Reducing Direct GHG Emissions at GE

Michael Grossner, PhD, PE
GE Global Research

GCEP - Carbon Management in Manufacturing Industries
April 16, 2008
General Electric

130-Year-Old, High-Tech, Growth Company

$163 Billion in Annual Revenues

Only Company Listed in Dow Jones Index Today That Was on Original List in 1896

315,000+ Employees Worldwide

Thomas Edison, 1892
GE Businesses

GE Commercial Finance
GE Money
NBC Universal

GE Infrastructure
Aviation
Commercial Aviation Services
Energy
Energy Financial Services
Oil & Gas
Transportation
Water & Process Technologies

GE Healthcare
Diagnostic Imaging
Global Services

GE Industrial
Consumer & Industrial
Appliances
Lighting
Electrical Distribution
Enterprise Solutions
Sensing & Inspection Tech
Security
GE Fanuc Intelligent Platforms
Digital Energy

Clinical Systems
Life Sciences
Medical Diagnostics
Integrated IT Solutions
Interventional, Cardiology and Surgery
16 cylinder horsepower (4400 hp)
with just 12 cylinders

Cuts key emissions up to 40%

10% lower lifecycle costs for customers
Ecomagination

1. **Double** revenue from ecomagination products

2. **Double** investment in clean R&D

3. **Improve** GE’s energy efficiency & lower greenhouse gas (GHG) emissions

4. **Keep** the public informed
Ecomagination 1-30-30

3 Improve GE’s energy efficiency & lower greenhouse gas (GHG) emissions

2004 baseline for calculations

Reduce absolute GHG emissions 1% by 2012

Reduce intensity of GHG emissions 30% by 2008

Improve energy efficiency 30% by 2012
GHG Emissions at GE (2006 data)

- non-energy
- indirect (purchased)
- direct combustion
Direct Emissions (2006 data)

- Liquid fuels
- Coal
- Alternative fuels
- Natural gas
## Direct Emissions

<table>
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<tr>
<th>Usage Type</th>
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# Test Cells

**Objective:**
Determine scope of energy recovery opportunities from test cell activities

**Process:**
- Site visits
- Examination of test data

**Identify:**
- Energy availability
  - (type, magnitude, frequency, duration)
- Energy usage

<table>
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<tr>
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<th>Site</th>
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<td>Grove City, PA</td>
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<tr>
<td>Energy</td>
<td>Greenville, SC</td>
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<td>Houston, TX</td>
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<td>Schenectady, NY</td>
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<td>Aviation</td>
<td>Lynn, MA</td>
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<td></td>
<td>Peebles, OH</td>
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<td></td>
<td>Evendale, OH</td>
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<tr>
<td>Oil &amp; Gas</td>
<td>Florence, Italy</td>
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</table>
Aviation Testing

Outdoor test stands
~650 hrs/yr per stand

Enclosed cells
Few are more consistently run (~2000 hrs/yr)

Power Generation:
Shaft work not available on jet engine tests
Wind-driven turbine infeasible

Heat Recovery:
Some potential for enclosed cells; economics of recovery poor (no direct heat usage nearby)
Energy – Gas Turbine Tests

Single combustor can tests
- Run ~1/day for 6-8 hours (1100 total hrs in 2006)
- Hot exhaust available...and combustion air is preheated!
- Few different configurations for recovery, but best has > 5 yr payback

Dynamometer tests
- Turbines brought in for service
- 600 hours total testing time in 2006
- BUT...only ~30 min of each test is loaded, 60 total hours (avg. 10 MW)
- 600 MWh available (in ~30 minute intervals)
- Even if you could capture all of that energy and store it:
- ~$60K/yr in power costs
Locomotive Production Testing

All new engines tested
Power generation capability
Maximize uptime of regen system

Heat from engine cooling
- System in place to recover waste heat from engine jacket and manifold into building heat
Test Cells

Energy recovery from engine testing

Besides Rail, not much opportunity for energy recovery in testing

Project payback too high (>5 years, most >10 years)

Major factor: test cell usage is typically 2-5% of a year

Usually not much use for direct heating near test activity
Glass Furnaces

Regenerative

Flue

Regenerator

Furnace

Combustion air

To stack ~900 °F

Flue

Regenerator

Has exhaust heat recovery wastes fuel to heat N₂
Glass Furnaces

Oxy-fuel

- Pure $\text{O}_2$
- Furnace
- $\sim 2500 \, ^\circ\text{F}$

10-20% efficiency improvement over regenerative furnaces

Saves fuel by not heating $\text{N}_2$

Hot exhaust not recovered
GE Glass Furnaces

Six furnaces in North America
International sites (Hungary, China, Brazil)

Example site: Logan, OH

Logan Glass Plant

recently converted from two regenerative furnaces to one larger oxy-fuel furnace
~260 tons per day of glass
130 000 scfh exhaust at 2500 °F
about 8 MMBtu/hr of useful heat
Glass Furnace Heat Recovery

Options for hot exhaust

1. Direct heating – best use of waste heat
   - preheat batch and cullet (~10% efficiency improvement)
   - preheat oxygen (~5% improvement), natural gas (~3% improvement)

2. Indirect heating (e.g. steam, etc.) elsewhere
   - no other heat needs at plant or nearby

3. Conversion to other energy (electricity / absorption chilling)
   - no chilling needed, steam to electricity possible
Glass Furnace Heat Recovery

Steam production and power generation

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<th>Savings</th>
<th>Payback</th>
<th>GHG reduction</th>
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<tr>
<td>Low</td>
<td>$100K/yr</td>
<td>~9 yrs</td>
<td>1200 MT CO₂/yr</td>
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Glass Furnace Heat Recovery

Praxair batch/cullet preheat technology

- Most efficient use of heat
- Will reduce gas consumption ~10%
- Technical risks
  - transport of batch/cullet
  - furnace pressure control
- Currently only pilot scale
- 50 tpd demo in 2008, 150 tpd 2009

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