

The Role of Gas in Coming Decades

Terry A. Goff
Manager Petroleum Business Unit
Caterpillar Inc.

*Presentation to the 22nd meeting of the United States-Japan Energy Policy Dialogue
Keidanren Guest House, Japan, November 16-17, 1998*

Good morning.

I am honored by the opportunity to open our second day of formal dialogue. In particular, it is a pleasure to discuss an energy source offering such unique economic and environmental benefits.

This morning, I am asked to characterize the role of natural gas within our future energy mix. As with many subjects it is often best to look to the past for guidance as we prepare for the future. Let me begin by briefly outline Caterpillar's role in the natural gas industry. I believe this brief description will effectively prepare our minds for a view of the future.

Over 50 years ago, Caterpillar leveraged the inherent power of its well-known diesel engines to develop its first natural gas-powered engines. This business decision grew from growing North American understanding that natural gas offered an attractive energy alternative to the then dominant coal and oil based energy sources. Led by the vision and demands of oil and gas industry customers, Caterpillar saw a role for itself through development of utilization technology. In this case, the natural gas engine offered the opportunity to explore, produce and use natural gas, then a largely neglected energy resource. Subsequently, Solar Turbines, a Caterpillar company for nearly 20 years, captured a similar vision, converting itself from an aeronautical firm that built parts of Charles Lindbergh's Spirit of St. Louis and developed the first jet engine afterburners, to an energy sector focus, developing dedicated land and offshore-based gas turbines as a core business and utilization technology.

I share these stories because of a fundamental belief that the future role of natural gas in our energy mix is limited only by the imagination of the entrepreneurs who will develop the enabling technologies that put this uniquely attractive energy source to economic and environmentally friendly use.

From our initial entry into the natural gas power systems business fifty years ago, today's family of Caterpillar gas engines and Solar gas turbines coupled with the products of our competitors, through their dependability, efficiency and versatility, make this industry a strong contributor to future natural gas utilization opportunities. This critical mass of technology and business focus, which is also alive and well in our competitors, is driving powerful new changes in the way we see our world, and the way we live in it. As our economic horizon continues to expand, as our world view shifts from regional to global, we believe gas engines

and turbines will facilitate natural gas' role as a primary energy source with unique distributed application characteristics wherever and whenever there's a need for clean, reliable and productive power.

Understanding how this strong experience base translates into a future role suggests we look at two particular areas, Natural Gas Economics and the Natural Gas Value Chain. Let me begin with some observations on the economic question.

NATURAL GAS ECONOMICS

World Energy Supply vs. Demand

- The world has a 66-year proven reserve of natural gas. (this figure is based on current reserves-to-production ratios)
- Despite increased consumption, the reserve remains constant
- South America and the former Soviet Union have 70- to 80-year proven reserves
- At current worldwide production rate, recoverable gas resources are estimated to be at a 200-year supply

Investing in Infrastructure

- Tremendous investments are being made in gas pipeline infrastructure worldwide
- 130,000 kilometers of pipeline are currently approved, or under construction. That's enough to stretch around the world more than three times
- This represents a 20% increase in world pipeline capacity

Plenty of Advantages

- The production cost of natural gas is 65% that of diesel fuel
- Natural gas has environmental advantages as well, particularly with respect to carbon emissions
- Countries are looking for ways to reduce the threat of climate changes. For example, in Denmark, the equivalent of a CO₂ tax has been enacted to encourage the shift to natural gas and reduce greenhouse gas emissions

NATURAL GAS VALUE CHAIN

Field Gas Compression

- Gas compression systems are used to collect gas and move it toward central gathering stations
- Gas compression systems are also used in oil production. The associated gas that exists with oil can fuel them. They reinject this gas into the oil well
- Reinjection helps the environment and increases oil production
- Associated gas-fueled generator sets are also for power generation on remote sites

Central Gathering

- Central gathering stations take in gas from many fields, where it is consolidated and moved with bigger reciprocating compressors toward gas processing plants
- The gas is then boosted to higher pressures before and after the stripping process
- Reciprocating engine-driven compression equipment typically does pre- and post-compression work. Then it enters into the high pressure transmission pipeline

Pipeline Transmission

- In the pipeline, gas is usually moved along by gas turbines
- At this point, the value chain adjusts for transportation and infrastructure reasons ... for example, in areas with land based transmission systems, as gas approaches a high-use area, it is frequently pumped into underground storage caverns
- Underground storage caverns are ideal applications for large reciprocating gas compression units because of their unique ability to adapt to changing pressure requirements
- In areas where gas is transported as LNG, processing plants and ocean going vessels play their role

Household Use

- Once the gas reaches either end use conversion and bottling plants or underground storage caverns, it can be made available to all types of consumers
- Gas is available in most urban homes today, either via piped connections or bottled technologies, natural gas becomes the only primary energy source available to this wide spectrum of consumers

Distributed Power

- Electrical power generated near the point of use represents a significant market segment for natural gas engines

- Distributed power is a tremendous growth opportunity for gas engine generator sets and power systems because of their high efficiency, low life cycle costs, reliability and environmental friendliness
- 85% total efficiency can be achieved through co-generation

Chillers

- A growing application is the use of reciprocating natural gas engines in chiller systems to turn natural gas into cold water for space cooling and industrial process cooling
- Chiller systems we provide range from 400 tons to 2,100 tons. They provide an exceptional coefficient of performance: 1.8 at rated load up to about 2.4 between 50-75% of rated load (which is where a chiller spends most of its operating hours). Normal gas-fired two-stage absorption units, on the other hand, have a coefficient performance of about 1.0
- Natural gas is readily available in the summer, a time when electricity is in short supply and air conditioning is at peak demand

Specialty Gas

- There is a growing opportunity for natural gas power systems to generate electricity from specialty gases
- Our own experience as a leading manufacturer of Waste-to-Energy systems, is turning landfill gas into electricity. In fact, Caterpillar alone has over 250 MW of active power generation working on three continents
- Other active specialty gas sectors include agricultural biogas applications, wastewater treatment plants and manufactured gas
- Coal seam gas further extends our understanding of specialty gases as energy sources as well. One such project in Australia generates 100 MW, eliminating random methane gas emissions and converting those emissions into useable energy
- When considering specialty gases, the impact of fuel cost is important. Fuel costs normally consume 80% of a project's budget. In the specialty gas applications mentioned above, the fuel, typically a waste product, is practically free. That makes natural gas engine technology an economical choice for generating electricity, as well as cleaning the environment

As I introduced this subject, I suggested our view of the future could be clarified by an understanding of our past. From our own more than 50 years of continuous manufacturing experience of reciprocating natural gas products we see some 29,000 Caterpillar natural gas engines producing more than 13 million horsepower worldwide. If each of these engines were equipped with a generator, they would produce enough power to meet the needs of 2.3 million 230 square meter homes. The past demonstrates the future's potential.

Thank you.