Number of vehicles will double

Need for sharply reduced fuel consumption

Internal combustion engines are at their limit
“The performance, low cost and fuel flexibility of ICEs makes it likely that they will continue to dominate the vehicle fleet for at least the next several decades.”
“The future has a plug. Everybody sees it.”

“The cruising distance is so short for EVs, and the charging time is so long. At the current level of technology, somebody needs to invent a Nobel Prize-winning type battery.”

Mitsuhisa Kato, Toyota’s Head of Research & Development, 7-July-2014
Cost is the issue

Fuel-efficient technologies being developed by automakers to meet government-imposed fuel-economy regulations are not being embraced by consumers...

It’s projected to cost billions of dollars to develop advanced hybrids and pure-electric and hydrogen-fuel-cell vehicles.

[Ford CEO Mark] Fields says.

“It requires a market response for adoption, and we’re not seeing it at this point.”
**Opposed Piston Engine**

Achates Power, Inc. has been investigating a two-stroke opposed piston diesel engine as an alternative to the conventional four-stroke diesel engine. In a recent publication, Achates reported on its study, which showed that an opposed piston diesel engine could provide over 30 percent improvement in fuel economy when compared to an equivalent four-stroke diesel engine in a light-duty full-size 5,500 lb pickup truck application (Redon et al. 2014).
“The simplicity and compactness of the OP engine, combined with its potential for brake fuel efficiency in excess of 45%, and low emissions suggest this is a power unit that needs re-evaluation.”

“Weight and cost comparisons indicate that the two-stroke OP engine could be approximately 34% lighter than the equivalent performance four-stroke and cost 12% less.”

Source:
Achates Power, Inc.

Founded In 2004 by Dr. James Lemke & John Walton $125M+ capital invested

7,000+ dynamometer test hours

- Clean
- Dramatically more efficient
- Multi-fuel capable
- Lower cost, mass and complexity

20%+ more efficient than

60%+ more efficient than

4.9L 3-Cylinder Engine – 275 HP, 1100 Nm

Global IP portfolio
- 2,500 claims
- Over 80 issued
- 130 pending patents

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The Achates Power Engine

Achates Power has modernized the record setting opposed-piston engine

- State-of-the-art:
  - Combustion
  - Fuel delivery
  - Air handling
  - Computer control
  
  ➔ meeting the most stringent emissions standards, including future US EPA Tier 3 / CARB LEV III light duty vehicle standards

- Demonstrated to be clean, efficient and cost effective:
  - No cylinder heads or valvetrain
  - Reduced combustion chamber heat losses
  - More efficient combustion ➔ earlier, faster and leaner
  - High stroke-to-bore ratio for efficient scavenging

**Low Combustion Chamber Surface Area to Volume Ratio**

**Patented Combustion System**

**Demonstrated Superior Combustion**
To improve engine efficiency by 20%:
- The U.S. National Research Council forecasts a cost increase of $23,000 for conventional 4-stroke engines

With the Achates Power OP Engine:
- Efficiency is improved by 20%
- Cost is reduced by 10%
- Conventional technologies can be applied for further efficiency gains
Demonstrated & Customer Validated Results

- Measured 44% best point Break Thermal Efficiency (BTE), 4.9L engine
  - Flat fuel map with wide speed range of high efficiency further increases real-driving advantage
- 48% best point BTE after implementing the 2020 Efficiency Roadmap
  - 32% cycle-average efficiency advantage over conventional engine
  - Combustion System Improvements
  - Air Handling System Improvements
  - Optimized Air System Components
  - Friction Reduction Mechanical Components

- 0.1% Fuel Specific Oil Consumption (FSOC)
- Emissions compliance confirmed
- Durability potential established
- Packaging into existing vehicles confirmed
- Mass and cost advantages dimensioned
Published Technical Results

Multi-Cylinder Opposed Piston Transient and Exhaust Temperature Management Test Results

Fabien Redon, Amrananda Sharma, and John Bradley
Achates Power Inc.

Abstract
In a recent paper, Opposed-Piston 2-Stroke Multi-Cylinder Engine Dynamometer Demonstrations [1] published in the SAE Intl. in January 2013, Achates Power presented work related to the first ever opposed piston multi-cylinder engine that demonstrated 

The results showed that the research 4.9L three cylinder engine was able to achieve 41% brake thermal efficiency at the best point and 

Multi-Cylinder Opposed Piston Transient and Exhaust Temperature Management Test Results

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achatesPOWER™
Achates Opposed Piston Engine Achieves Ultra-Low NOx More Efficiently Than a Comparable Four-Stroke

Greater Fuel Efficiency Advantage at Low NOx

Engine Out range for 0.02 g/hphr tailpipe emissions

Engine Out range for 0.2 g/hphr tailpipe emissions

BSFC Ford Powerstroke 6.7L 4 stroke
BSFC API A-48-3 4.9L

B50 condition, 4-stroke data is from Ford Powerstroke 2010 SAE Paper and Bosch Presentation

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Opposed Piston Gasoline Compression Ignition

- $9 Million grant from the U.S. Department of Energy's ARPA-E
  - With support from Argonne National Laboratory and Delphi Automotive
  - Develop a three-liter, three-cylinder opposed-piston gasoline compression ignition engine

- Two clean, efficient and cost effective technologies – OP and GCI – together will make the perfect high-volume engine for markets all around the world.
  - Fuel efficiency gains of more than 50 percent compared to a downsized, turbo-charged direct injection gasoline engine
  - Reduces the overall cost of the powertrain system
FIGURE 8.3  NHTSA technologies for spark ignition 14 engines in midsize cars shown on a plot of NRC-estimated incremental 2025 MY direct manufacturing cost in 2010 dollars versus percent reduction in fuel consumption.

FIGURE 8.4  HSE engine technologies, hybrid, and advanced diesel technologies in midsize cars shown on a plot of NRC-estimated incremental direct manufacturing cost in 2010 dollars versus percent reduction in fuel consumption.
Achates Power Engine – The Most Cost Effective
Technology Development

Achates Power Technology Development

1998 2004

Company formed
Research commences

A40/1

A48/1 A48/3

Achates Power

Fairbanks Morse Engines *
Truck engine project
Car engine project
Truck engine project
Car engine project
Truck engine project
Truck engine project

NGCE
ACE

US Army *

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Next Generation Combat Engine – Demonstration of Technology

- 28 month program awarded December 2012

Technical Requirements:
- 70 hp / liter displacement power density
- 0.36 lbs / hp/hr BSFC
- 0.71 kW / kW heat rejection

“Achates Power has realized the potential for impressive efficiency in their development of the opposed piston architecture. We have worked with Achates Power for a number of years now and applaud their engineers and engineering rigor, and we look forward to continuing our collaboration. This contract acknowledges the U.S. Army recognizes the special value of this engine design in their application and Achates Power’s ability to optimize it.”

Dr. John Wall, Chief Technical Officer, Cummins, Inc.

Advanced Combat Engine

- First phase award to API & Cummins February 2015
- TRL 6 by EOY 2018

Technical Requirements:
- 41.6 hp / ft³ engine volume
- 0.32 lbs / hp/hr BSFC
- 0.45 kW / kW heat rejection
Large Engines for Marine and Power Generation

- Selected as technology development partner.
- Licensee of Achates Power patents.
- FME has manufactured opposed piston engines since 1936. By applying API’s patented design improvements, FME will improve emissions, power density, and efficiency – at the same time.
- 206 mm bore / 508 mm stroke
- 16.9L per cylinder; 6, 9, and 12 cylinder versions
- 2 – 4 mW

“Achates Power has an incredible amount of intellectual property and has done a lot of work to improve the fuel efficiency, power ratio and emissions performance of opposed-piston engines.”

Stephen Macadam, President & CEO, EnPro Industries, Inc.
Thank You!

For more information

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