

# Combined Cooling, Heat and Power Technology Overview

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2002 Energy  
Workshop and Exposition

*Hot Challenges, Cool Solutions*

Palm Springs, California

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*Keith Davidson*



# Energy Nexus Group

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- Professional services company focusing on distributed energy
- Subsidiary of Onsite Energy Corporation
- Company Origins in Co-generation and On-site Power
- Active in Distributed Generation and Combined Heat and Power



# Discussion Topics

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- CHP Market Overview
- Remaining CHP Potential
- Technology Medley
- Economic Considerations
- Assessing Project Viability

# Potential DG Applications

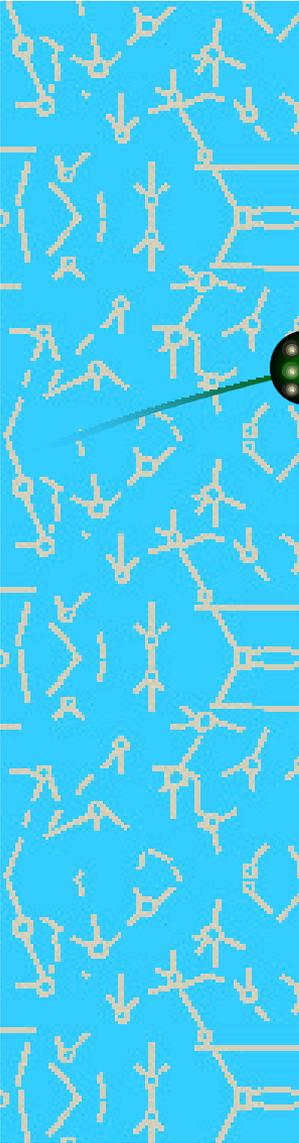
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- ***Combined Heat and Power*** - common practice by large industrials; large untapped potential in small industrial and commercial
- ***Peaking*** - potential growth market for customer peak shaving (500 to 2000 hours/year) by light industrial and commercial
- ***Premium Power*** - emerging market to provide quality power to sensitive customers
- ***Niche Applications*** - providing power in remote or isolated applications, shut in gas wells, and other niche markets such as landfill and municipal waste

# Combined Heat and Power

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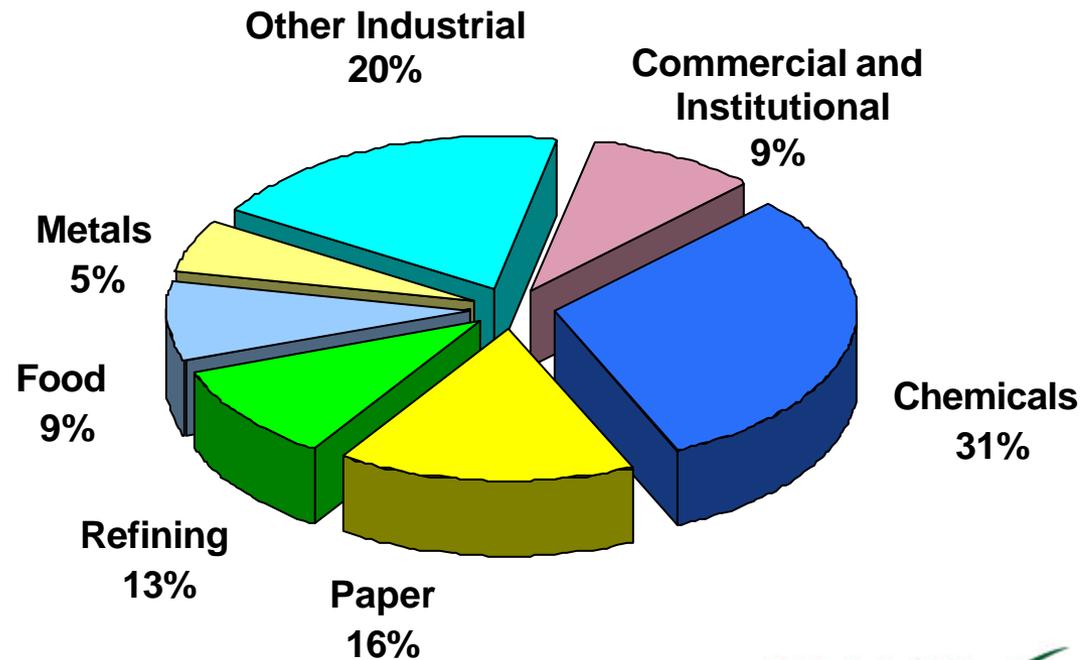
- Traditionally the most effective DG option
- CHP sequentially produces electricity, thermal or mechanical energy
- Total system efficiency is key to economics
- O&M costs are critical
- High operating hours covers high capital costs
- CHP is attractive from an energy policy perspective



# CHP Market Overview

# Industrials Represent 90% of Existing CHP

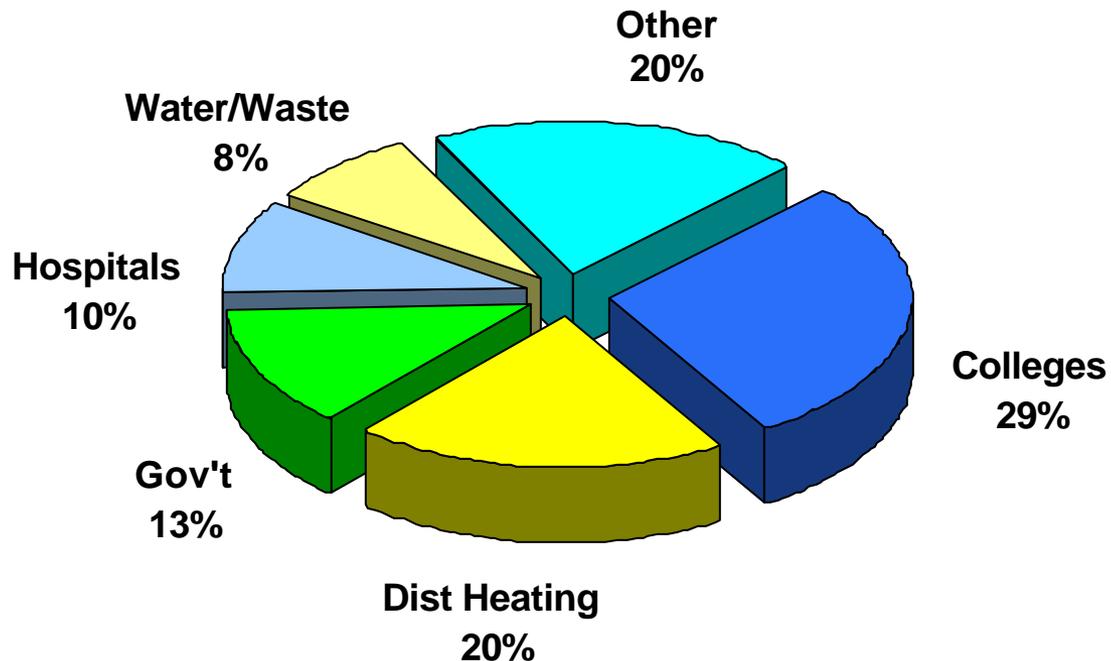
- Existing CHP Capacity (1999) 52,800 MW



Source

# Existing Commercial CHP

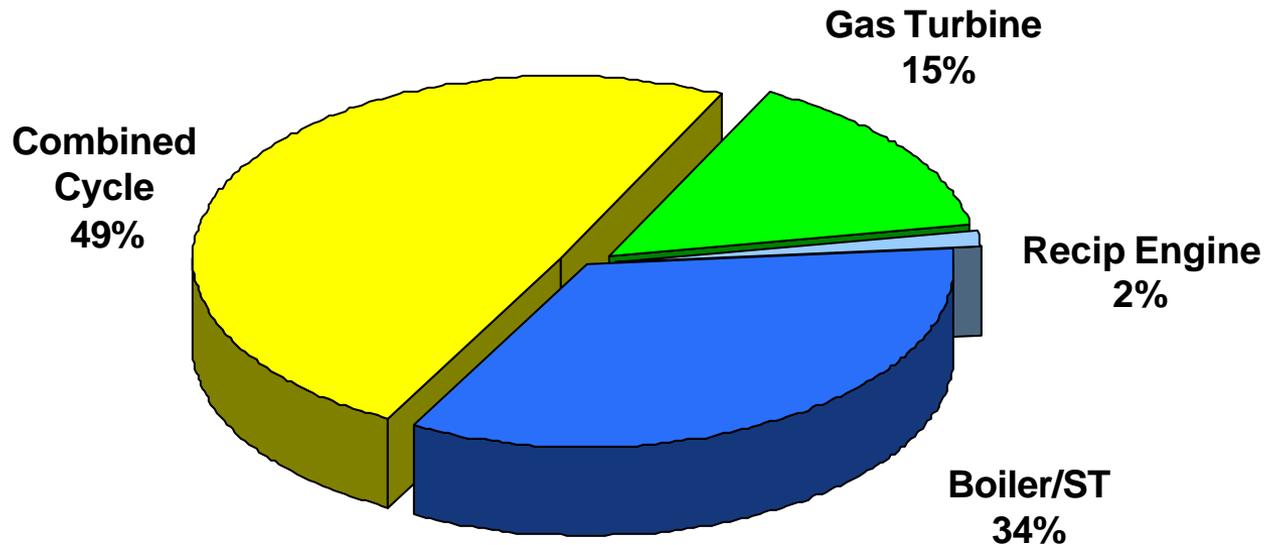
- Existing Commercial CHP Capacity (1999) 4,930 MW



Source

# Gas Turbines Dominate Capacity

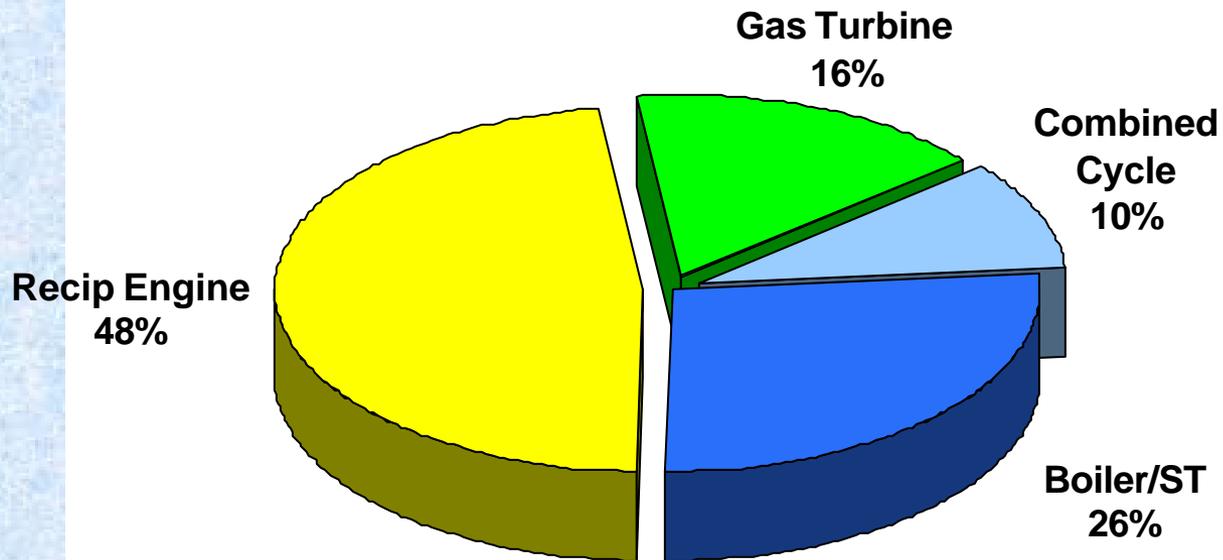
- *Existing CHP Capacity: 52.8 GW*



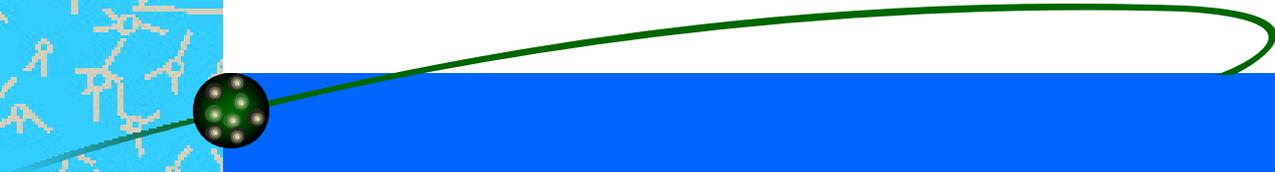
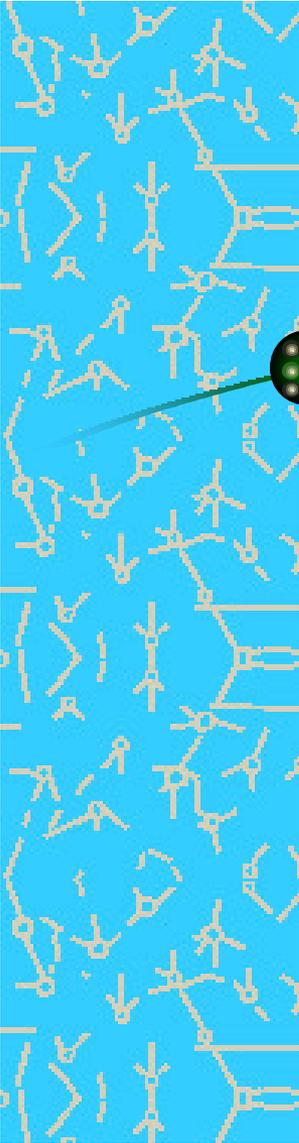
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# Recip Engines Dominate Sites

- *Existing CHP Installations: 2167 sites*

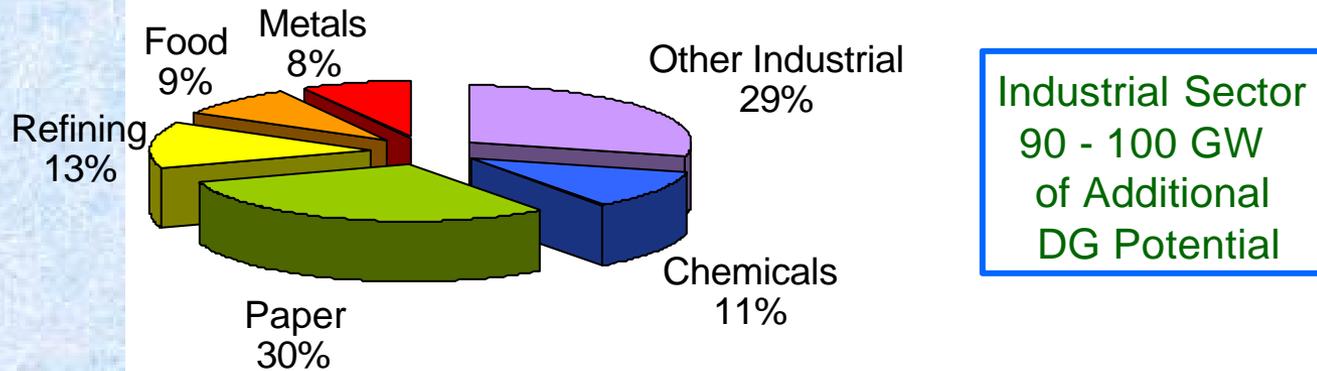


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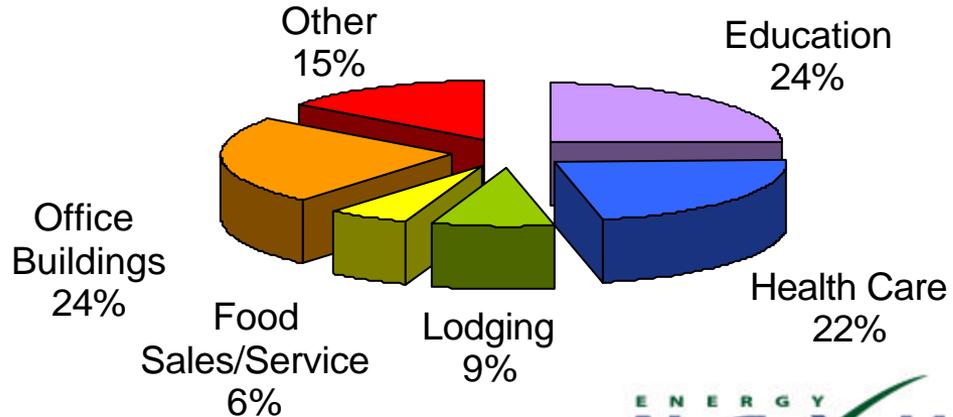


# CHP Market Potential

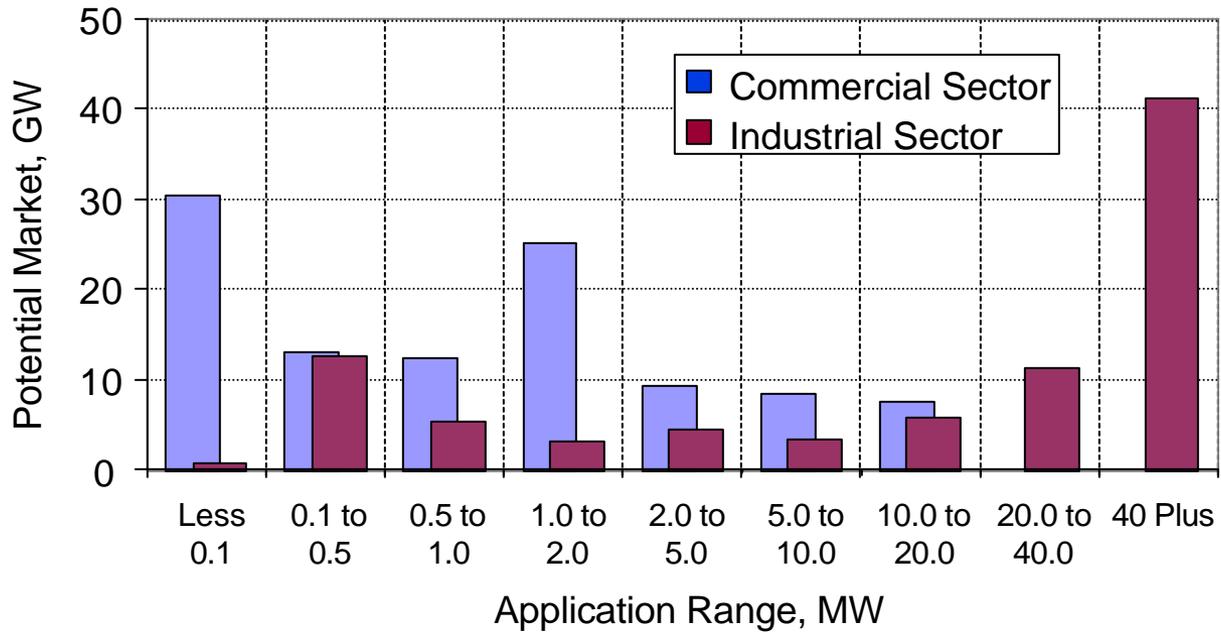
# Broad CHP Opportunities Remain

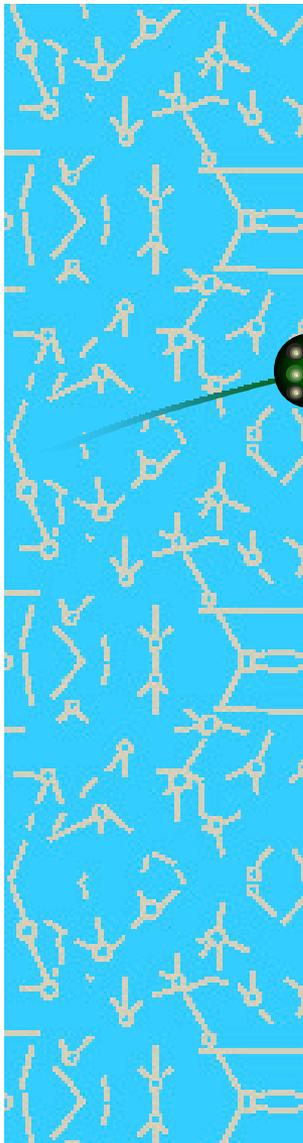


Commercial Sector  
75 to 100 GW  
of New  
DG Potential



# US CHP Market Opportunities

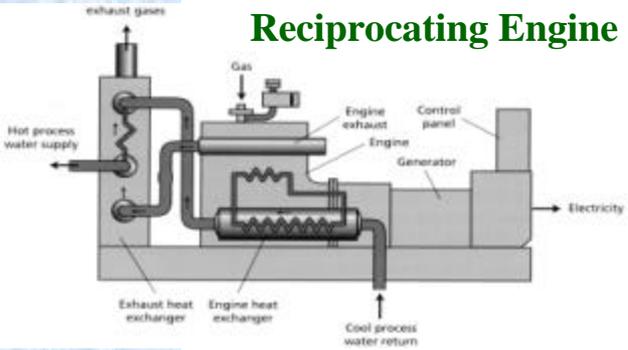




# Technology Medley



# CHP Technology Options

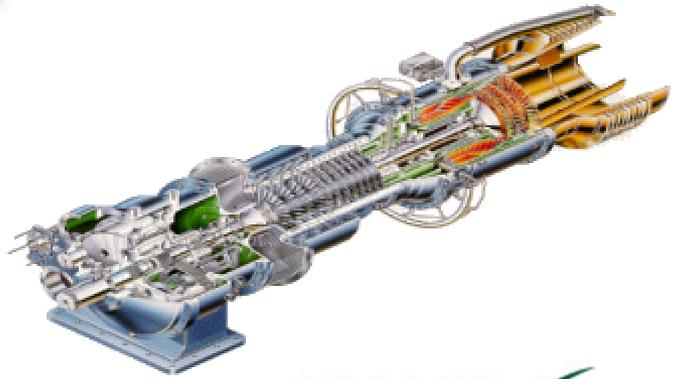


**Microturbine**



**Fuel Cell**

**Gas Turbine**



# Technology is a Key Driver for DG

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- The cost of small generation technologies has declined
- The performance of small generation technologies has increased
- Controls, sensors and communications have advanced

On-site generation  
is becoming a  
viable option for  
more users

# What Affects Technology Choice and System Design?

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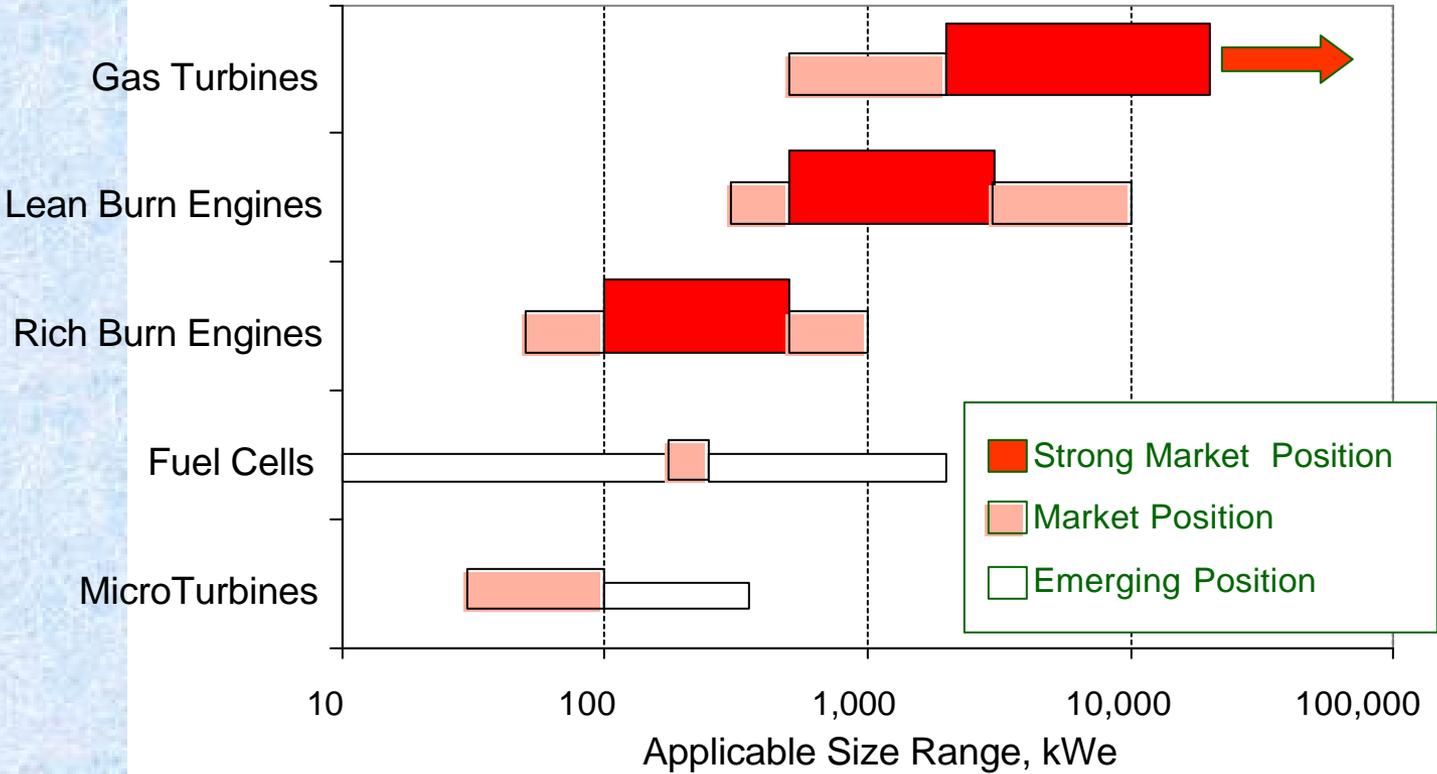
- Energy costs and fuel availability
- Electrical load size/factor/shape
- Load criticality
- Thermal load size/shape
- Special load considerations
- Regulatory requirements

# What Differentiates Technologies?

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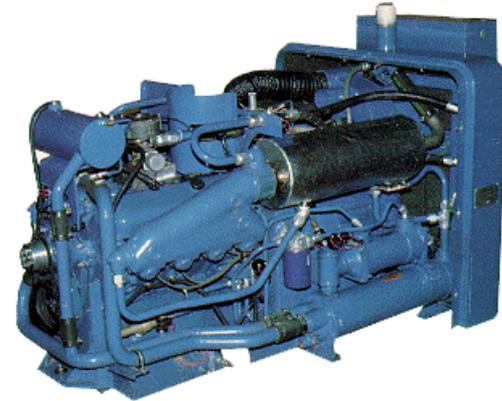
- Size
- Fuels
- Efficiency
- Capital costs
- O&M costs
- Amount and quality of thermal energy
- Emissions
- Risk

# Technology vs. Size Coverage



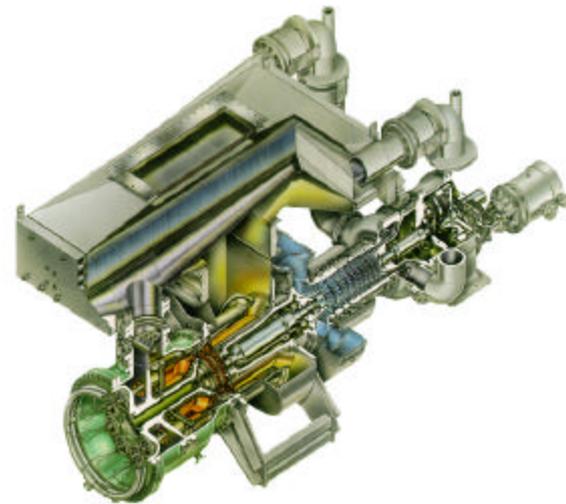
# Reciprocating Engines

- Size Range: 30 - 6,000 kW
- Electric efficiency: 28 - 38%
- Fast startup (10 secs) capability allows for use as standby
- Thermal energy in the form of hot water or low pressure steam
- High maintenance requirements (lots of moving parts)
- Emissions can be an issue



# Industrial Gas Turbines

- Size range: 500 kW - 50 MW
- Electric efficiency (22-40%)
- Start-up time: 10min - 1hr
- High pressure steam or high temperature direct heat
- Established technology for many power and direct drive applications
- Multi-fuel capable, but economics and emissions favor natural gas



# Microturbines

- Size range: 25 - 300 kW
- Electric efficiency: 20 - 30%
- Start-up time: >1 min.
- Fuel compressor usually required
- Small CHP, Power only and Peaking
- Commercial introduction underway



# Fuel Cells

- Size range: 3 - 3,000 kW
- Start-up time: 3hrs -
- Electric efficiency: 36-65%
- Low emissions - exempt in some areas
- Only PAFC is commercially available
- Cost is biggest market issue



# Fuel Cell Technologies

*Proton exchange  
membrane fuel cell  
(PEMFC) <250 kW*



*Phosphoric acid fuel cell  
(PAFC) 200 kW - 10 MW*



*Solid Oxide  
Electrolyte Fuel  
Cell (SOFC)  
1-150+ MW*



*Molten Carbonate  
electrolyte Fuel  
Cell (MCFC)  
1-100+ MW*

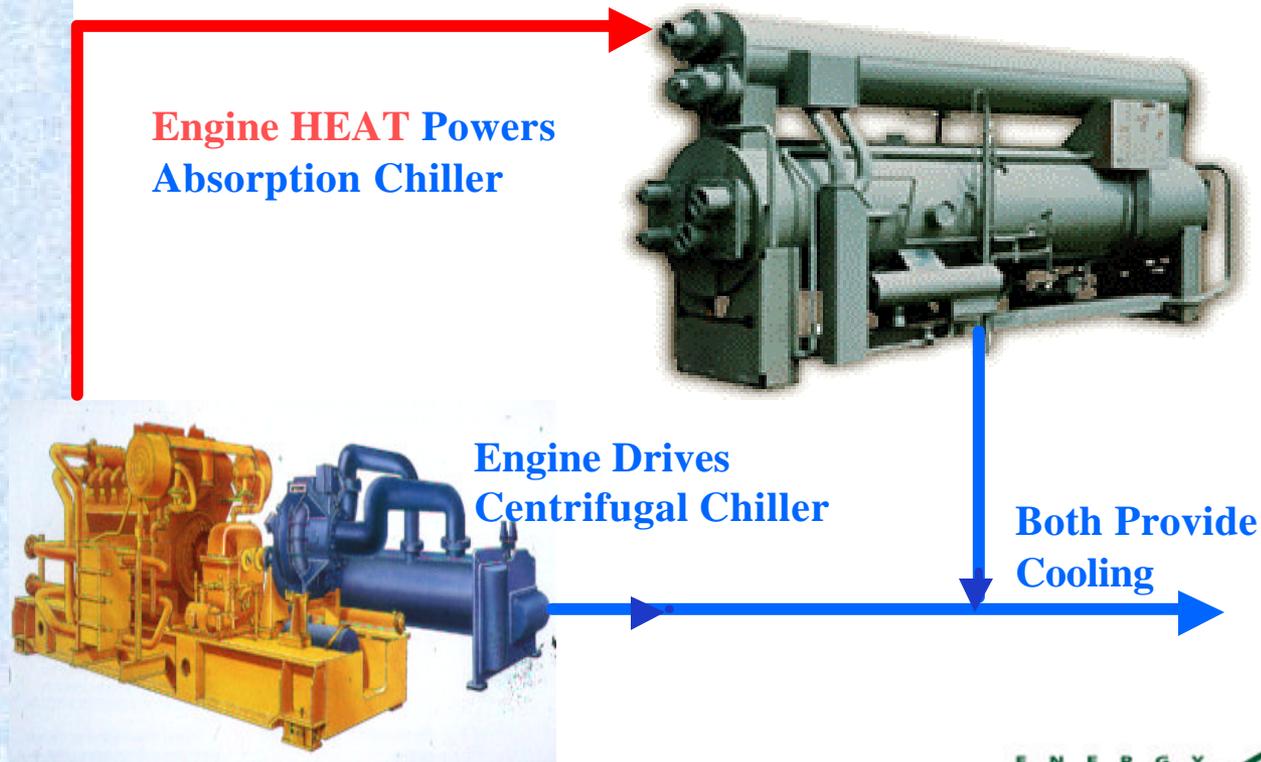
# Absorption Cooling

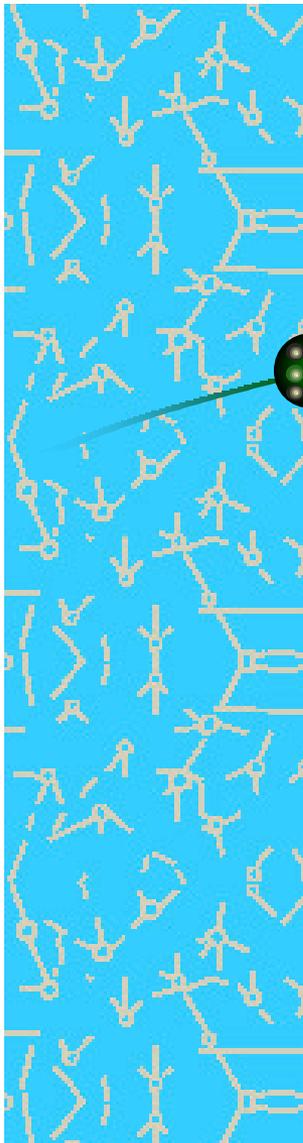
Single Stage Steam



Two Stage Steam

# CHP is Not Always Electric

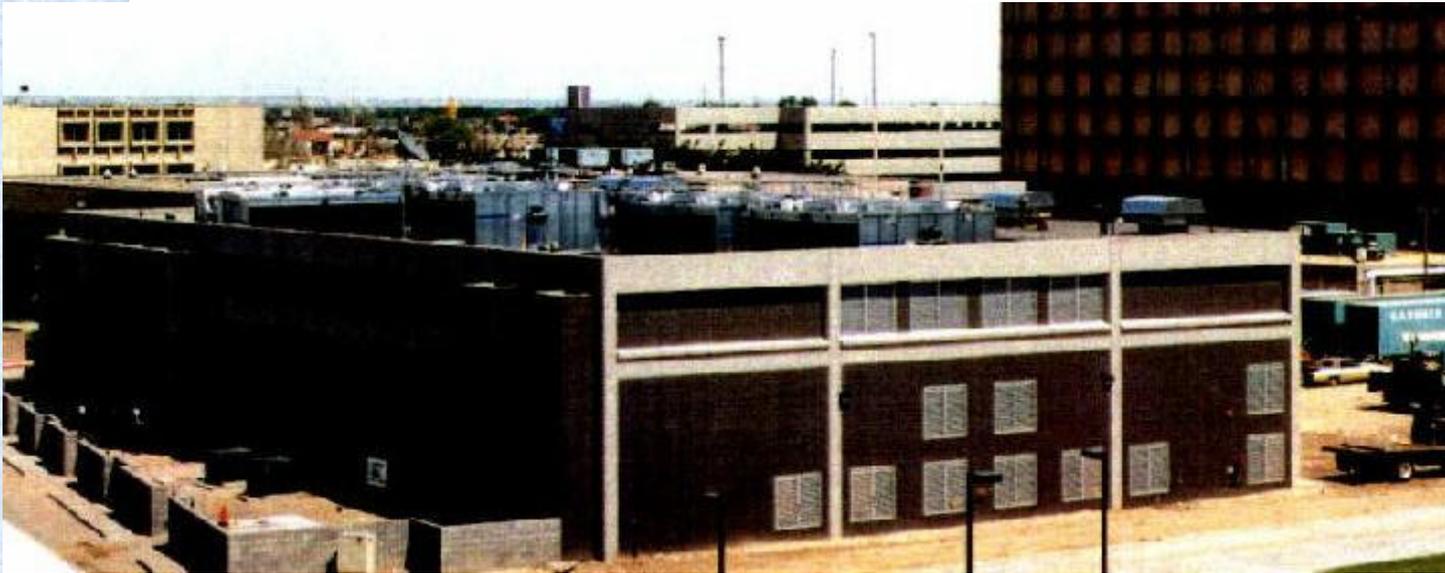




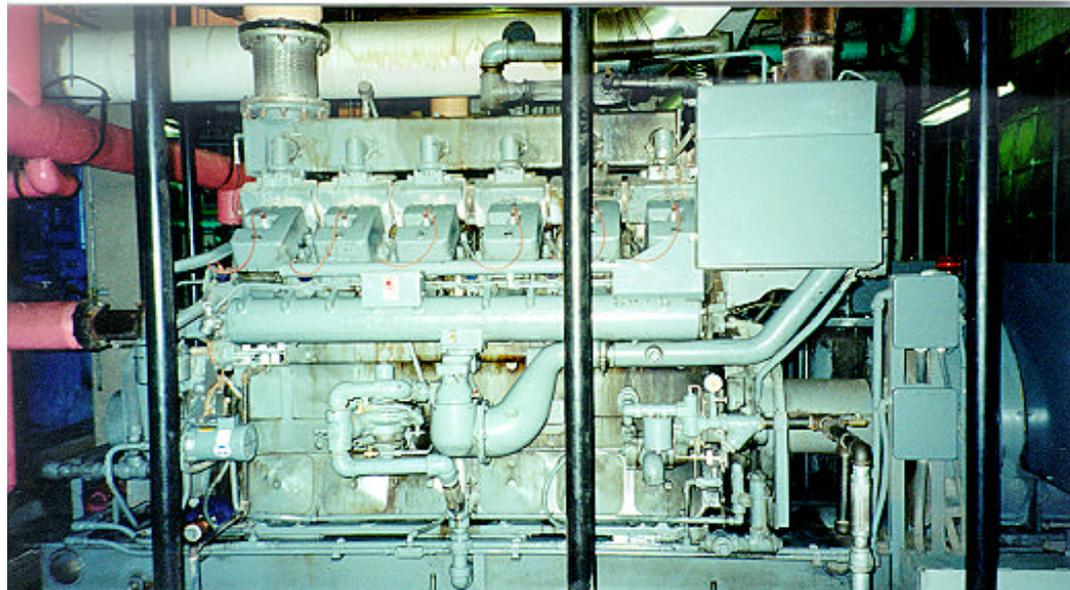
# Technology Case Study

# Thomason Hospital Central Plant El Paso, Texas

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# Engine Generators - 2,400 kW

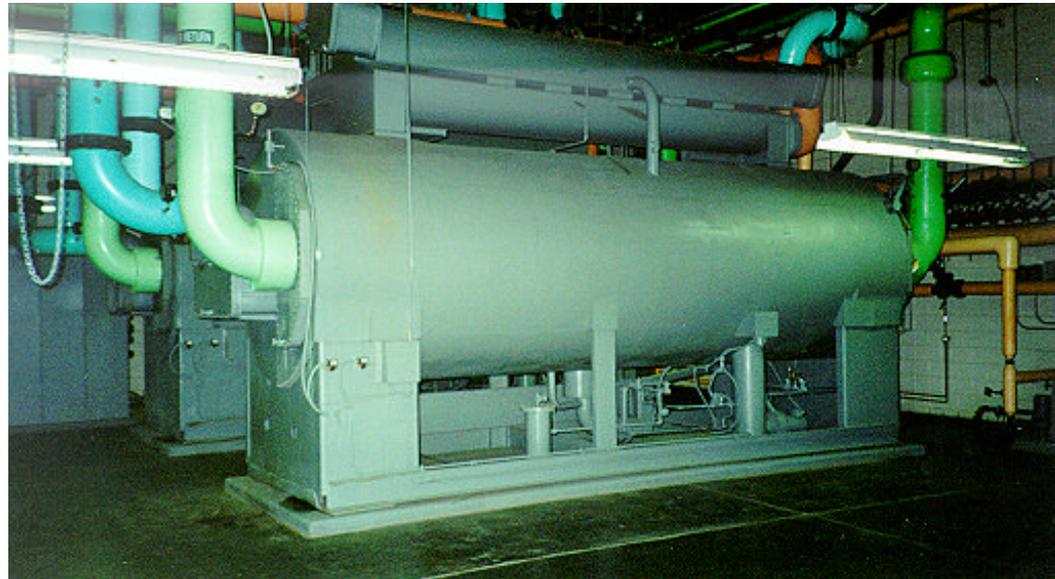


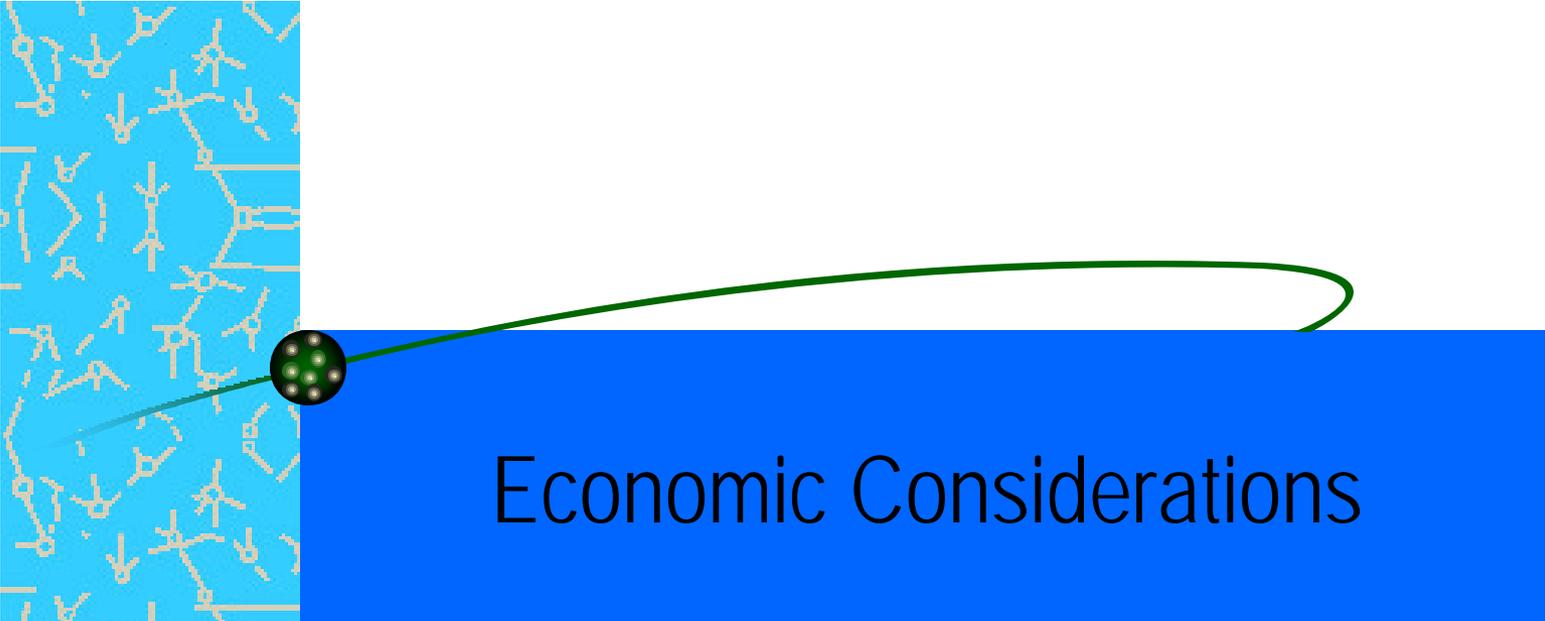
# Engine Chillers - 1,300 Tons



# Absorption Chillers - 1,300 Tons

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# Economic Considerations

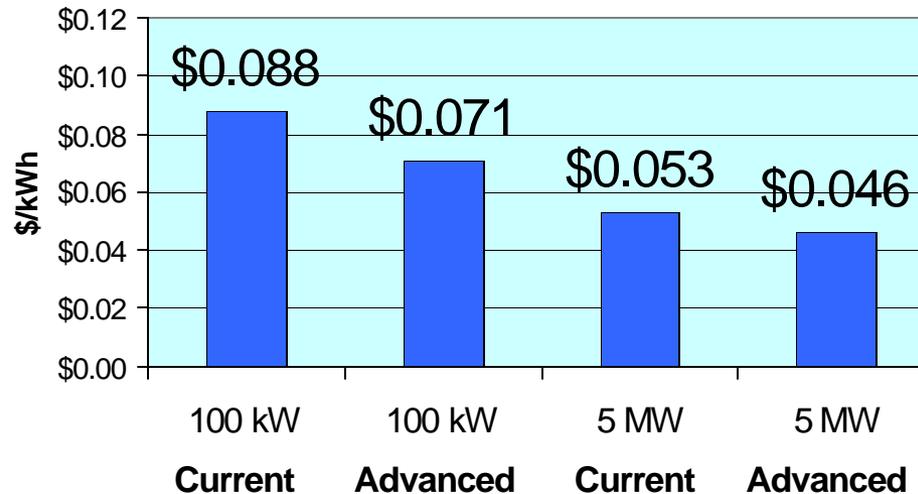
# Comparison of Current and Advanced Technology

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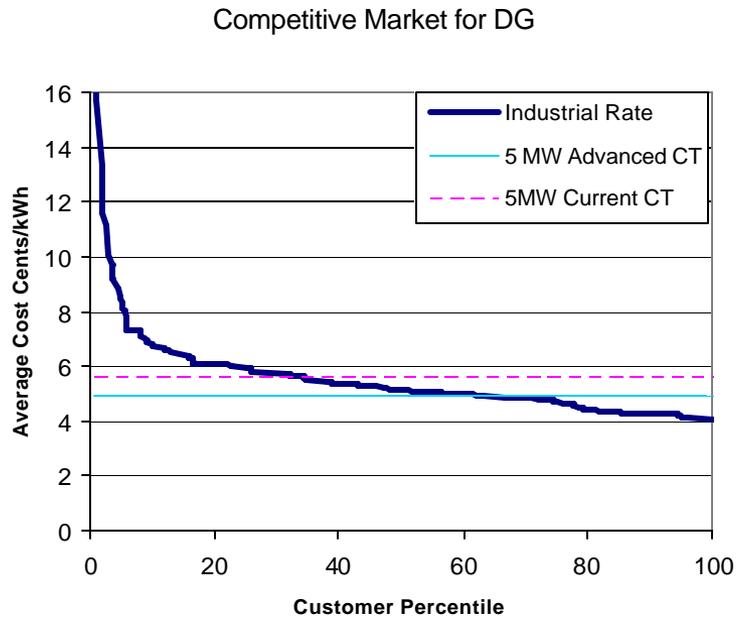
- 100 kW System
  - ✓ Current: \$1390/kW, 28% electric efficiency
  - ✓ Advanced: \$915/kW, 35% electric efficiency
- 5,000 kW System
  - ✓ Current: \$1075/kW, 28% electric efficiency
  - ✓ Advanced: \$950/kW, 36% electric efficiency

# Comparison of Current and Advanced Technology

## Effective CHP Power Costs

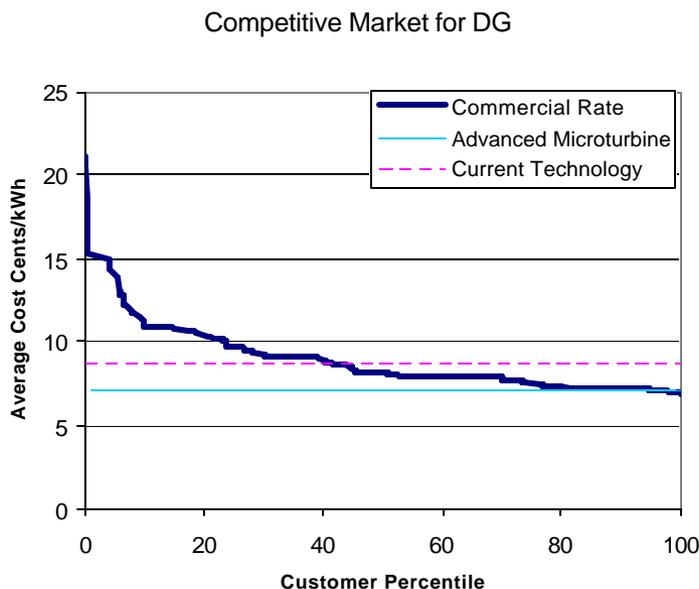


# 5 MW CHP System Net Power Costs Compared to U.S. Industrial Electric Rates



- Median industrial customer pays 5.1 cents/kWh -- but regional variation is significant
  - Current technology 5MW CT in CHP duty is competitive in 40% of the market
  - Advanced technology system extends competitive range to 75% of the market
- Natural Gas = \$4.50/MMBtu

# 100 kW CHP System Net Power Costs Compared to U.S. Commercial Electric Rates

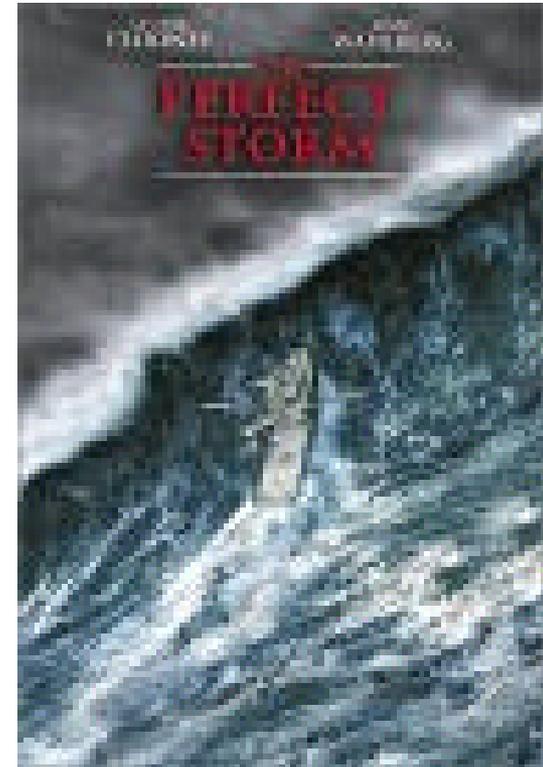


- Median commercial customer pays 8.2 cents/kWh -- but regional variation is significant
  - Current technology 100 kW micro-cogen system is competitive in 40% of the market
  - Advanced microturbine system extends competitive range to 95% of the market
- Natural Gas = \$5.50/MMBtu

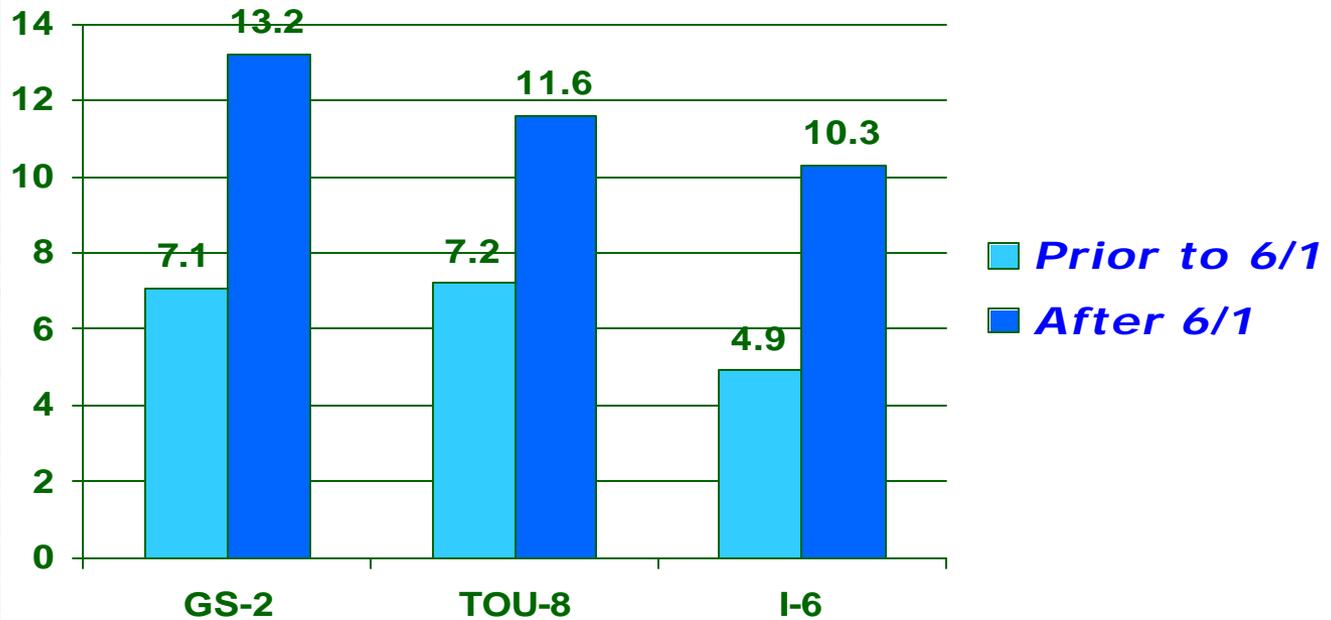


# California – The “Perfect Storm”

- High Demand Growth
- Capacity Shortfalls in Western Region
- Strained Old Inefficient Gas Power Plants in California
- Electric Transmission Constraints
- Tight U.S. Natural Gas Market magnified at California Border
- Infant, Immature Regulatory and Market Structure

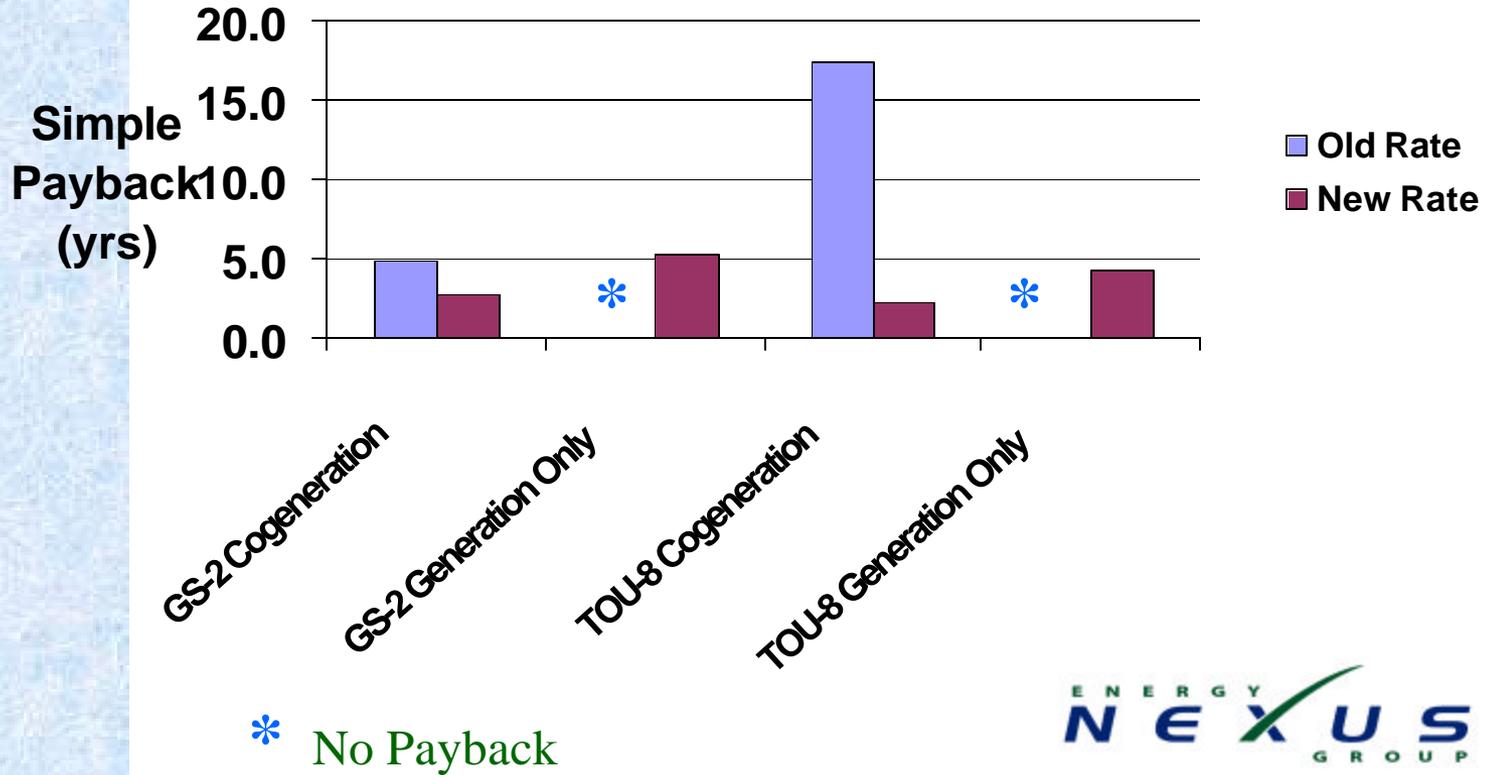


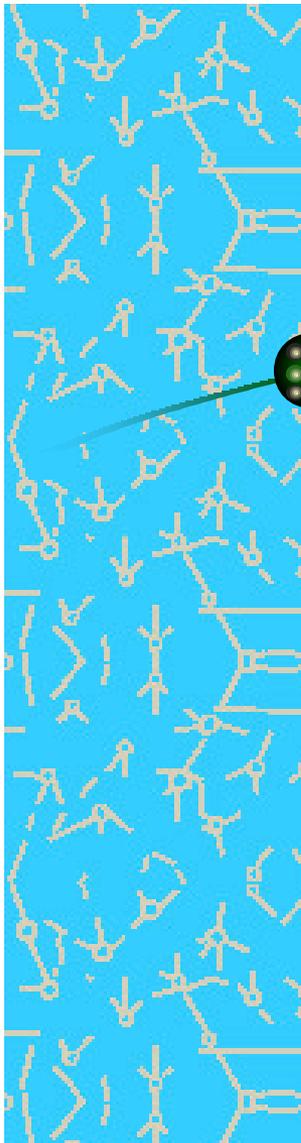
# The "Wake" After the Storm



*Various SCE Marginal Electric Rates (c/kwh)*

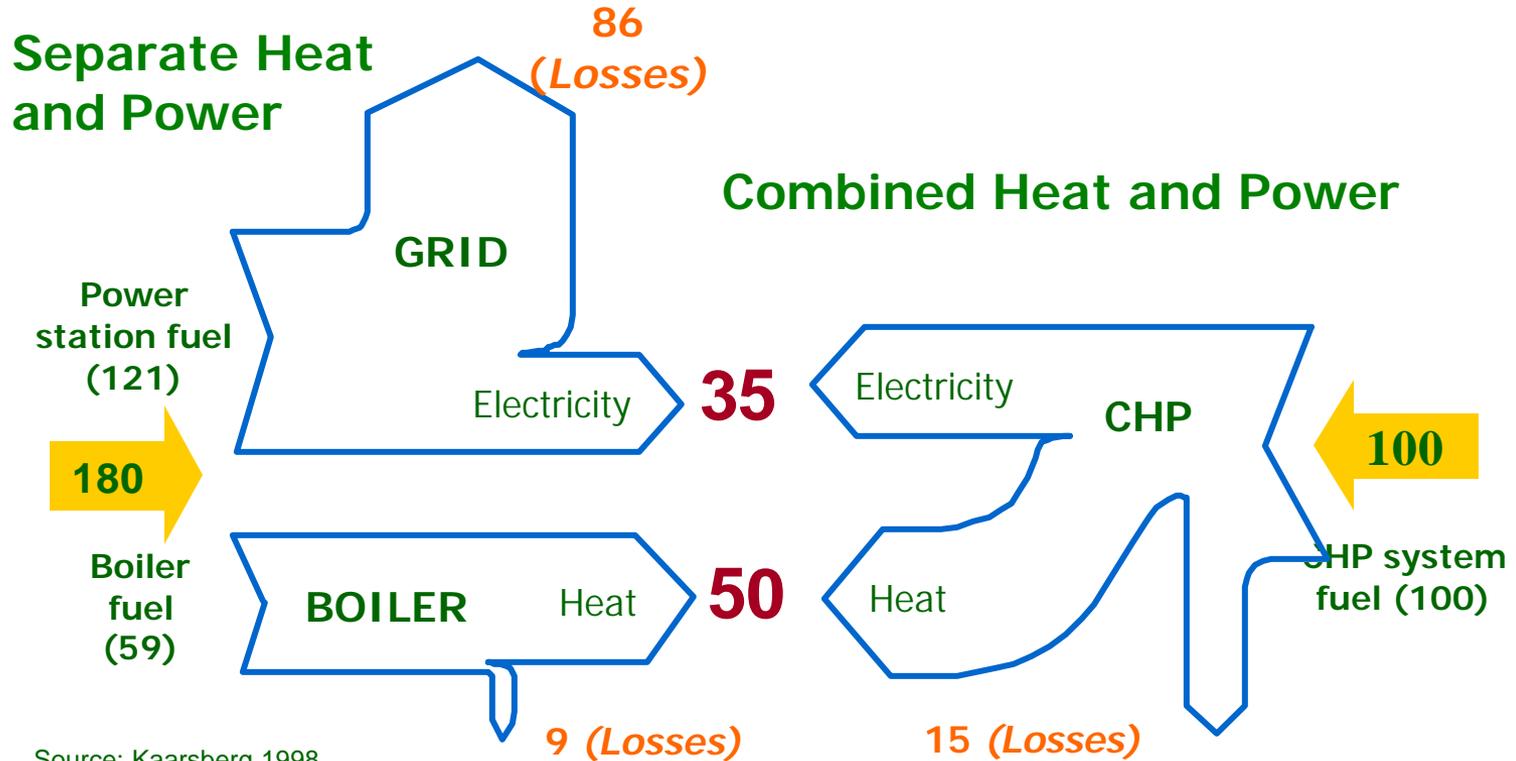
# The Impact of Rates on On-site Generation





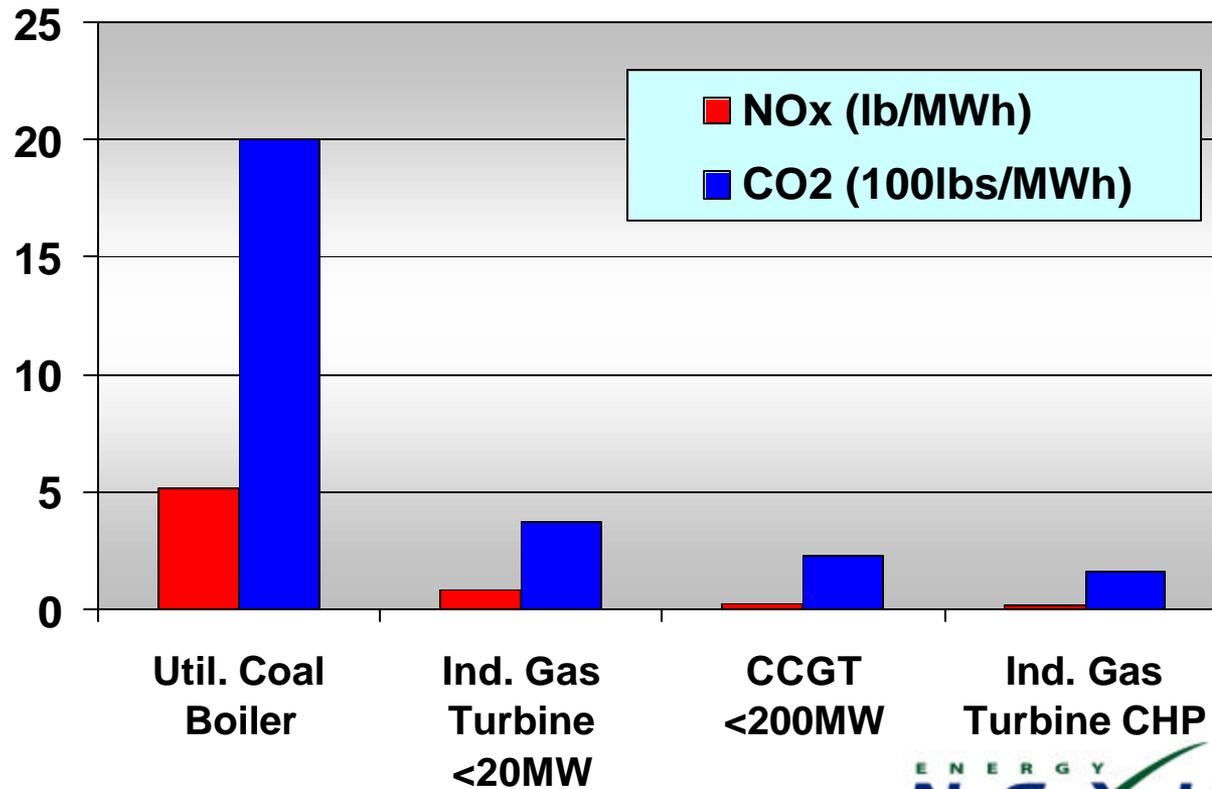
# Other Benefits

# CHP Uses Less Energy



Source: Kaarsberg 1998

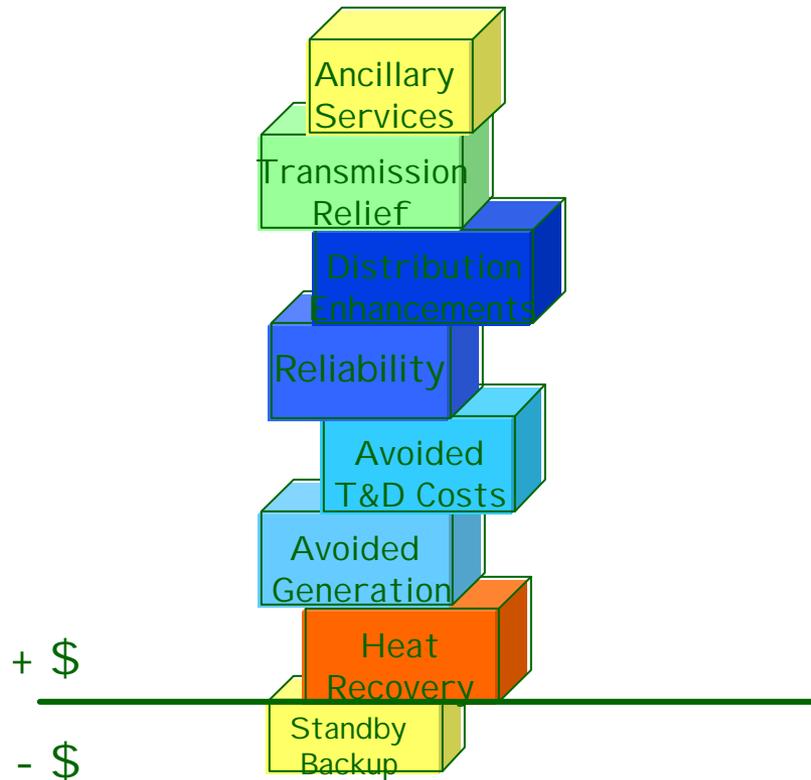
# CHP Reduces Emissions



Source: Onsite Energy 1998

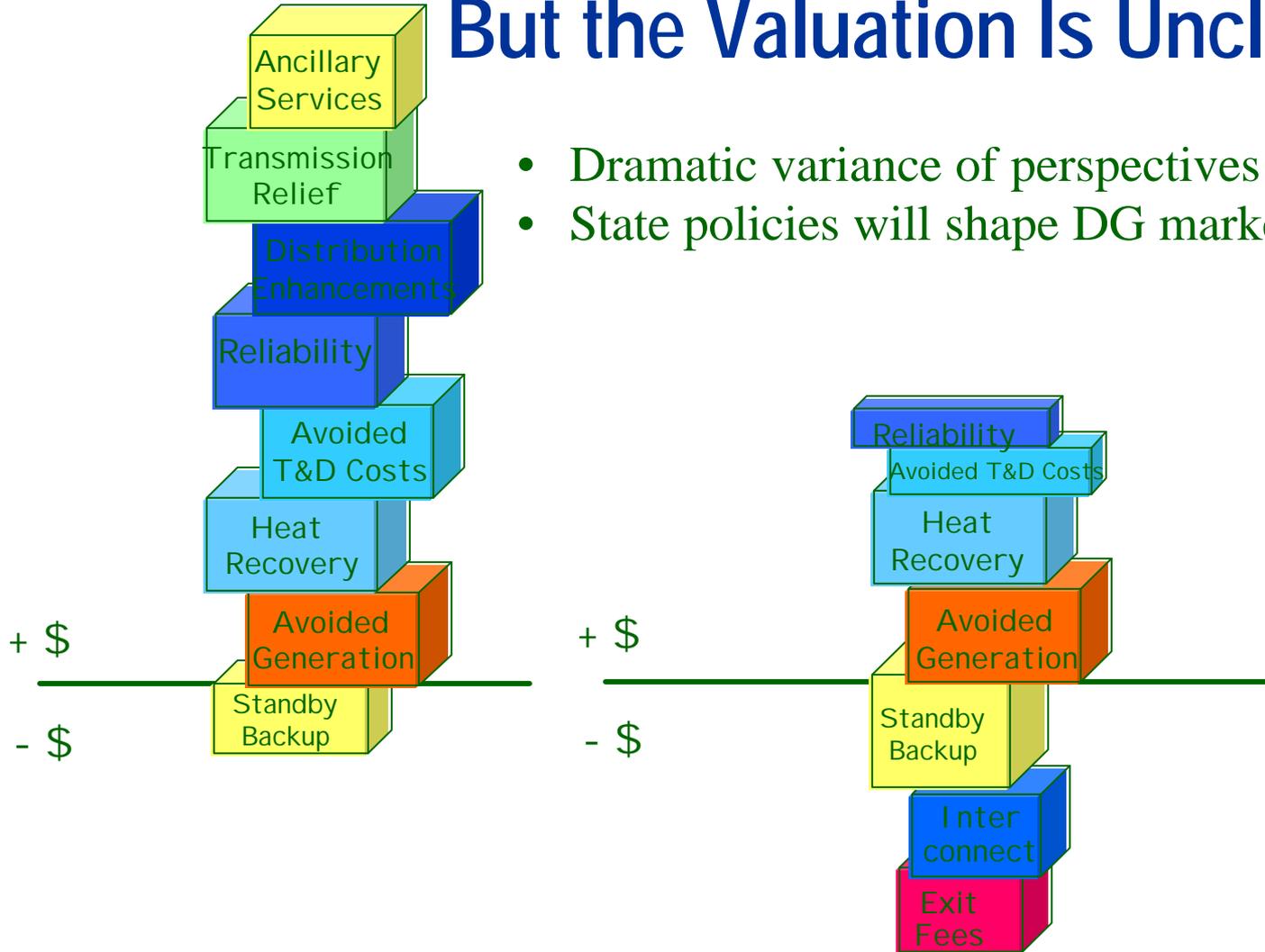


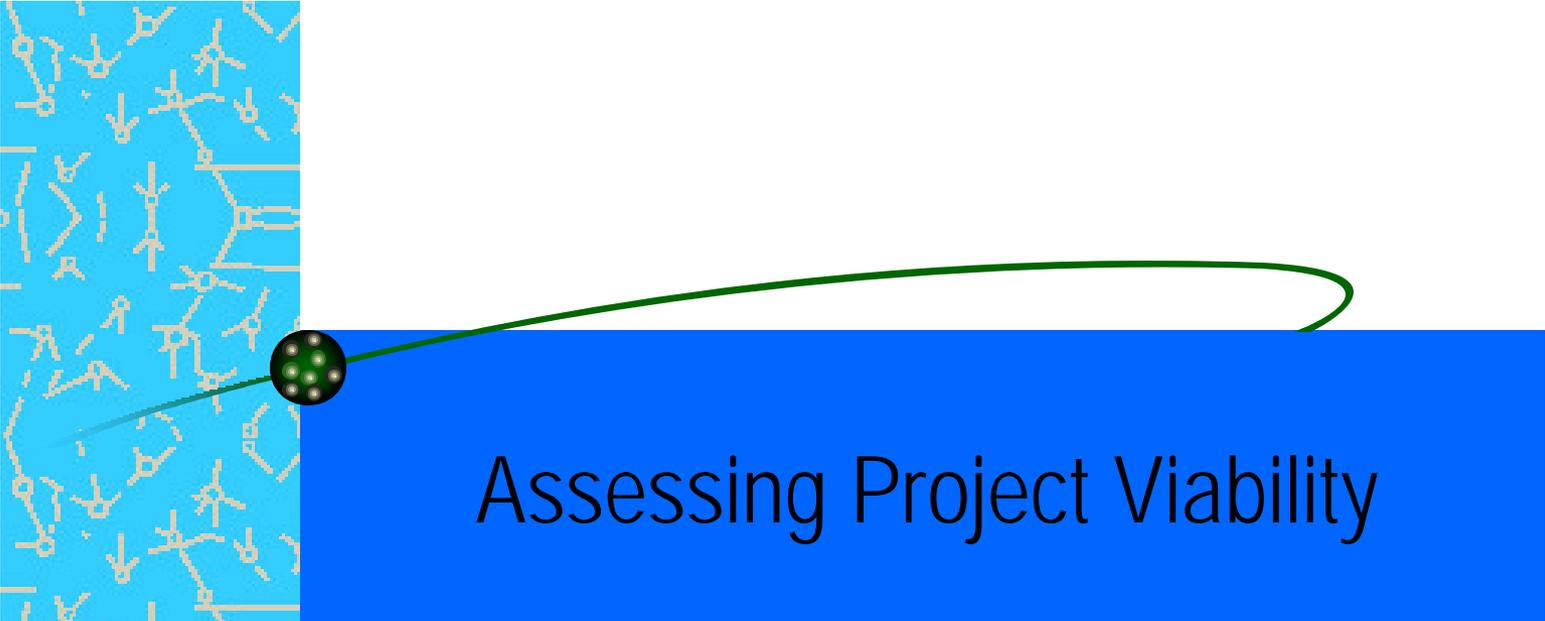
# Distributed Generation Offers Real Economic Benefits



# But the Valuation Is Unclear

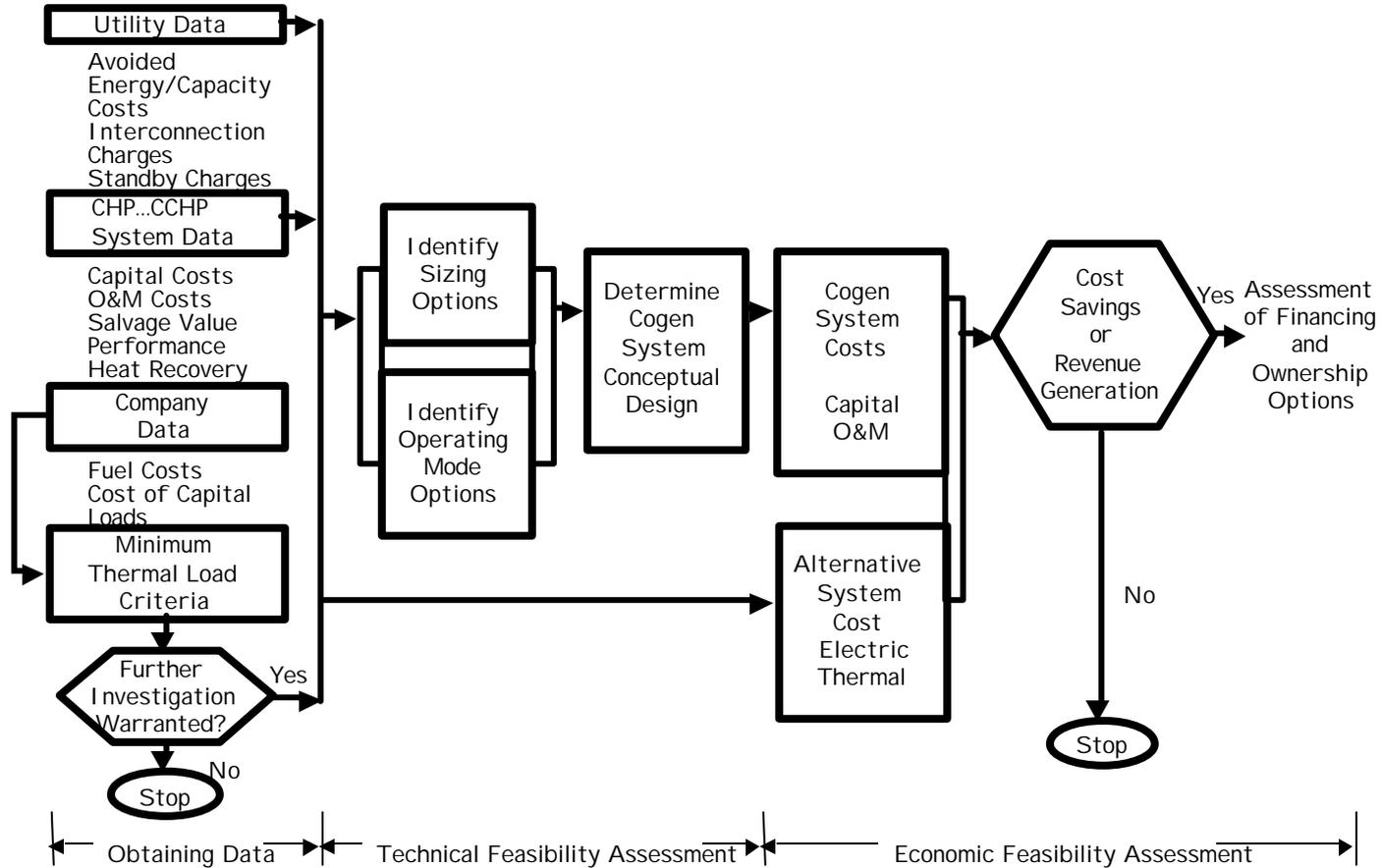
- Dramatic variance of perspectives
- State policies will shape DG market





# Assessing Project Viability

# Assessing CHP Feasibility



# Critical DG Market Issues

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- Standby and backup tariffs
- Interconnection requirements
- Quantifying grid benefits
- DG access to energy markets
- Public support/incentives
- Permitting and siting procedures
- Non-Bypassable Charges

# Summary

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- Wide range in technology performance in terms of cost, efficiency and emissions
- New technologies being tested in niche markets
- All technologies are improving
- Match to cost, performance, regulatory and risk requirements of the user



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