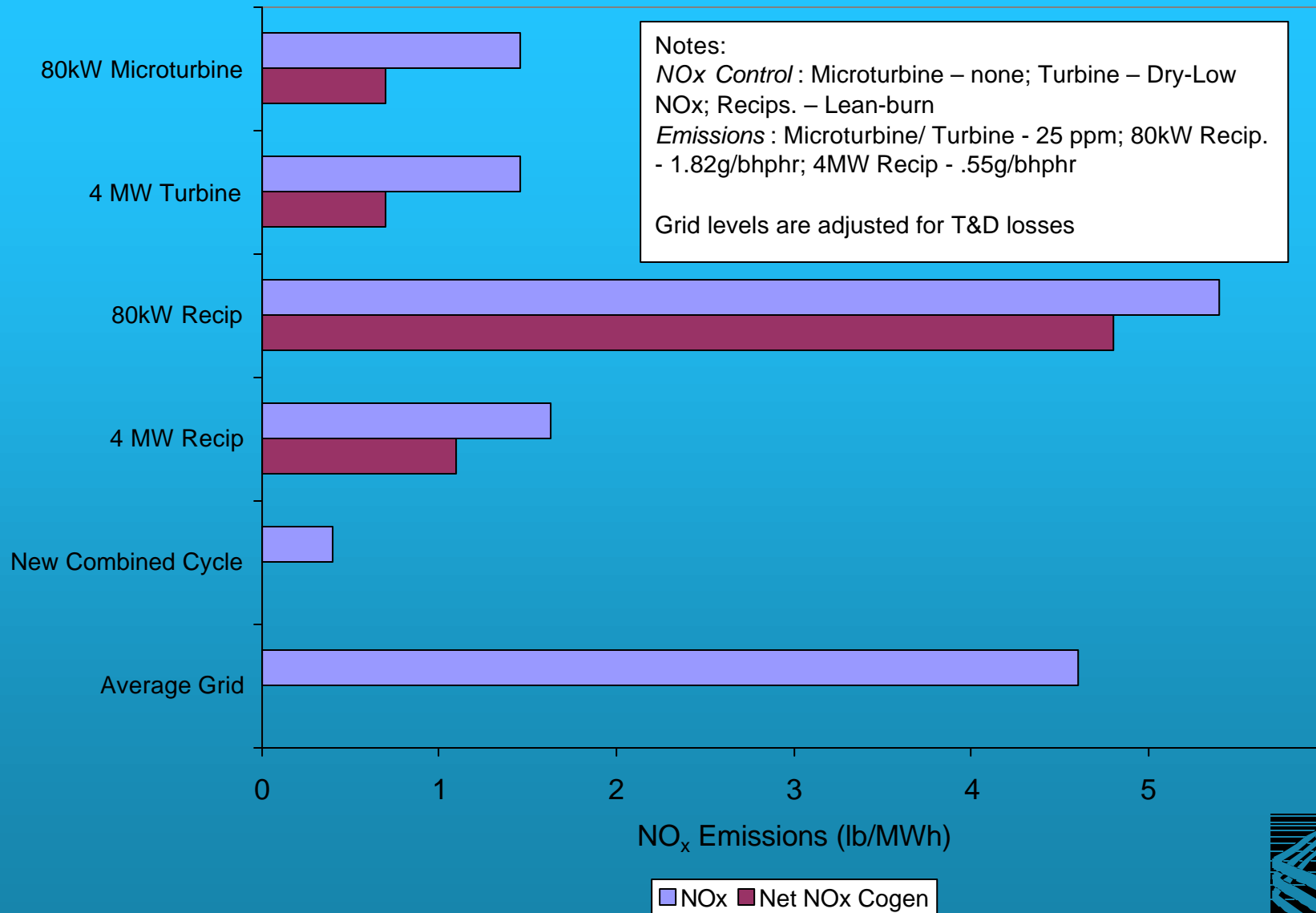
# Third Party vs. End-user Ownership

<b>Scenario Data</b>		
Site Load (MW)	10	10
Load Factor	66%	66%
CHP Unit Type	5 MW Turbine	5 MW Turbine
CHP Unit Installed Cost (\$000)	3,250	3,250
Energy Charges (cents/kWh)	4.8	3.8
Demand Charges (\$/kW)	15	12
Natural Gas Price (\$/MMBtu)	4	4
<b>Original Consumption</b>		
Electricity		
Energy (kWh)	57,153,700	57,153,700
Demand (kW)	10,000	10,000
Boiler Fuel (MMBtu)	228,615	228,615
<b>Consumption with CHP</b>		
Electricity		
Energy (kWh)	16,842,100	16,842,100
Demand (kW)	5,000	5,000
Boiler Fuel (MMBtu)	30,014	30,014
<b>CHP Unit Operation</b>		
Power Generated (kWh)	40,311,600	40,311,600
Load Factor	92%	92%
Fuel Consumption (MMBtu)	443,688	443,688
<b>Energy Expense (excluding CHP unit fuel)</b>		
Original Electric Bill	4,183,375	3,131,838
New Electric Bill	1,528,419	1,119,999
Original Boiler Fuel Bill	685,846	685,846
New Boiler Fuel Bill	90,041	90,041
<b>Customer Cash Flows</b>		
Net Electricity Bill	2,654,955	2,011,839
Net Boiler Fuel Bill	595,805	595,805
CHP Unit Fuel	1,331,063	1,331,063
CHP Unit Maintenance	200,779	200,779
Back Up Charges	250,000	250,000
Property Taxes and Insurance	65,000	65,000
Tax Effect	462,652	160,157
Net Cash Flow (yr1)	1,121,266	600,645
Total Project NPV (10yr)	5,508,907	1,468,081
<b>Simple Payback (yrs)</b>	<b>2.8</b>	<b>5.1</b>
<b>IRR</b>	<b>34.9%</b>	<b>15.5%</b>

# Environmental Regulation

- High electric price regions overlap with nonattainment areas
- Emissions control requirements have been a moving target
  - » Reasonably available control technology (RACT) -> Best available control technology (BACT) -> Lowest achievable emissions reduction (LAER)
  - » Even less strict areas are experiencing requirements for the most expensive options (i.e. LAER in one state can be another's BACT)
    - For engines, SCR is becoming a more common requirement
    - For turbines, SCR with dry low NOx or even the relatively unproven SCONOx
- When expensive control technologies are required, few smaller (i.e. less than 25 MW) projects move forward
- Solution:
  - » Output based regulations consider the full output of CHP systems and not just the fuel used
  - » These would favor CHP, and result in an overall emissions decrease if widely implemented

# Impact of CHP on NO<sub>x</sub> Emissions



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# Market and Policy Outlook for CHP

# CHP Outlook

- Large market potential exists for both industrial and buildings segments
- Significant barriers remain
  - » Backup, standby, and sell-back rates as well as exit fees
  - » Cost and performance of units needs improvement
  - » Environmental regulations and permitting can be a deal breaker
  - » More favorable tax treatment would boost projects
  - » Interconnection still a major issue
- Market and policy responses can address these barriers