Caterpillar Inc. Sustainability Commitment

Gas Generator Sets

“Our vision is to contribute, through our diverse businesses, to a society in which people’s basic needs are not only met but fulfilled in a way that sustains the environment.”
Topics Covered

- Caterpillar Inc.
- Caterpillar Manufacturing
- Low BTU Gas Applications Worldwide
  - Low Energy Fuels
    - Landfill gas to energy
    - Digester Gas
    - Industrial Biogas
    - Ag Biogas
    - Coal Mine Methane
- Cat Dealer
  - Experience/Consulting
  - Product Support
Caterpillar Inc. 2008 Sales & Revenues by Geographic Region

(dollars in millions)

(1) Does not include internal engine transfers of $2,622 billion, $2,549 billion and $2,310 billion in 2008, 2007 and 2006. Internal engine transfers are valued at prices comparable to those for unrelated parties.

(2) Does not include revenues earned from Machinery and Engines of $306 million, $400 million and $466 million in 2008, 2007 and 2006, respectively.

<table>
<thead>
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<th>Region</th>
<th>2008</th>
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<td>$28,062</td>
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Manufacturing
Caterpillar Technology Leadership
Caterpillar Gas Engines

- All Caterpillar gas engines are built on the frame of diesel engines for:
  - Strength and long life
  - Large active engine population
  - Application synergy
  - Better parts availability

- 80% parts commonality with diesel engines
  - Engine block
  - Crankshaft
  - Main bearings
  - Connecting rods
  - Cylinder heads
Caterpillar Electric Power Experience

70 Years Experience (1939 - Present)
Over 450,000 Gas and Diesel Installations Worldwide
(Installations over 350 kW)
243,000 MW Installed Worldwide

Cat brand electric power products
World Leader in Heavy-Duty Gas Engine Sales

EXPERIENCE

- **Caterpillar Shipped >11,200,000+ Gas bkW in Last Decade**
  - More than 42,000 stationary gas engines shipped
  - 2.9 billion estimated operating hours
  - 2.35 million bkW in gas engines shipped in 2008 alone
• **Low Energy Fuel Heat Range**
  
  − **Coal Seam Gas** 13.8-35.6 MJ/Nm³ (370-955 btu/ft³)
  − **Landfill Gas** 10.2-25.7 MJ/Nm³ (275-700 btu/ft³)
  − **Digester and Biogas** 10.2-25.7 MJ/Nm³ (275-700 btu/ft³)
  − **Syngas / Wood Chip Gas** 4.0-11.9 MJ/Nm³ (160-320 btu/ft³)
  − **Manufactured Gas** 4.0-35.6 MJ/Nm³ (160-955 btu/ft³)
Landfill Gas-To-Energy

**Description**

Sanitary landfills produce large amounts of methane and CO₂ gas due to the natural biological digestion of the organic materials incorporated in the fill. Internal combustion engines are used to consume (destroy) the Landfill gas extracted from landfills with the aid of a gas collection system. The gas produced is composed of about 50 percent methane, about 50 percent carbon dioxide and a small amount of non-methane organic compounds.

**Industries**

<table>
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<th>Applications</th>
<th>Heat Intensive Applications</th>
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<tr>
<td>Municipal Landfills</td>
<td>Locations close to the landfill</td>
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<td>Private Landfills</td>
<td>Greenhouses</td>
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<tr>
<td></td>
<td>Chemical Processes</td>
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<tr>
<td></td>
<td>Food Processing</td>
</tr>
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</table>
Landfill Gas-To-Energy

Caterpillar Advantage

- 30+ years experience in the industry
- Engines designed to tolerate fuel contaminants (modified cooling systems, improved metallurgy)
- Factory supplied mobile solutions available
- Competitive owning and operating costs
- Total system efficiencies to 90+% with heat recovery
- Designed for utility parallel operation
- Systems backed by superior Cat parts and service networks

Cat Product Available

kW range: 350-2000 kW
Landfill Experience

- First commercially available landfill gas generator sets installed in Chicago Illinois USA in 1983.
- Over 1,550 MW of landfill product installed worldwide.
  - Continue to add over 150 MW/year
- Over 55,000,000 hours of operation on landfill gas.
Caterpillar Solutions to Landfill Gas Contaminants

• Landfill gas contains corrosive contaminants
  – 4 categories of corrosive contaminants:
    • Sulfur compounds
    • Halide compounds
    • Acids
    • Silicon compounds

• Engines designed to optimize engine operation in landfill environment
  • Corrosion resistant A/C core
    • Match current Caterpillar corrosive fuel requirements
  • Oversized corrosion resistant fuel system for very low inlet fuel pressure
  • Bright metals removed from areas that might contact fuel, blow-by with fuel borne contaminants
Optimized Engine Jacket Water Temperature

- **110°C (230°F) Jacket Water outlet temperature**
  - Protects internal engine components from corrosion by preventing condensation of water, not allowing sulfuric and other acids to form

- **Positive crankcase ventilation**
  - With warmed intake air to prevent condensation and corrosion from blow-by gasses with fuel borne contaminants
  - Extends oil life
Landfill Customer: Biogeração Energia S.A.

Biogeração Energia S.A.
São Paulo, Brazil

24 Cat gas gen sets producing 22 MW

- 170,000 MW-hrs/yr (enough energy for 58,000 homes)
- Reduces 1.5 MMt/yr CO₂e initially
- 16 MMt CO₂e in the next 16 years
- CER CO₂ value ~ $240 mil (at $15/Mt)
**Description**

Sewage treatment, or domestic wastewater treatment, is the process of removing contaminants from wastewater and household sewage, both runoff (effluents) and domestic. It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants.

**Industries**

**Applications**
- Wastewater treatment facilities

**Heat Intensive Applications**
- Locations close to the landfill
- (Used to improve landfill gas quality)
- Greenhouses
- Chemical Processes
- Food Processing
Digester Gas

Caterpillar Advantage

• Engines designed to tolerate fuel contaminants (e.g. high temp cooling)
• World class fuel efficiency
• Competitive owning and operating costs
• Total system efficiencies to 90+% 
• Designed for utility parallel or ‘island mode’ operation
• Systems backed by superior Cat parts and service networks

Cat Product Available

kW range: 50-4000 kW
Digester Gas Customer: City of Hamilton

The dealer delivered the complete cogeneration system in a stand-alone module with a sound-attenuated enclosure. At the heart of the system is a Cat gas engine in a configuration designed to be durable and reliable in burning low-energy fuels without needing extensive fuel conditioning.

“The facility operates continuously, fulfilling nearly all of the wastewater treatment plant heat load and 20 percent of its electrical load. Total cogeneration plant efficiency exceeds 80 percent. Projected simple payback on the cogeneration equipment is five years.”
Industrial Biogas

Description

Water is often used in the processing of foods, beverages and ethanol made from agricultural crops. The waste water from the process is collected and treated as effluent in a digester plant. The anaerobic digestion of the effluent creates a biogas that consists of varying amounts of methane and CO₂. The methane can be collected for consumption in a gas generator set to create electricity while enabling emissions credits.

Industries

Applications
- Food processing
- Beverage processing

Heat Intensive Applications
- Heat for facility process or cleaning
- Locations close to the facility
- Greenhouses
- Chemical Processes
- Food Processing

Commercial Byproducts
- Fertilizers
- Soil enhancement products
- Animal bedding
Industrial Biogas

Caterpillar Advantage

• World class fuel efficiency
• Competitive owning and operating costs
• Total system efficiencies to 90+%
• Systems backed by superior Cat parts and service networks

Cat Product Available

kW range: 350-2000 kW
Industrial Biogas Customer: Guangzhou Zhujiang Brewery

Guangzhou Zhujiang Brewery Group Co. Ltd.
Guangzhou, People’s Republic of China

The Cat dealer began by presenting a comprehensive cost analysis to the brewery, including initial investment and operating costs, estimating that up to 95% of their biofuel methane could be used by the new system. Currently, the overall efficiency of the generator sets is up to 80%. The brewery’s current cost savings from the system is estimated RMB400,000 (over USD58,000) per month.
Ag Biogas
Ag Biogas

Description

Organic matter is flushed or loaded into large lagoons (pits), or sealed containers where bacteria in the natural anaerobic digestion process produce biogas (typically 65% methane and 35% CO₂). The effluent can be heated to accelerate the process (38 degrees C or 56 degrees C). In many parts of the world, ag biogas is responsible for up to 10% of greenhouse gases. The methane can be collected for consumption/ destruction in a gas generator set to create electricity while enabling emissions credits.

Industries

Applications
Swine Farrowing/ Feeding
Cattle Feeding & Milking
Fowl Brooder House/ Feeding

Heat Intensive Applications
Locations close to the operation
Heat for operation facilities
Heat for improved digester operation
Greenhouses
Food Processing
Etc.

Commercial Byproducts
Fertilizers
Soil enhancement products
Animal bedding
Ag Biogas

Caterpillar Advantage

• Extensive experience - unattended engine applications
• World class fuel efficiency
• Competitive owning and operating costs
• Designed for utility parallel operation
• Systems backed by superior Cat parts and service networks

Cat Product Available

kW range: 50-2000 kW
Ag Biogas Plants

• **Biogas plants**
  – Methane and $\text{H}_2\text{S}$ generated during decomposition of organic wastes
  – Rarely will blowers be used to aerate effluent
    • Not cost effective… can hold effluent for longer periods of time
  – Engine heat is sometimes used to warm the mixture, promoting faster decomposition
Ag Biogas Customer: Nong Rai Farm

Nong Rai Swine Farm
Rayong, Thailand

Cat® 105 kW generator set
Cat® 70 kW generator set

“As the generator sets would be running continuously, it was important to work with a supplier that could provide guidance on engine care and also have parts available in a timely manner when necessary. Caterpillar was chosen because of its reputation for quality power generating equipment and extensive field validation of similar units operating on methane gas.”
Application Leading – Agriculture (Methane Gas-to-Energy)

http://www.cat.com/cda/layout?m=39300&x=7
Coal Mine Methane
Coal Mine Methane

Description

Methane gas is naturally occurring in coal seams. It is released during coalification process. One of the ways Kyoto participants pursue the goal of carbon reduction is through the Clean Development Mechanism (CDM). One of the most promising and effective greenhouse gases used in CDM projects is coal mine methane (CMM). Cat gas engines can “destroy” the methane gas to create electric energy while enabling emissions credits.

Industries

Applications
Privately held coal mines
State-owned coal mines
Abandoned coal seams

Heat Intensive Applications
Locations close to the sight of generation
Mine facilities heating and cooling
Chemical Processes
Food Processing
Coal Mine Methane

Caterpillar Advantage

• Engine tolerance with changing methane concentrations
• World class fuel efficiency
• Proven lowest owning and operating costs with maximum reliability
• Total system efficiencies to 90+% - proven combined cycle application
• Designed for utility parallel or ‘island mode’ operation
• Systems backed by superior Cat parts and service networks

Cat Product Available

kW range: 50-4000 kW
Coal Mine Methane Customer: Energy Developments Ltd.

Energy Developments Limited
BHP Billiton’s Appin and Tower Coal Mines
New South Wales, Australia

94 Cat 1,030 kW generator sets

“Consuming 600,000 m³ of coal seam gas per day (supplemented when necessary by natural gas), the generating equipment delivers a combined 94 MW of continuous capacity to the local utility grid.”

“Through a progressive maintenance program, EDL has safely extended time between major overhauls from the standard 40,000 hours to more than 60,000 hours in some cases.”
Coal Mine Methane Customer: Jincheng Sihe Mine

Jincheng Sihe Mine
Shanxi Province, China

60x 2 MW Cat gen sets in a combined cycle steam turbine application producing 120MW @ 1060m (3,500 ft) altitude

• Largest CMM project worldwide
• 840,000 MW hrs/yr sold to utility
• 233,600 GJ heat recovered (winter only)
• System efficiency of 80%
• 2.9 MMTCO2e CERs
  • Economic value: $45.3M/yr @15US

http://www.cat.com/cda/layout?m=8703&x=7&f=177263#/methane/
Sustainable Application of Reciprocating Gas Engines Operating on Coal Mine Methane Gas

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Thomas Yu, Caterpillar (China) Investment Co., Ltd., thomas_yu@cat.com
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Abstract
Coal provides 25 percent of global primary energy needs and generates 40 percent of the world’s electricity, according to the World Coal Institute. The People’s Republic of China produces the largest amount of hard coal – an estimated 2.5 billion metric tons in 2008 alone. The anthropogenic release of methane (CH₄) into the environment is a byproduct of the coal mining process and the global warming potential of this methane continues to draw attention globally. Stakeholders responsible for coal and power production are looking for ways to safely and economically mitigate the release of coal mine greenhouse gases.

Sequestration of coal mine methane (CMM) as an alternative fuel for reciprocating gas engines generator sets is a mature and proven technology for greenhouse gas mitigation. Prior to commissioning CMM-fueled power systems, the methane gas composition must be evaluated. The project is then developed utilizing an integrated systems approach.

As with any type of alternative energy, the economics of electric power CMM projects play a major role in the success of the project. Profiles of existing applications that document reliable and efficient utilization of CMM for gas reciprocating engines will be offered to illustrate the success of such systems.

There is considerable opportunity for growth in the Asia-Pacific region for electric power applications using CMM. Caterpillar’s experience in this type of power generation has been proven successful at several sites in China and beyond, where the growing economy demands sustainable solutions to meet rising power needs.

Keywords: coal mine methane, reciprocating gas engines, sustainable development, alternative energy, electric power, system integration

Introduction
The restructuring of China’s economy and the resulting rapid growth of both agriculture and industry have contributed to a more than tenfold increase in gross domestic product (GDP) since 1978 – and that figure grew at a higher rate each year. In 2007 alone, the real growth rate of China’s GDP was an estimated 11.4 percent. Measured on a purchasing power parity basis, China stands as the second-largest economy in the world after the United States. [1]

With this very swift economic growth comes swiftly increasing demands for power from both industries and consumers – China’s energy consumption has more than quadrupled since 1980. In 2006, China’s electricity usage reached 2,868 trillion kWh and natural gas consumption was approximately 50.9 billion cubic meters, with natural gas consumption equaled 6.55 million barrels per day. [1]

China’s government recognizes the need for environmental responsibility in the pursuit of greater power production. This government has taken action with official governmental management programs like the nationwide campaign to reduce energy consumption launched in 2006. [2] The Kyoto Protocol, perhaps China’s most important environmental commitment, is an international agreement on the United Nations Framework Convention on Climate Change that requires participating developed countries to reduce their greenhouse gas emissions below levels specified for each of them. These targets must be met within a five-year time frame between 2008 and 2012. [3]

http://www.cat.com/cda/layout?m=39300&x=7

Caterpillar: Confidential Green
Dealer Experience/Consulting
Over 131,000 Dealer Employees to Support Cat Products

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<th>Region</th>
<th>Cat Dealer Employees</th>
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<th>Cat Dealer Net Worth</th>
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Product Support – Operation and Maintenance

SERVICES

- Oil Analysis
- Coolant Analysis
- I-R Analysis
- Particle Counting
- Product Inspections
- PM Services
- PM Kits
- Customer Service Agreements
- Repair Options
- Exchange Components
- Management Software
- Convenient Locations
- Training Materials
- Training
- Product Support Staff
- Used Equipment

- Quality Rebuilds
- Parts Inventories
- Used Parts
- Field Service
- Quality Repair Facilities
- Genuine Parts
- Salvage Capabilities
- Equipment Management Consultations
- Technical Support
- Trained Professionals
- Reusability Expertise
- Warranty / Goodwill Administration
- Special Tooling
- Inspection Services
- Flexible Financing
- Equipment Rental
- Remote Monitoring

GUIDANCE

- Application materials written by industry experts, including Application & Installation Guide Books and white papers.
Why Select Caterpillar Total Gas Power Solutions?

- **PRODUCT**
  - Technology leader commitment to R&D
  - Broad spectrum of Caterpillar’s gas product offering allows best-fit solutions to customers
  - Package system solutions
  - Cat engines are well known for durability and reliability
  - Best island mode performance in industry (DG)
  - High temp jacket water for maximum tri-generation/CHP heat recovery
  - Optimized corrosion resistance maximizes low energy application performance
  - Wide range of gaseous fuel applications
Why Select Caterpillar Total Gas Power Solutions?

• PEOPLE
  – Before the sale:
    • A&I engineering capability and total systems provider
  – After the sale:
    • Strong dealer product support network
    • Qualified field service engineers
  – Enterprise committed to sustainable development
Why Select Caterpillar Total Gas Power Solutions?

**EXPERIENCE**
- Global industry leader
- 70 years in the business
- Established relationships with project developers
- 450,000 gas and diesel installations worldwide
  - Installations over 350 kW
- 243,000 MW of Electric Power systems installed worldwide
Why Select Caterpillar Total Gas Power Solutions?

- DISTRIBUTION
  - Spare parts availability worldwide
  - Global distribution centers enable timely delivery
  - 131,000 factory trained dealer employees to support your products/applications in region