The Role of Natural Gas Fired Reciprocating Engines in the Distributed Energy Market – Market Forces and Opportunities

Presented by:

Ted Bronson, Associate Director

Distributed Energy

GTI

April 23rd, 2002

gti

Overview

- Introduction – Why Recips?
- Reciprocating Engine DE Markets
- Reciprocating Engines in Power Generation - Costs
- Regulatory Issues and Initiatives
- Power Generation Emissions
- Conclusions and Recommended Actions

Introduction

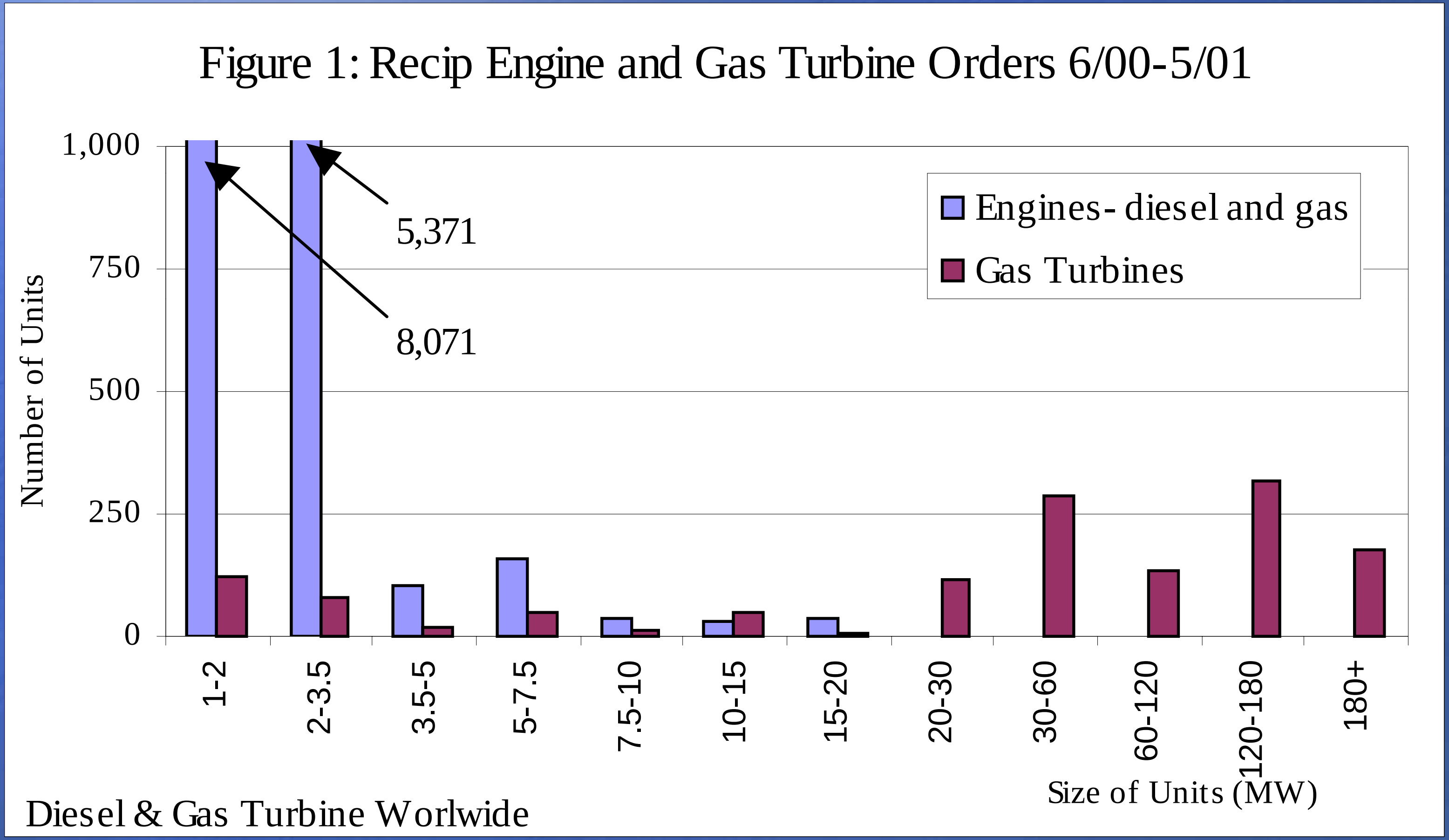
- GTI – Leading efforts to develop emerging DE technologies
  - Microturbines
  - Fuel Cells – PEM, Solid Oxide, Molten Carbonate
  - Gas-Renewable Hybrid Systems
  - Packaged DE Systems

Introduction

- Why Recips?
  - Untapped potential of Building IES market
  - Proven and Improving
  - One of few industries large enough to force change to a competitive market
- Today's presentation
  - Focus on Characteristics of Market and its Forces
  - Discuss approaches with Regulators to open DE market

Reciprocating Engine DE Markets

- Reciprocating Engines Dominate Distributed Energy Market below 7.5 MWs



Reciprocating Engine DE Markets

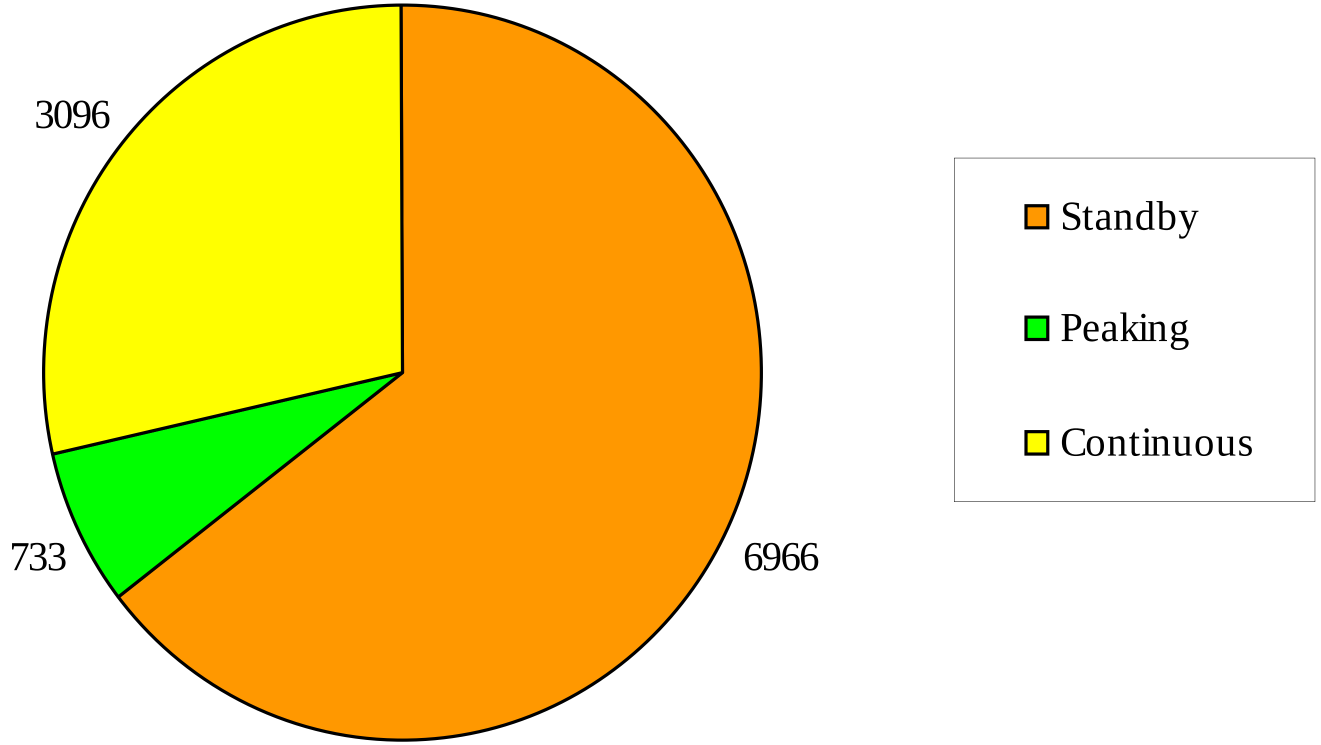
- **Why do recips dominate at smaller sizes?**
  - Lower installed costs
  - Several established competitors with numerous products
  - Excellent load-following characteristics
  - Versatility in operation
  - Fuel versatility
  - Fast start-up to full load operation
  - Relatively low exhaust gas emissions levels
  - Excellent operational performance at variable loads and high ambient temperatures
  - Proven Reliability at these sizes
  - Significant heat recovery potential
  - Operator familiarity and ease of maintenance
  - Well established sales and service infrastructure

gti[SM]

Reciprocating Engine DE Markets

Reciprocating Engine Operating Strategies

Figure 2: Breakdown of Engine Orders by Role 2001



Diesel & Gas Turbine Worlwide

*Due to trend to reduce grid peak load demand, expect on-peak DER to be a more economic option in the future.

Reciprocating Engine DE Markets

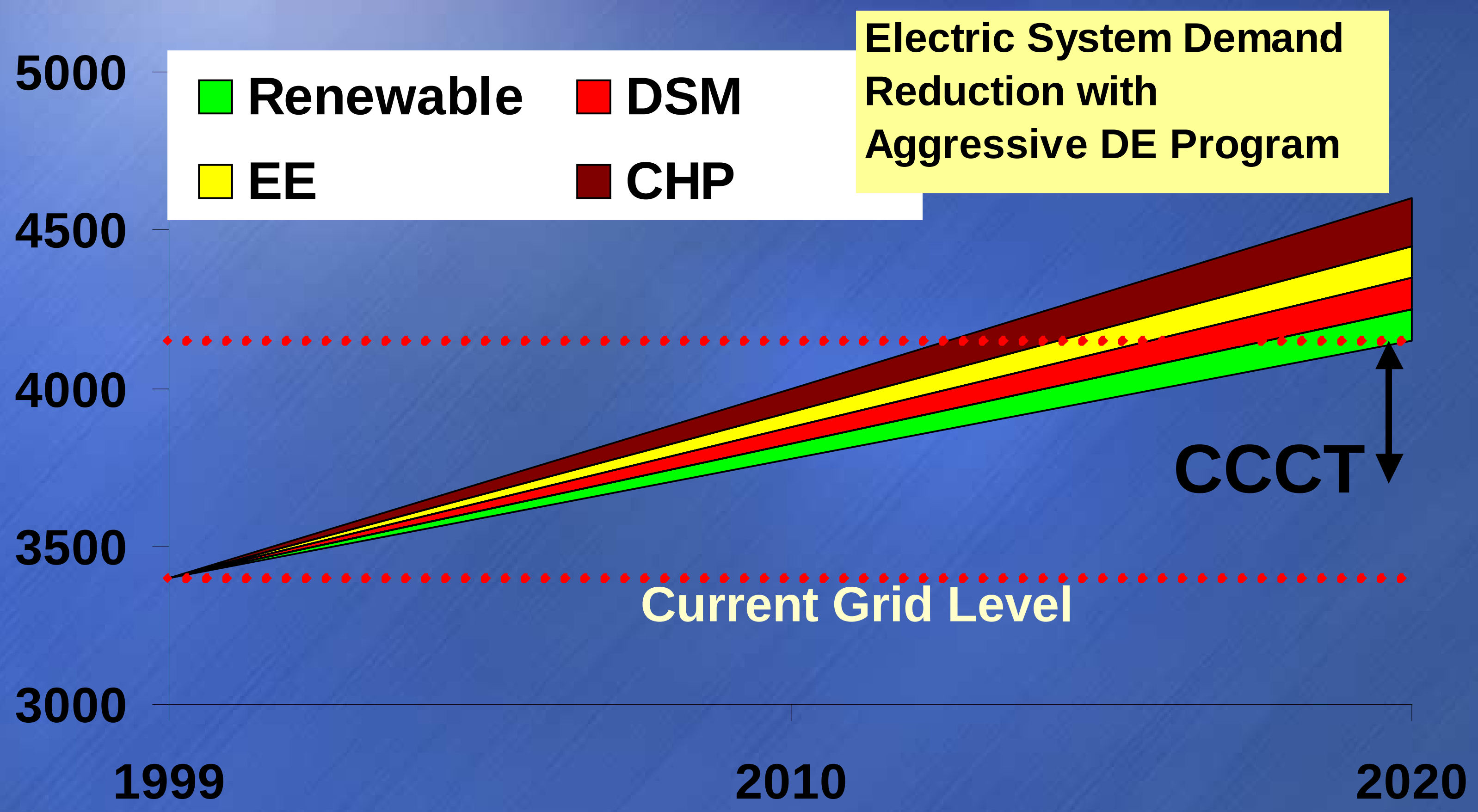
- DE Market beginning to grow
  - Stationary reciprocating engine orders up 68% from May ’00 to June ’01
  - Natural gas fired reciprocating engine orders up 95%
- Consumers excercising choice to better control the reliability and availability of their power
- High costs of power outages and peak power key
  - PUCs beginning to increase peak power rates (IL, TX) to lower peak on grid
  - Expect emerging rates to make on-peak DE more economically attractive in the future

Reciprocating Engine DE Markets

- Emerging Power Generation Applications
  - Industrial CHP
    - Efficiency and environmental benefits
  - Integrated Energy Systems (BCHP)
    - "Plug and Play" applications
    - DOE's Packaged System Program
  - Energy Security
    - "A more independent and decentralized energy system, less reliant on central power plants (e.g. potential targets) and excessive T&D networks is safer and less vulnerable to disruption" – Union of Concerned Scientists
  - Metropolitan Energy Planning
  - Improved / High 9s Reliability

gti[SM]

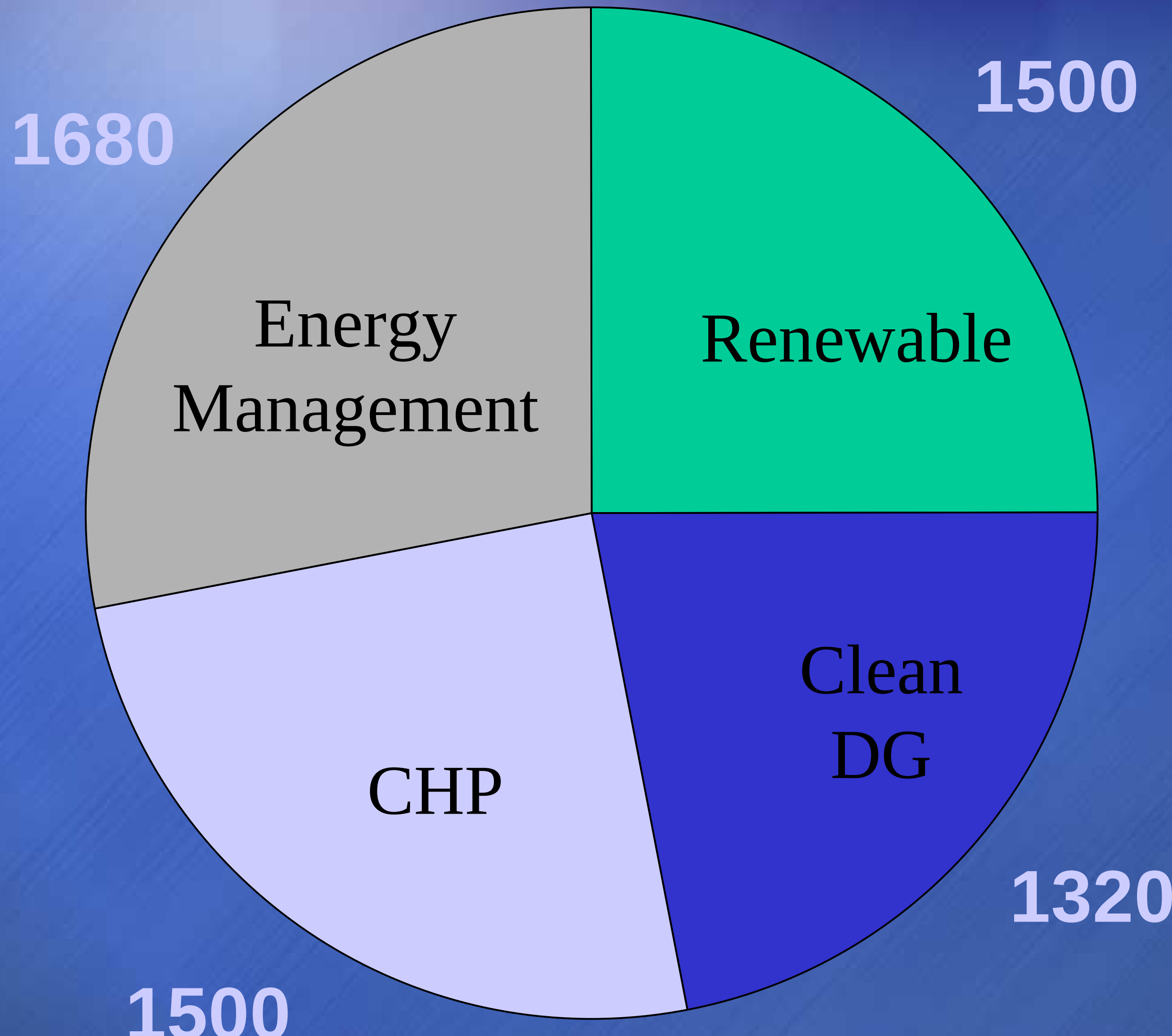
Supply 30% of Projected Growth



gti

AEO 2001

Chicago Goal 6000 Million kWh



=Projected Growth over next 10 Years

Reciprocating Engine DE Markets: High 9s Reliability

Industry Costs of Grid Failures

Industry	Average Cost of Downtime
Cellular Communications	$41,000 per hour
Telephone Ticket Salesa	$72,000 per hour
Airline Reservations	$90,000 per hour
Credit Card Operations	$2,580,000 per hour
Brokerage Operations	$6,480,000 per hour

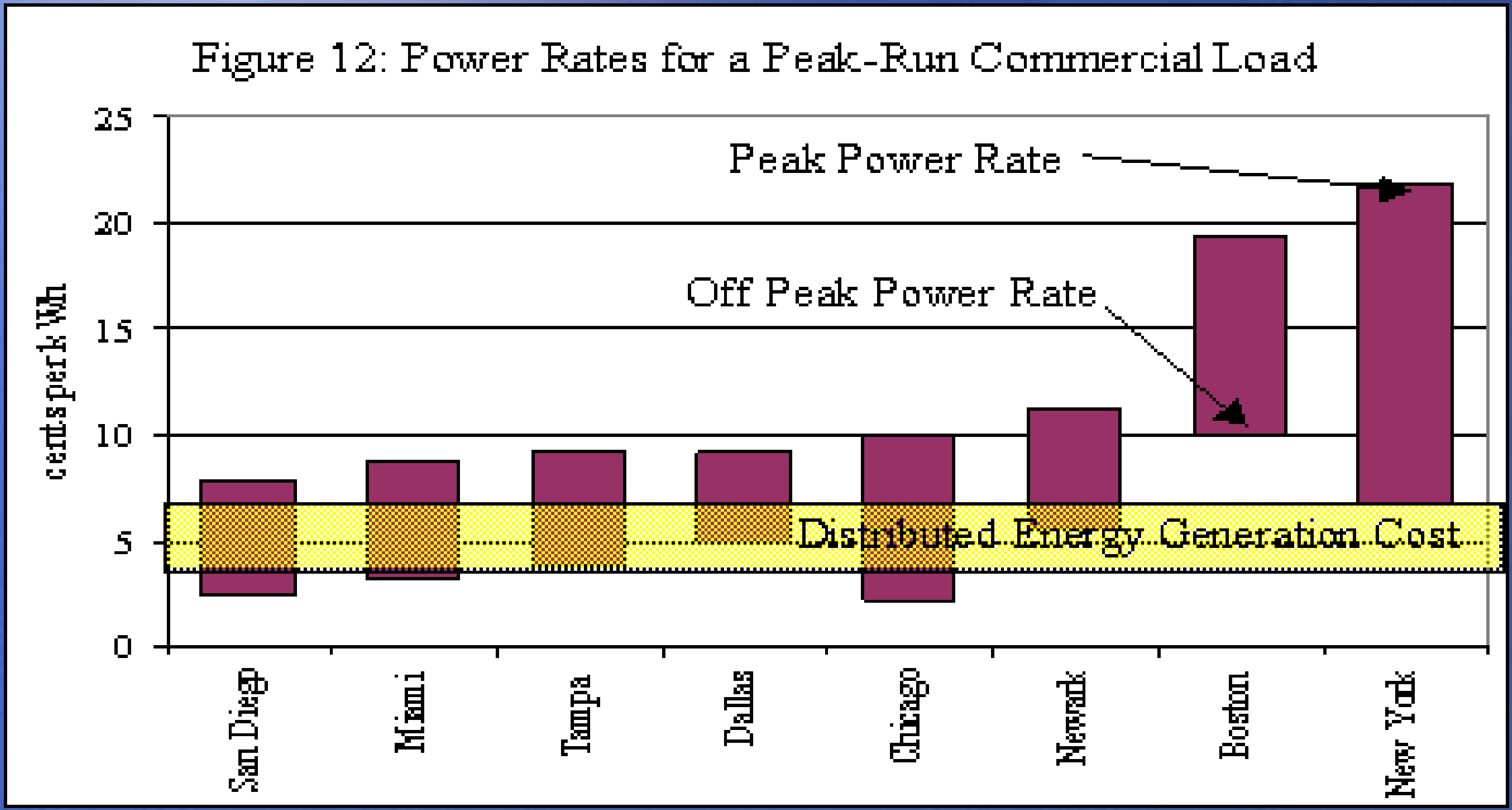
gti

Reciprocating Engines Impact on Power Generation – Costs

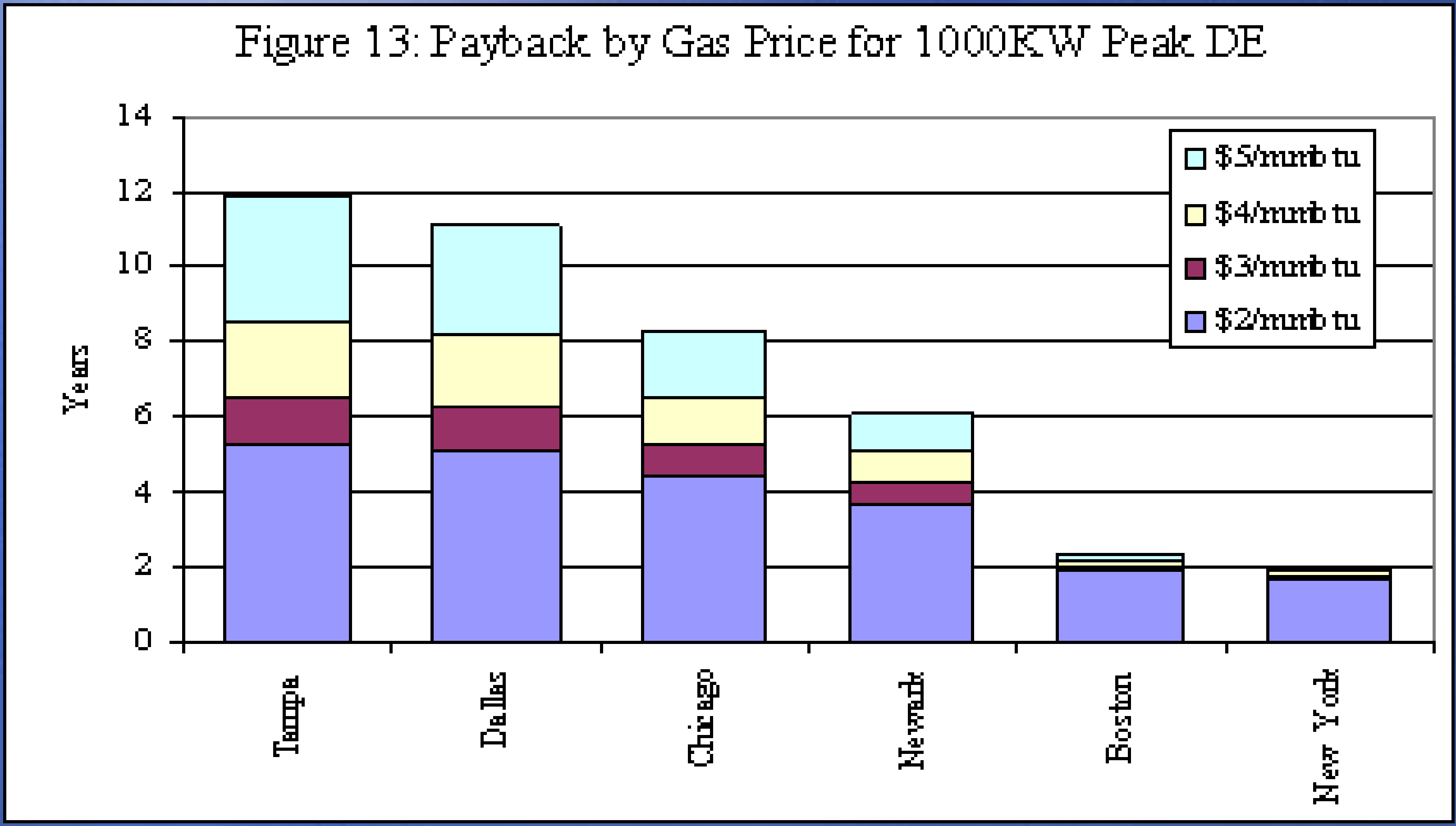
- Project Total Installed Cost Economics
  - Higher for smaller units (500-1500 kws, vs >5 MWs)
  - Challenge for IES / Building Program
  - Drive to packaged systems and lower unit costs
- Factors impacting Payback
  - Operating Cost
  - Local Utility Rate structures
  - Heat Recovery
- Cost is major factor of Reciprocating Engine dominance of < 7.5 MW market (Still not competive in some applications)

gti[SM]

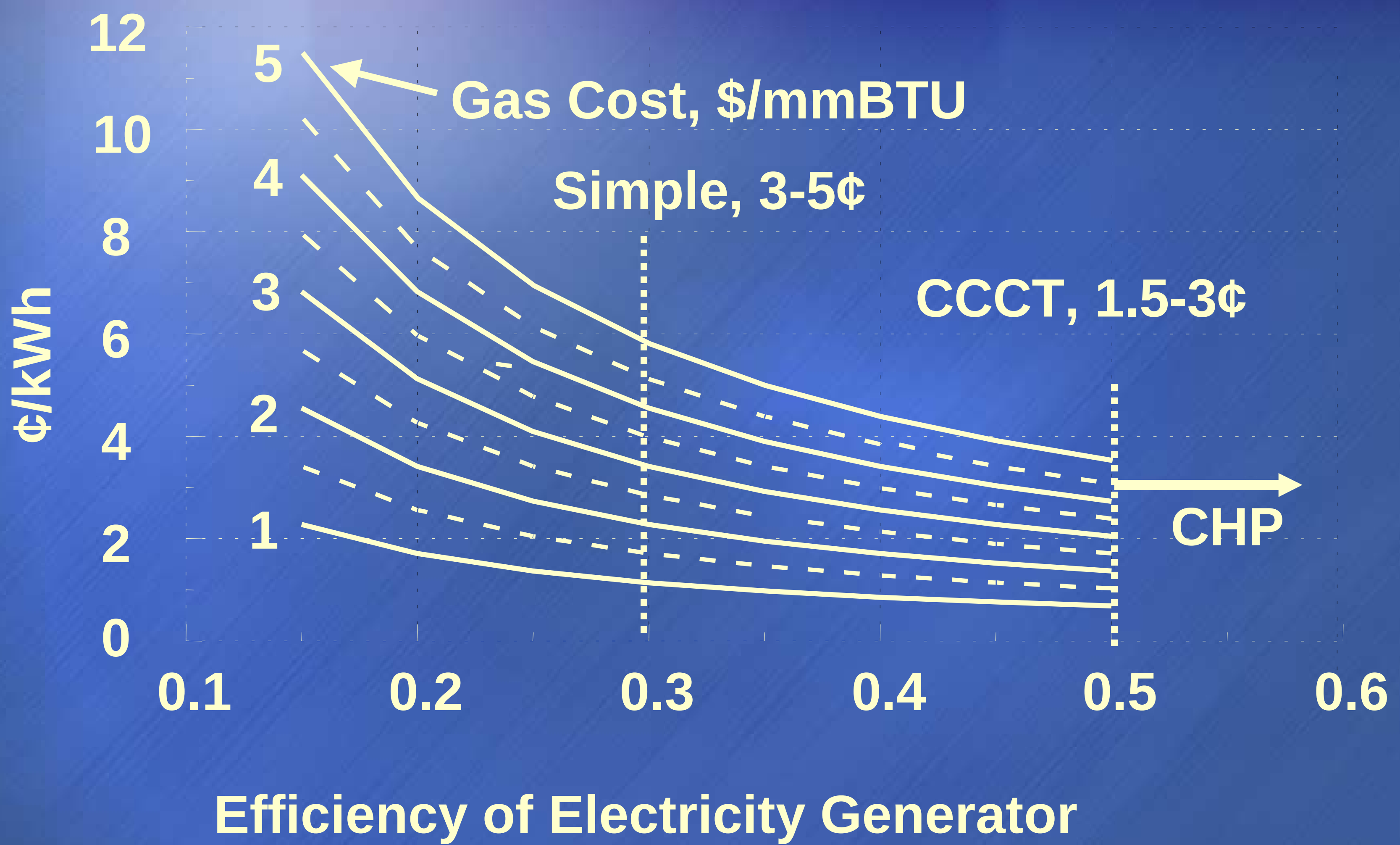
Reciprocating Engines Impact on Power Generation – Costs



Reciprocating Engines Impact on Power Generation – Costs



Cost of Gas Driven Electricity Generation



GTI Calculation

Regulatory Issues and Initiatives

- **Myths concerning DE and Reciprocating Engines:**
  - **DE results in increased power costs for captive grid customers**
    - **Message: DE only represents portion of planned growth, and will serve to increase grid utilization and moderate electicity prices**
  - **Too much DE may cause instability to the grid**
    - **Message: Recent GE study identified virtually no impact to 20%; Holland and Denmark utilizing over 40 and 50% DE.**
  - **DE and Recips are "dirty" technologies**
    - **Message: It depends on use, location and application (more later)**

gti[SM]

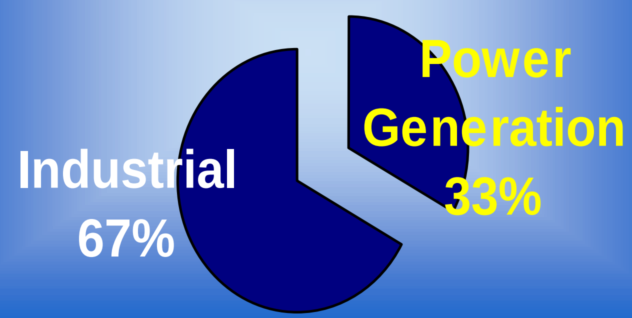
Regulatory Issues and Initiatives

- Existing institutional and market barriers (see DOE report Making Connections)
  - Standby Rates
  - Renegotiated Rates
  - Impact of Deregulation
  - Tariff Issues
  - Other utility issues
  - DE Emissions Standards (CA, TX, RAP)

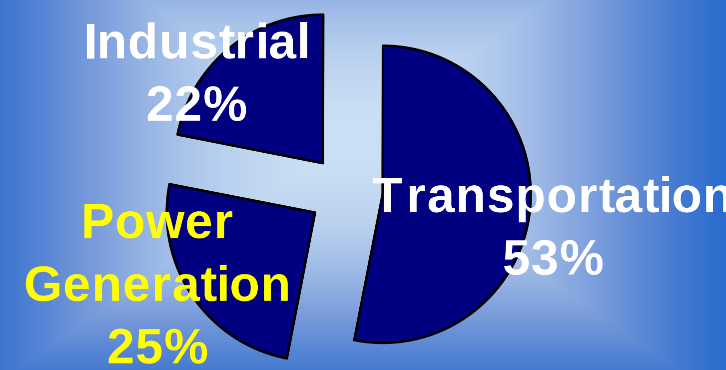
gti

Power Generation Emissions

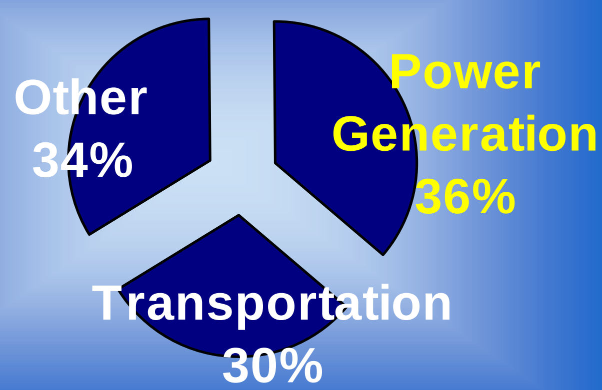
National Anthropogenic Mercury Emissions by Principal Combustion Source



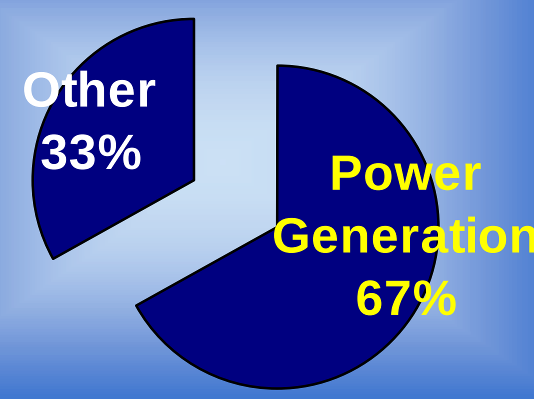
National NO_x Emissions



U.S. CO_2 Emissions by Sector



National SO_x Emissions



EPA

Power Generation Emissions

Emissions by Generation Type (lbs/MWh)[i]

Generator Type	NO_x	CO_2	SO_x
Natural Gas CCGT	0.09-3.8	770	~0
Oil (2.2 % sulfur) fueled steam electric plant	3.0-3.7	1,770	25.4
Oil (0.3 % sulfur) fueled combustion turbine	3.7-6.8	2,190	4.4
Coal- Steam Electric	6.1-9.4	1,960-2,310	46.6
Diesel Engine	**17.0**	**1,700**	**5.0**
Natural Gas Engine	**3.2**	**970**	**0.01**

---

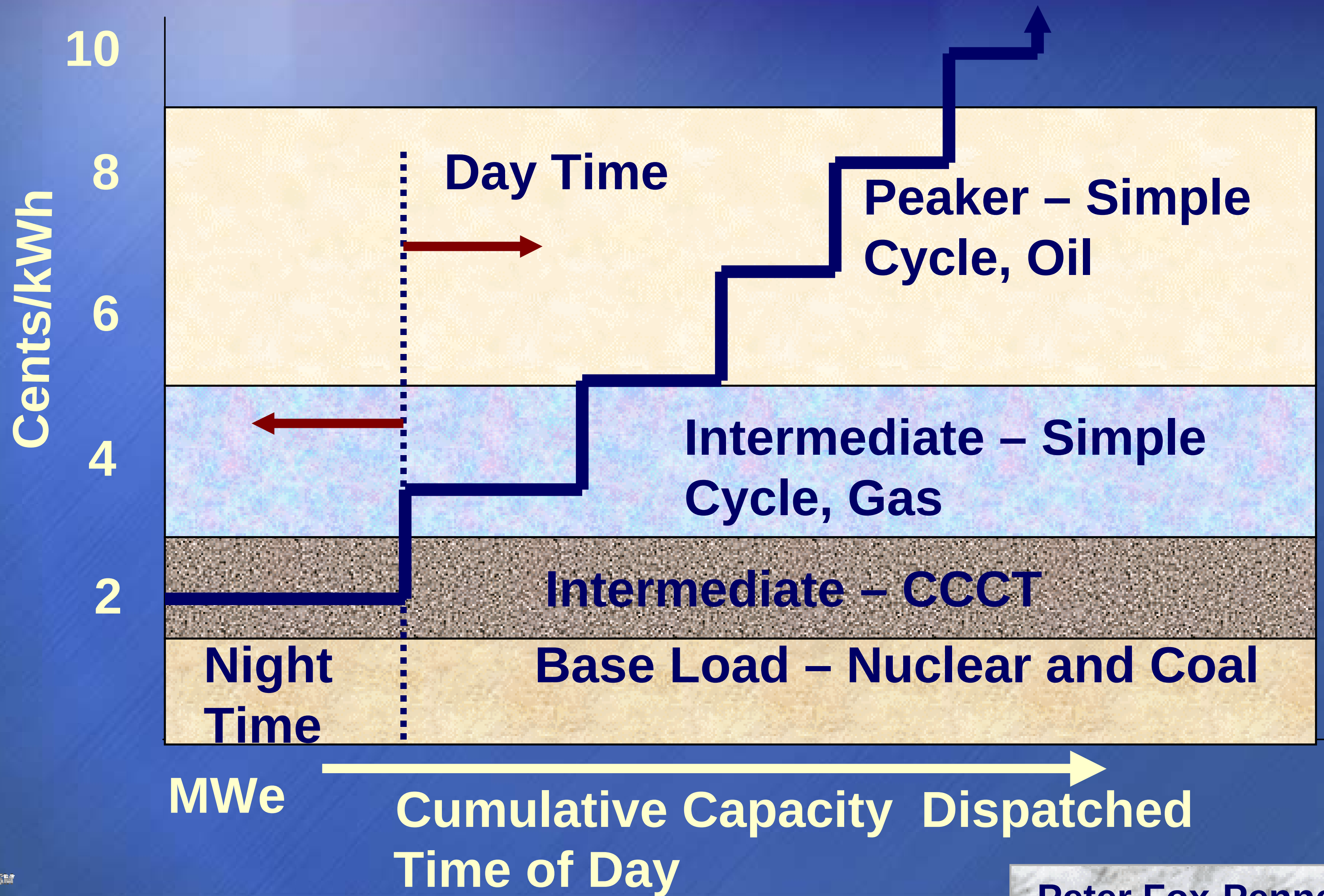
[i] Engine Source: 2002 projections by Distributed Utility Associates for the California Air Resources Board. Other Generating Technology Source: Power Scorecard Methodology by Pace Law School Energy Project. September 22, 2000.

gti

Power Generation Emissions

- What does DE offset?
  - Location: Type and location of plants by region
  - Time of Use: On Peak vs. Off Peak Emissions

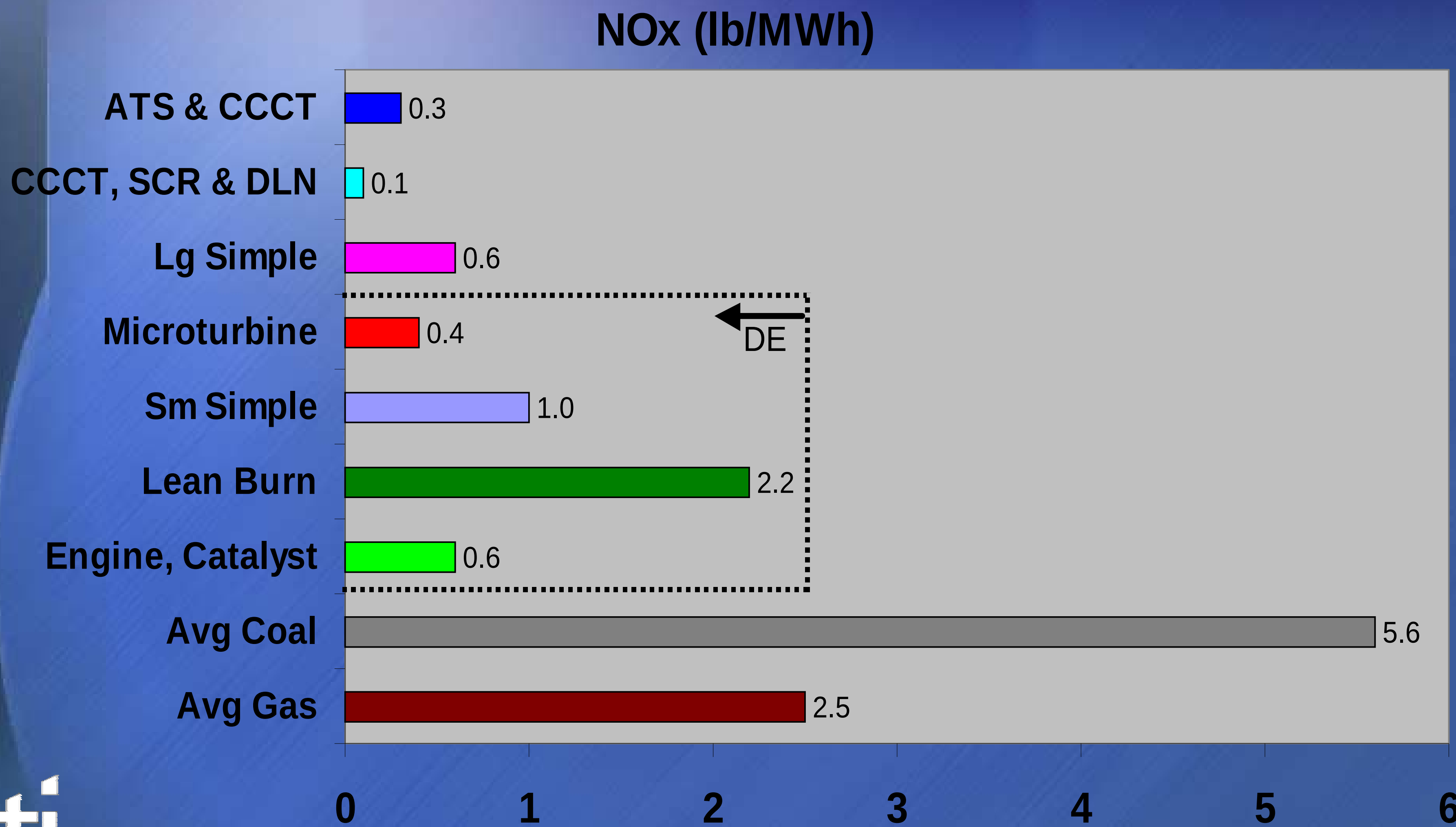
Generation – Marginal Price



gti

Peter Fox-Penner

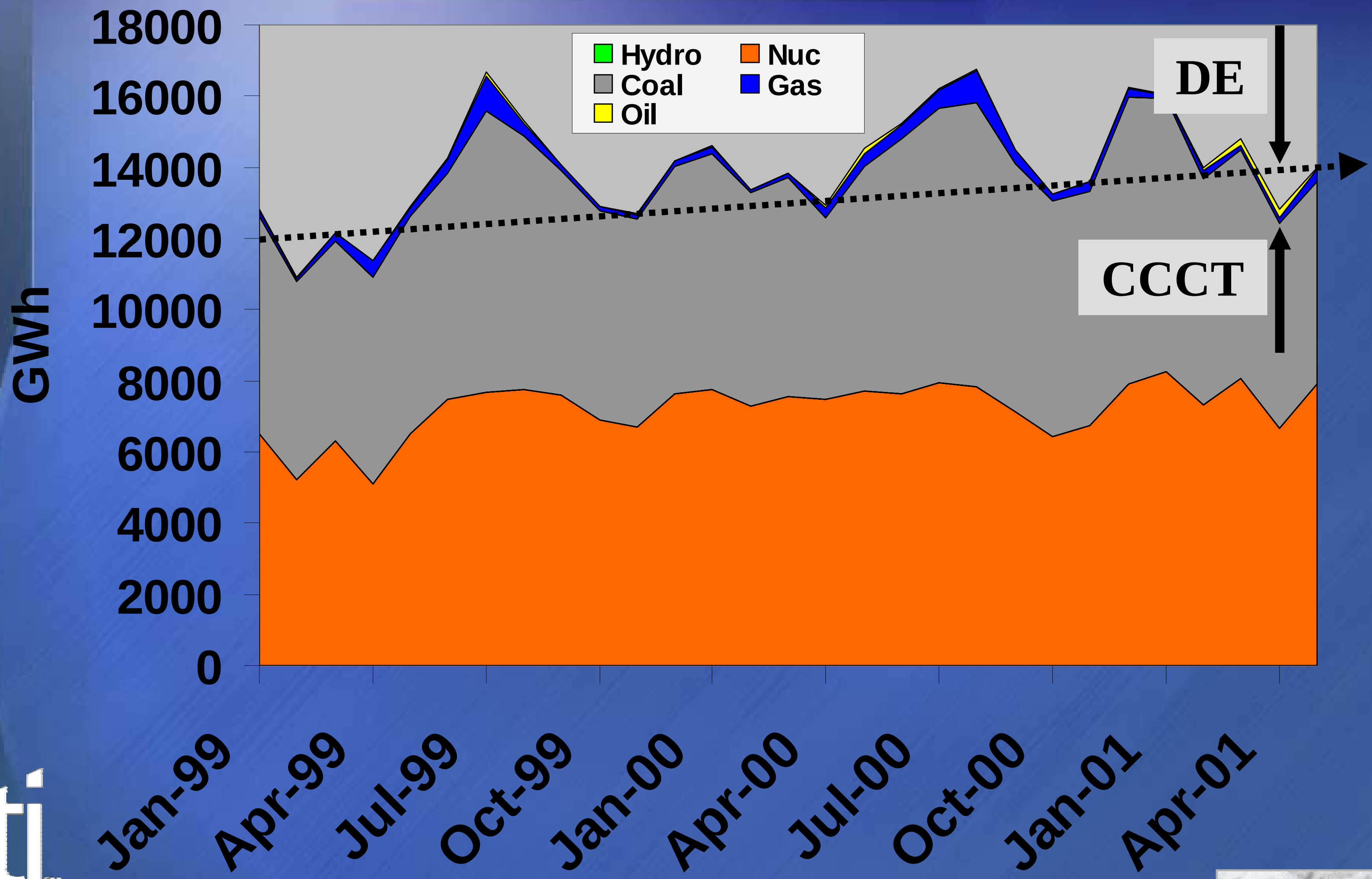
DE Improves Power Gen Emissions



* Modified by GTI

RAP Report

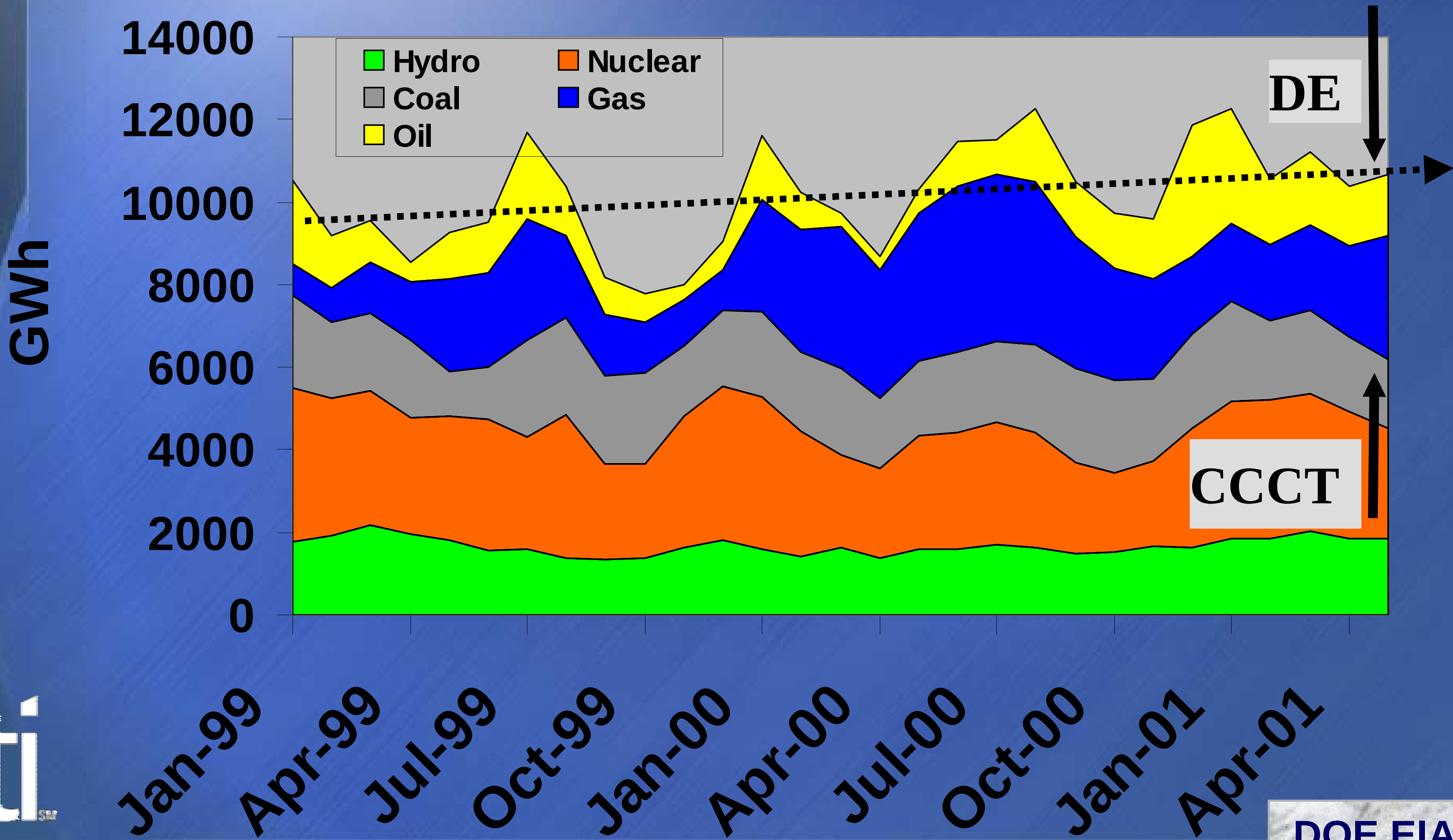
Illinois Generation



DOE EIA

New York Generation

- 7,000 – 1MW DE Plant to displace Gas & Oil > 2.5 lbs/MWh



DOE EIA

DE Emissions Impact Summary

- DE can have a positive impact on emissions in most States (not Texas and CA)
- CCCT Represent a small portion of the electricity generation sector
- CCCT will be selected before simple cycle gas and oil
  - DE will reduce the need for increases in simple cycle gas boilers/turbines and coal fired electricity
- CCCT does not appear to be a player in markets dominated by coal and nuclear (such as the Midwest)

Conclusions and Recommended Actions

- Reciprocating Engines can serve as a bridge, or enabling technology to new DE technologies
  - Capital and infrastructure necessary to reduce barriers and drive down installed costs
- Unnecessary, overly stringent standards may eliminate reciprocating engines as a choice in some markets, resulting in several limits to the overall DE market
- Reciprocating Engine Manufacturers and DOE can work together to:
  - Further improve engines (lower costs, improved emissions)
  - Develop integrated products for specifed, emerging markets that reduce overall costs.
- Reciprocating Engine Manufactures should work to drive national and regional industry groups working to remove barriers and open up the DE market

References

- 1996 Cost of Downtime Study" by Contingency Planning Research.
- "Annual Energy Outlook – 2002", Energy Information Administration, December 2001
- "Chicago's Energy Plan" by City of Chicago Department of Environment, 2001.
- "DG Power Quality, Protection and Reliability Case Studies Report". GE Corporate Research and Development, September 2001
- "Distributed Energy: The Power Paradigm for the New Millennium" by Ann-Marie Borbely and Jan Kreider, 2001
- "Energy Security - Solutions to Protect America's Power Supply and Reduce Oil Dependence", Union of Concerned Scientists, January 2002
- Natural Gas Monthly, DOE/EIA-0130, November 2000
- Draft Natural Gas Petroleum Council Report, December 15, 1999
- Electric Utility Restructuring: A Guide to the Competitive Era, Peter Fox-Penner, 1998
- May 2001, and "Profits and Progress Through Distributed Resources" – February 2000, David Moskovitz
- EPA, Report – "National Air Pollutant Emissions Trends" – March 2000
- "Making Connections: Case Studies of Interconnection Barriers and their Impact on Distributed Power Projects" by United States Department Of Energy Distributed Power Program, Revised July 2000.
- .National CHP Roadmap. by United States Combined Heat and Power Association, March 2001.
- "Power to Choose" Distributed Energy Series by the Gas Technology Institute, February 2002.
- Cooling, Heating, and Power for Buildings. http://www.bchp.org
- Diesel & Gas Turbine Worldwide
- Environmental Benefits of Distributed Generation; Joel Bluestein, Energy and Environmental Analysis, Inc., December 18, 2000.
- United States Environmental Protection Agency, Egrid Database, 1998.

gti℠