

achatesPOWER™

Fundamentally Better Engines®

THE ACHATES POWER OPPOSED-PISTON ENGINE

Clean, Efficient, Cost Effective

Achates Power develops Opposed-Piston Engines for ultra-clean, ultra-efficient and cost effective transportation.

Achates Power Technology Enables Opposed-Piston Engines

Founded in 2004 with the mission to build cleaner, more efficient engines, Achates Power is working with leading engine manufacturers to bring the Opposed-Piston Engine to market.

The company has an impressive global Intellectual Property portfolio spanning more than **200 issued patents**, more than **200 pending patent applications**, and **2,500 claims**.

With more than \$160 million in cash investment, Achates Power is backed by the Oil and Gas Climate Initiative (OCGI), Climate Investments; Sequoia Capital Partners; RockPort Capital Partners; Madrone Capital Partners; InterWest Partners; and, Triangle Peak Partners.

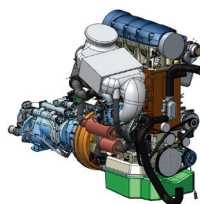
*The company is working with **global engine original equipment manufacturers (OEM)** to bring the Opposed-Piston Engine to market. Engine programs include:*



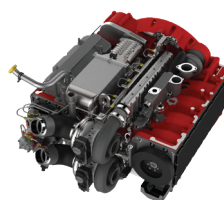
2.7 LITER



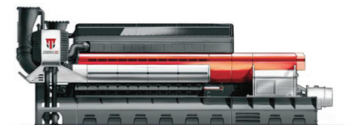
5 LITER



10 LITER



14 LITER



200 LITER

A FUNDAMENTALLY BETTER ENGINE

The Opposed-Piston Engine, is the most efficient and cost-effective way to meet future regulatory standards.

More than 11,000+ dynamometer test hours have proven it to be clean and dramatically more efficient than conventional four-stroke engines.

+ 30% more efficient than diesel

+ 50% more efficient than gasoline

A Fit for All Fuels

The Opposed-Piston Engine is a compression ignition engine capable of using gasoline, diesel, natural gas, JP8, and biofuels/renewal fuels. Its technology **leverages existing fueling standards and infrastructure** currently being used by consumers.

A Fundamentally Better Architecture

Lower cost. Lower mass. Less complexity.

The Achates Power Opposed-Piston Engine is engineered to achieve superior thermal efficiency by virtue of its **lower heat losses, improved combustion, and reduced pumping losses**.

The engine design eliminates the cylinder head for an improved surface-area-to-volume ratio of the combustion chamber for **reduced heat transfer and rejection**. It takes advantage of the inherent power density of a two-cycle engine by reducing both displacement (reducing the size, mass, and cost of the engine) and brake mean effective pressure (BMEP). Reduced BMEP results in:

- + Lower nitrogen oxides operation and enables more rapid combustion to improve efficiency.
- + Leaner and more efficient combustion at the same boost level, which has the additional benefit of generating less particulate matter.

The Opposed-Piston Engine has efficient, uniflow scavenging that decouples the pumping work from the engine speed.

At low loads, the engine can have increased internal exhaust residuals and reduce the supercharger work at the same time, improving efficiency while reducing nitrogen oxides (NO_x). This operation also enables increased exhaust gas temperatures to achieve rapid catalyst light-off during cold starts to maximize aftertreatment system efficiency.

A Fundamentally Cost-Effective Engine

The cost of an engine consists of three main parts: materials, fuel systems/controls and aftertreatment systems. The Opposed-Piston Engine architecture helps reduce the cost of two of these areas:

- + **Materials** – Material costs can be reduced 15% through the elimination of the cylinder head, valvetrain, and other conventional engine components. Compared to a supercharged V6, the 2.7L Opposed-Piston Engine has 60% fewer parts, providing an approximate 10% cost reduction.
- + **Aftertreatment Systems** – The Opposed-Piston Engine architecture offers a reduction in the aftertreatment system size, generating a potential 30% cost reduction.

Finally, the cost to manufacture an Opposed-Piston Engine is similar to any engine. It can be built in existing OEM factories.

OPPOSED-PISTON GASOLINE COMPRESSION IGNITION ENGINE

The Opposed-Piston Gasoline Compression Ignition Engine (OPGCI) combines proven, efficient technologies in an engine that has the potential to be approximately 50% more efficient than today's gasoline engines, with comparable power; torque; noise, vibration and harshness (NVH); and, size. This performance is achieved without vehicle light weighting or aerodynamic improvements. It does this by using the benefits of compression ignition, with a readily available fuel source—gasoline—in the highly efficient opposed-piston architecture, refined by Achates Power. Based on the Mid-Term Evaluation models, it is projected to cost \$1,000 less per vehicle than widely accepted technology roadmaps.

The OPGCI engine was designed and developed by Achates Power with a \$9 million award from the Department of Energy's ARPA-E, along with partners Delphi Technologies and Argonne National Laboratory.

Improving Light Truck Efficiency is Imperative

Designed for mass production, the Opposed-Piston Engine provides the power and performance the light duty truck segment needs, using today's manufacturing and fuels infrastructure.

The Achates Power OPGCI engine in a light-duty truck is estimated to achieve 37 mpg (CAFE combined)—nearly five mpg better than the proposed CAFE 2025 requirements for this size vehicle.

	City MPG (sticker)	HWY MPG (sticker)	CAFE Combined MPG
OP Gasoline (GCI)	23	33	37
OP Diesel	26	36	42

Using Achates Power OPGCI engines in full-size light-duty trucks has the same carbon dioxide impact as eliminating the emission of more than half (53%) of the cars sold each year (5 million).

Today's Light-Duty Trucks			
15,962 miles per year	20.4 miles per gallon	782 gallons per year	\$2,028 per year
OPGCI Saves			
258 gallons per year	\$669 per year	\$8,382 over the life of the vehicle	



POWERFUL APPLICATIONS



LIGHT DUTY VEHICLES

Years of testing and the launch of a light-duty pickup truck demonstrator, in partnership with Aramco, support the Opposed-Piston Engine's ability to meet current and future federal and state regulatory vehicle emissions and fuel economy standards, while providing a new benchmark in efficiency.



MEDIUM / HEAVY DUTY COMMERCIAL VEHICLES

Commercial vehicles are 5% of total vehicles on the road, yet use 25% of the fuel and emit 40% of the nitrogen oxides. The OP Engine has the potential to improve heavy duty (HD) class 8 truck fuel efficiency with a 90% reduction in NOx and 15% reduction in CO₂. It is estimated the technology can save 43 million metric tons of carbon dioxide, 74,000 tons of nitrogen oxides, 632 tons of Reactive Organic Gas, and 519 tons of particulate matter a year across the United States.



MILITARY

Achates Power and Cummins are developing the next generation U.S. Army Advanced Combat Engine (ACE). ACE is a key component of the Army's 30-year strategy to modernize tactical and combat vehicle—Bradley Family of Vehicles (BFoV) and the Next Generation Combat Vehicle (NGCV).

Deployed in the Bradley Family of Vehicles, the Opposed-Piston Engine offers:
+ 50% more power + 25% better fuel efficiency + 30% less volume



HIGH HORSEPOWER: POWER GENERATION, MARINE + RAIL

Achates Power is working with large engine manufacturers to deliver engines that meet Tier 4 Final emission standards while setting new benchmarks for efficiency. The engine architecture has 15% fewer moving parts than conventional engines, which improves reliability and serviceability and eliminates the need for minor overhauls.

THE RIGHT ENGINE RIGHT NOW

The global transportation industry needs a fundamental, step-function improvement in the internal combustion engine efficiency to power the approximately 100 million vehicles that will be produced and sold year-in and year-out for decades to come.

The demonstrated performance of the Achates Power Opposed-Piston Engine responds directly to the global transportation industry's needs. It offers a dramatic improvement in performance compared to conventional engines.

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