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

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Distributed Energy
GTI

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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 Engines Dominate Distributed Energy Market below 7.5 MWs

Figure 1: Recip Engine and Gas Turbine Orders 6/00-5/01

- Engines - diesel and gas
- Gas Turbines

Diesel & Gas Turbine Worldwide

Size of Units (MW)
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
Reciprocating Engine DE Markets

Reciprocating Engine Operating Strategies

Figure 2: Breakdown of Engine Orders by Role 2001

*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
Supply 30% of Projected Growth

Electric System Demand Reduction with Aggressive DE Program

Current Grid Level

CCCT

Renewable
DSM
EE
CHP

1999 2010 2020

AEO 2001
Chicago Goal 6000 Million kWh

- Energy Management: 1680
- Renewable: 1500
- CHP: 1500
- Clean DG: 1320

=Projected Growth over next 10 Years
# Reciprocating Engine DE Markets: High 9s Reliability

## Industry Costs of Grid Failures

<table>
<thead>
<tr>
<th>Industry</th>
<th>Average Cost of Downtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular Communications</td>
<td>$41,000 per hour</td>
</tr>
<tr>
<td>Telephone Ticket Salesa</td>
<td>$72,000 per hour</td>
</tr>
<tr>
<td>Airline Reservations</td>
<td>$90,000 per hour</td>
</tr>
<tr>
<td>Credit Card Operations / hour</td>
<td>$2,580,000 per hour</td>
</tr>
<tr>
<td>Brokerage Operations</td>
<td>$6,480,000 per hour</td>
</tr>
</tbody>
</table>
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 competitive in some applications)**
Reciprocating Engines Impact on Power Generation – Costs

Figure 12: Power Rates for a Peak-Run Commercial Load

- Peak Power Rate
- Off Peak Power Rate
- Distributed Energy Generation Cost
Reciprocating Engines Impact on Power Generation – Costs

Figure 13: Payback by Gas Price for 1000KW Peak DE
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 electricity 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)
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)
Power Generation Emissions

National Anthropogenic Mercury Emissions by Principal Combustion Source

- Industrial: 67%
- Power Generation: 33%

National NO\textsubscript{x} Emissions

- Industrial: 22%
- Power Generation: 25%
- Transportation: 53%

U.S. CO\textsubscript{2} Emissions by Sector

- Other: 34%
- Power Generation: 36%
- Transportation: 30%

National SO\textsubscript{x} Emissions

- Other: 33%
- Power Generation: 67%
<table>
<thead>
<tr>
<th>Generator Type</th>
<th>NO\textsubscript{x}</th>
<th>CO\textsubscript{2}</th>
<th>SO\textsubscript{x}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas CCGT</td>
<td>0.09-3.8</td>
<td>770</td>
<td>~0</td>
</tr>
<tr>
<td>Oil (2.2 % sulfur) fueled steam electric plant</td>
<td>3.0-3.7</td>
<td>1,770</td>
<td>25.4</td>
</tr>
<tr>
<td>Oil (0.3 % sulfur) fueled combustion turbine</td>
<td>3.7-6.8</td>
<td>2,190</td>
<td>4.4</td>
</tr>
<tr>
<td>Coal- Steam Electric</td>
<td>6.1-9.4</td>
<td>1,960-2,310</td>
<td>46.6</td>
</tr>
<tr>
<td>Diesel Engine</td>
<td>17.0</td>
<td>1,700</td>
<td>5.0</td>
</tr>
<tr>
<td>Natural Gas Engine</td>
<td>3.2</td>
<td>970</td>
<td>0.01</td>
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</table>

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

- **Base Load – Nuclear and Coal**
- **Intermediate – Simple Cycle, Gas**
- **Peaker – Simple Cycle, Oil**
- **Intermediate – CCCT**
- **Night Time**
- **Day Time**

Cents/kWh

MWe

Cumulative Capacity

Dispatched Time of Day

Peter Fox-Penner
DE Improves Power Gen Emissions

<table>
<thead>
<tr>
<th>Technology</th>
<th>NOx (lb/MWh)</th>
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<tbody>
<tr>
<td>ATS &amp; CCCT</td>
<td>0.3</td>
</tr>
<tr>
<td>CCCT, SCR &amp; DLN</td>
<td>0.1</td>
</tr>
<tr>
<td>Lg Simple</td>
<td>0.6</td>
</tr>
<tr>
<td>Microturbine</td>
<td>0.4</td>
</tr>
<tr>
<td>Sm Simple</td>
<td>1.0</td>
</tr>
<tr>
<td>Lean Burn</td>
<td>2.2</td>
</tr>
<tr>
<td>Engine, Catalyst</td>
<td>0.6</td>
</tr>
<tr>
<td>Avg Coal</td>
<td>5.6</td>
</tr>
<tr>
<td>Avg Gas</td>
<td>2.5</td>
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* Modified by GTI

RAP Report
New York Generation

- 7,000 – 1MW DE Plant to displace Gas & Oil > 2.5 lbs/MWh
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 specified, 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.
- Natural Gas Monthly, DOE/EIA-0130, November 2000
- May 2001, and “Profits and Progress Through Distributed Resources” – February 2000, David Moskovitz
- “Power to Choose” Distributed Energy Series by the Gas Technology Institute, February 2002.
- Diesel & Gas Turbine Worldwide