

Combined Cooling, Heat and Power Technology Overview

2002 Energy
Workshop and Exposition

Hot Challenges, Cool Solutions

Palm Springs, California

June 4, 2002

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Energy Nexus Group

- 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

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



Potential DG Applications

- **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

- 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

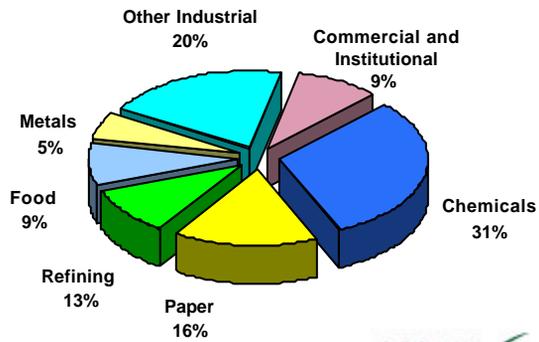


CHP Market Overview



Industrials Represent 90% of Existing CHP

- Existing CHP Capacity (1999) 52,800 MW

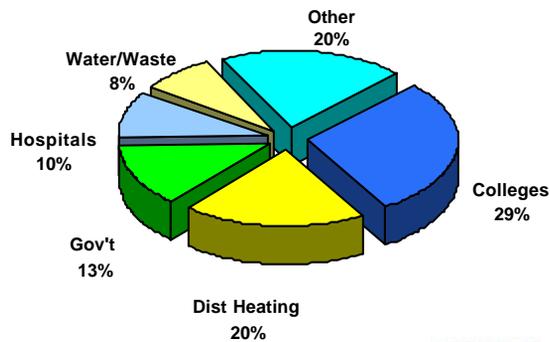


Source

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Existing Commercial CHP

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

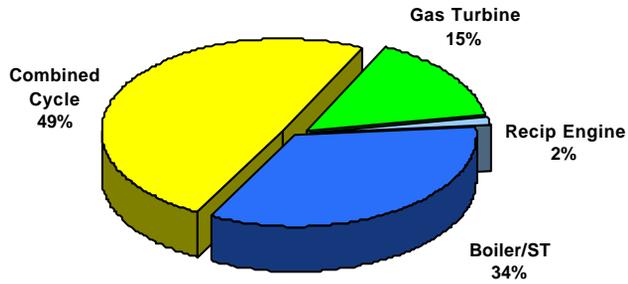


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Gas Turbines Dominate Capacity

- Existing CHP Capacity: 52.8 GW

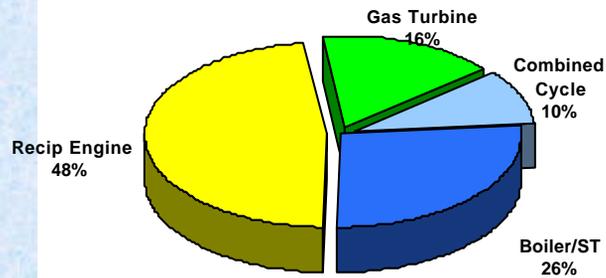


Source



Recip Engines Dominate Sites

- Existing CHP Installations: 2167 sites



Source





CHP Market Potential



Broad CHP Opportunities Remain

Category	Percentage
Paper	30%
Other Industrial	29%
Refining	13%
Chemicals	11%
Food	9%
Metals	8%

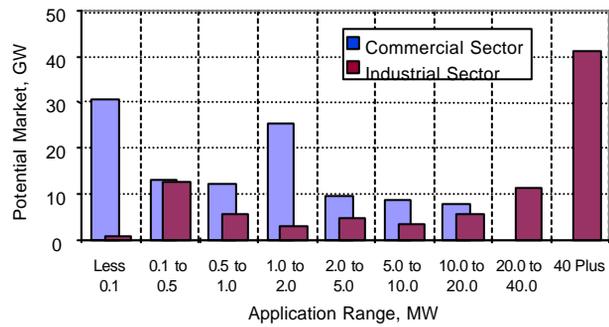
Industrial Sector
90 - 100 GW
of Additional
DG Potential

Commercial Sector
75 to 100 GW
of New
DG Potential

Category	Percentage
Office Buildings	24%
Education	24%
Health Care	22%
Other	15%
Lodging	9%
Food Sales/Service	6%



US CHP Market Opportunities

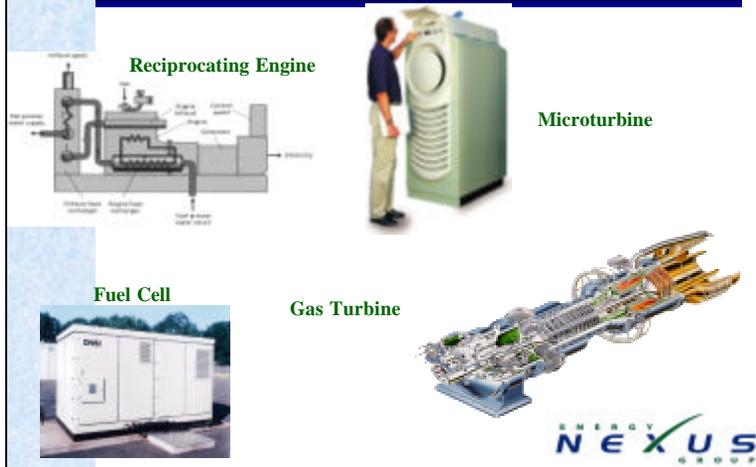


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Technology Medley

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CHP Technology Options



Technology is a Key Driver for DG

- 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?

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

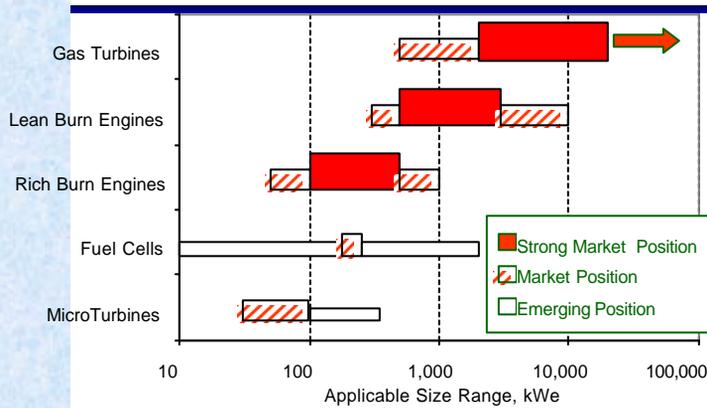


What Differentiates Technologies?

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



Technology vs. Size Coverage



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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



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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



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SOLUTIONS

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



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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



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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*

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Absorption Cooling

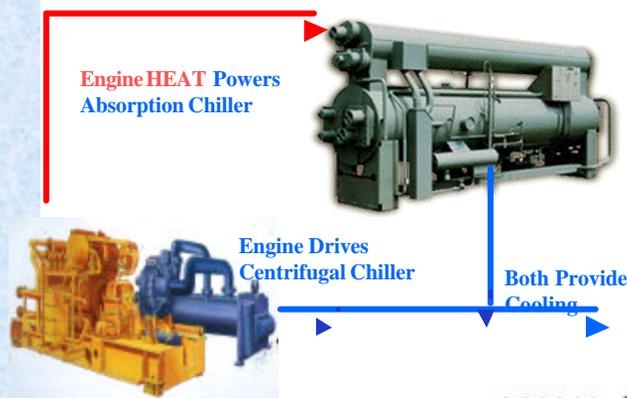
Single Stage Steam



Two Stage Steam



CHP is Not Always Electric





Technology Case Study



**Thomason Hospital Central Plant
El Paso, Texas**



Engine Generators - 2,400 kW



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Engine Chillers - 1,300 Tons



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Absorption Chillers - 1,300 Tons



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Economic Considerations

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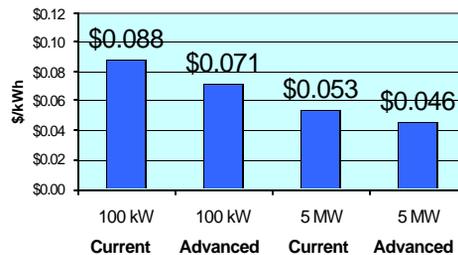
Comparison of Current and Advanced Technology

- 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

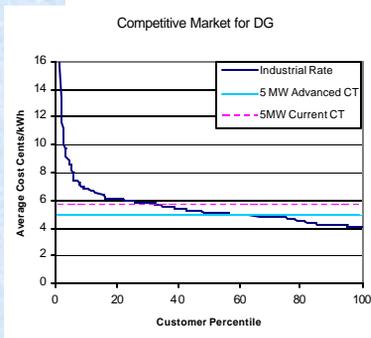


Comparison of Current and Advanced Technology

Effective CHP Power Costs



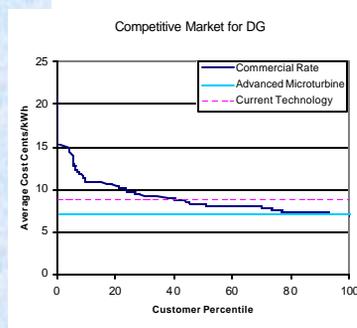
5 MW CHP System Net Power Costs Compared to U.S. Industrial Electric Rates



- 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



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



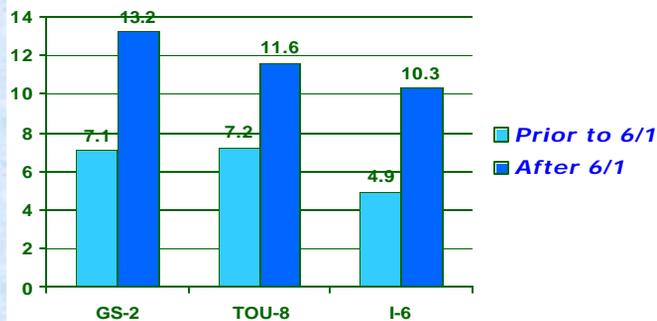


California – The “Perfect Storm”

- 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



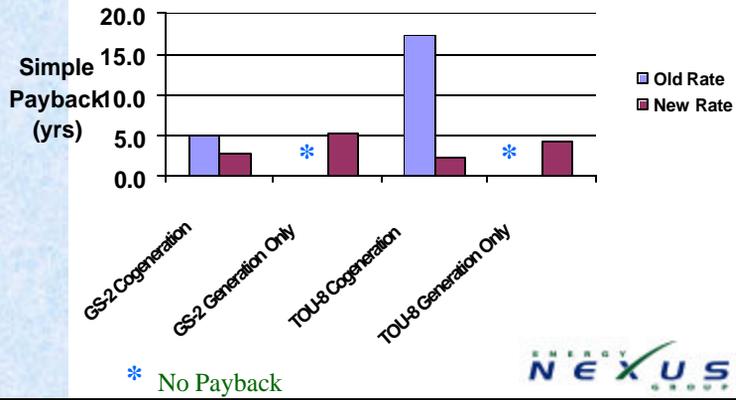
The “Wake” After the Storm



Various SCE Marginal Electric Rates (c/kwh)



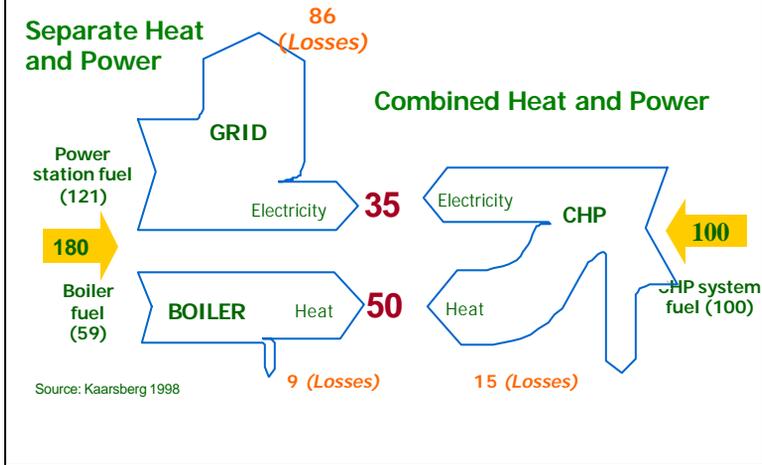
The Impact of Rates on On-site Generation



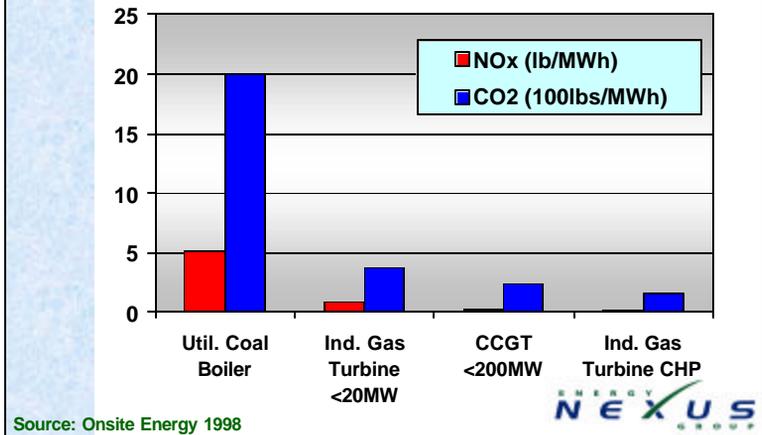
Other Benefits

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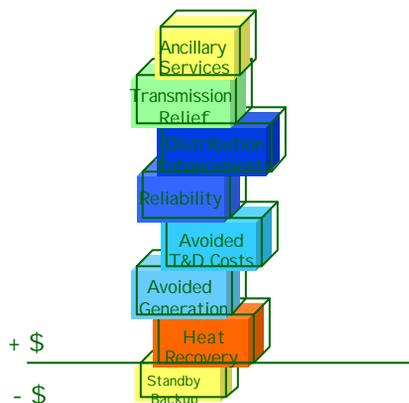
CHP Uses Less Energy



CHP Reduces Emissions

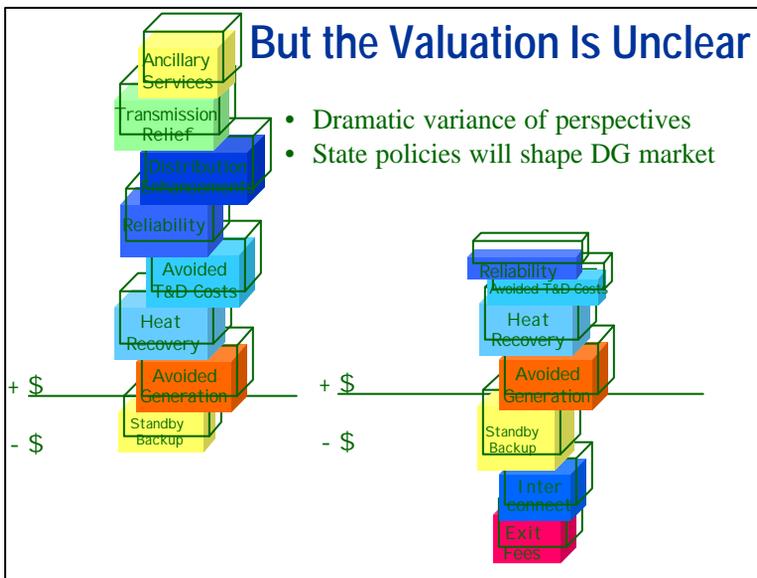


Distributed Generation Offers Real Economic Benefits



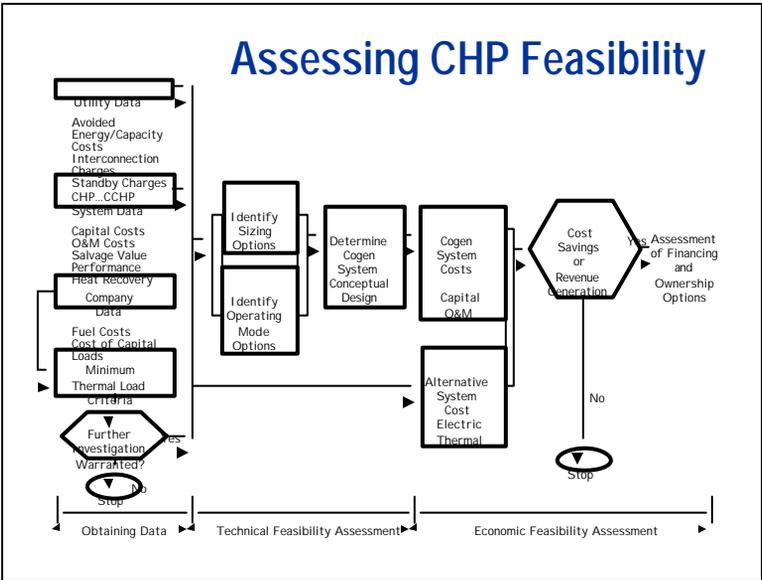
But the Valuation Is Unclear

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





Assessing Project Viability

Critical DG Market Issues

- 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

- 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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