TECH BRIEF

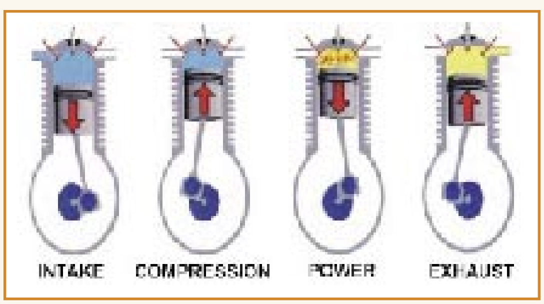
GAS-FIRED RECIPROCATING ENGINES

DISTRIBUTED ENERGY TECHNOLOGIES

To meet the country's need for cleaner, more reliable and efficient energy, the U.S. Department of Energy's Office of Distributed Energy and Electric Reliability and its Programs are working with energy technology suppliers and end-users to promote the understanding and adoption of distributed energy. Distributed Energy Technologies can be located at or near the building or facility where the energy is used to provide greater power reliability and reduced emissions. Controls and communications, energy storage, and combined cooling, heating and power are End-Use Integration and Distribution systems. High Temperature Superconductivity is one way to harness high-tech to efficiently distribute power. Tools and systems that increase the reliability and performance of the existing energy grid are part of Transmission Reliability.

Gas-fired reciprocating engines are the fastest-selling, least expensive distributed generation technology in the world today. Although most widely used in automobiles, reciprocating—or internal combustion (IC)—engines are also used to power devices such as air compressors, pumps, and electric generators for buildings.

Commercially available natural gas versions of the IC engine produce power from 0.5 kW to 10 MW, have efficiencies between 37 and 40 percent, and can operate down to NO_x levels of 1 gram per horsepower hour (hp-hr).



Four-stroke reciprocating engines resemble automobile engines, but combust natural gas.

When properly treated, these rugged engines can run on fuel generated by waste treatment (methane) and other biofuels. By using recuperators that capture and return waste exhaust heat, reciprocating engines also can be used in combined cooling, heating, and power (CHP) systems in buildings to achieve energy-efficiency levels approaching 80 percent.

Gas-fired reciprocating engines offer many advantages over other technologies for small-scale power generation, including the ability to provide highly reliable, inexpensive backup power, provide power for remote locations, and generate onsite power during peak periods when utility charges are at their highest.

Reciprocating engines require fuel, air, compression, and a combustion source to function. Depending on the ignition source, they generally fall into two categories: spark-ignited (SI) engines, typically fueled by gasoline or natural gas; and compression-ignited (CI) engines, typically fueled by diesel oil.

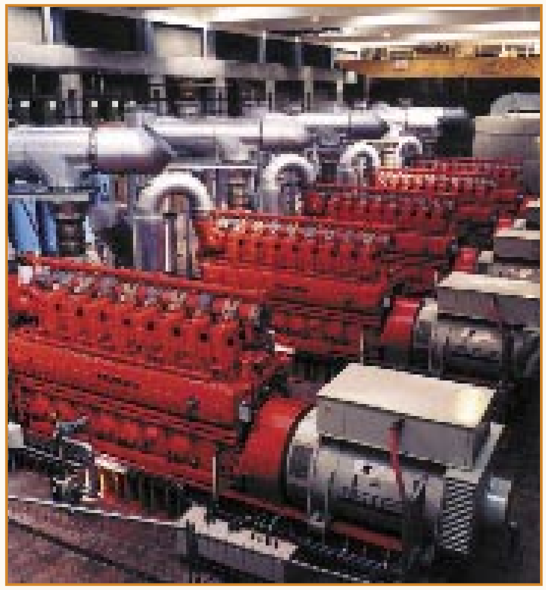
MARKET POTENTIAL

- Reciprocating engines have the largest share of the small power generation market and can be used in a variety of applications due to their small size, low unit costs, and useful thermal output.
- With fast start-up time, gas-fired reciprocating engines can play integral back-up roles in many building energy systems.

ENVIRONMENTAL BENEFITS

- Reciprocating engines have low greenhouse gas emissions when run on biofuels.
- Sophisticated exhaust gas treatment, such as selective catalytic reduction system, allows for emissions low enough to meet California and Texas emission standards.

The four-stroke SI engine has an intake, compression, power, and exhaust cycle. In the intake stroke, as the piston moves downward in its cylinder, the intake valve opens and the upper portion of the cylinder fills with fuel and air. When the piston returns upward in the compression cycle, the spark plug fires, igniting the fuel/air mixture. This controlled combustion forces the piston down in the power stroke, turning the crankshaft and producing useful shaft power. Finally, the piston moves up again, exhausting the burnt fuel and air in the exhaust stroke. The CI engine operates in the same manner, except diesel fuel and air ignite when the piston compresses the mixture to a critical pressure. At this pressure, no spark or ignition system is needed since the mixture ignites spontaneously, providing the energy to push the piston down in the power stroke.



Rugged, affordable reciprocating engines can be used in industrial, commercial, institutional, and residential applications.

APPLICATIONS

With their wide power range and operating flexibility, reciprocating engines can be used for many purposes—local power grid and substation support, peak-shaving, remote power, CHP applications, high-density electric loads, standby power, and mechanical drive used for compressors and pumps—in industrial, commercial, institutional, and residential applications.

PROGRAM GOALS & ACTIVITIES

The goal of the Gas-Fired Reciprocating Engine Program is to lead a national effort to design, develop, test, and demonstrate a new generation of gas-fired reciprocating engines for DER applications that are cleaner, more affordable, reliable, and efficient than products that are commercially available today.

Performance targets for the next generation of reciprocating engines include:

- **High Efficiency** – The target for fuel-to-electricity conversion efficiency (low heating value) is 50% by 2010, a 30% increase from today's average efficiency.
- **Environment** – Engine improvements in efficiency, combustion strategy, and emissions reduction will substantially reduce overall emissions to the environment. The NO_x target for the gas reciprocating engine is 0.1g/hp-hr, a 95% decrease from today's NO_x emissions rate.
- **Fuel Flexibility** – Natural gas-fired engines are to be adaptable to future firing with dual fuel capabilities. Dual fuel options may be considered in the design.
- **Cost of Power** – The target for energy costs, including operating and maintenance costs, is 10% less than current state-of-the-art engine systems while meeting new projected environmental requirements.
- **Availability, Reliability, and Maintainability** – The goal is to maintain levels equivalent to current state-of-the-art systems.

U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy

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FOR FURTHER INFORMATION

Distributed Energy and Electric Reliability Program
www.eren.doe.gov/deer.html

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