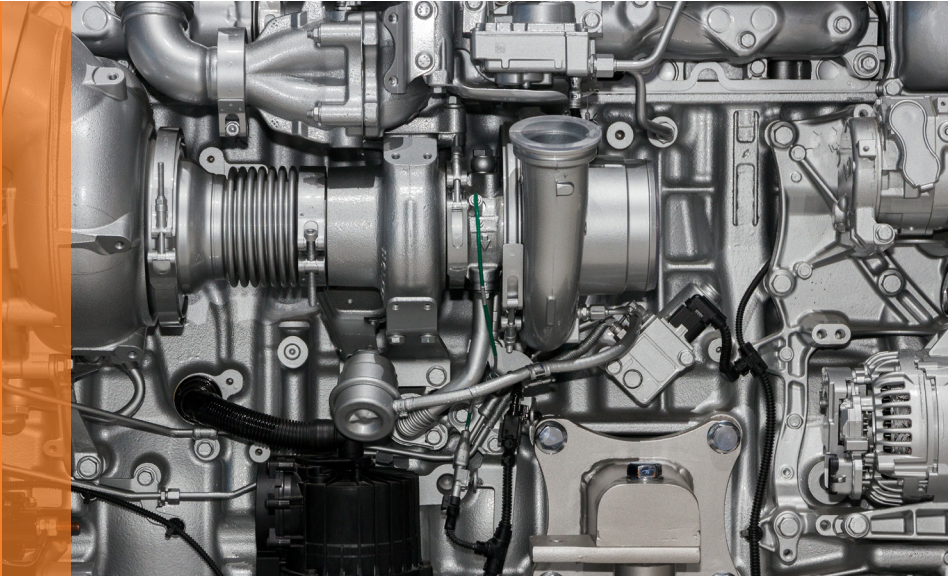# NEW SOOTLESS DIESEL ENGINES ARE STRONGER AND CLEANER

Achieving next-gen emissions for heavy-duty applications

Through the Chain Reaction Innovations startup studio program at Argonne National Laboratory, ClearFlame Engines is developing novel alternatives to diesel-fueled engines.

ClearFlame
ENGINES

ClearFlame Engines' technology overcomes hurdles to using liquid fuels in diesel engines while maintaining performance.

ClearFlame's modified engines is expected to exceed competitors' performance and reduce emissions in the following ways.

Diesel engines[1]
□ Estimated 34 percent lower cost of ownership because of lower fuel costs per 1 million miles driven
□ 100 times lower engine-out soot emissions
□ 30 percent increase in engine power and torque
□ Utilization of simple and effective three-way catalysis

Natural gas engines[2]
□ Estimated 20 percent lower cost of ownership because of estimated projections of lower fuel costs per 1 million miles driven
□ 42 percent increase in engine torque and power
□ 5 percent increase in efficiency
□ No requirement for expensive pressurized gas storage tanks or multiple fuels

ClearFlame Engines outperform current diesel-fueled technologies while achieving the emission levels and fuel flexibility of the best alternative engines.

ClearFlame Engines' patented technology is a sootless, drop-in diesel engine replacement with the potential to disrupt heavy-duty transportation and power generation. This technology simultaneously achieves higher efficiency, enhanced performance, simplified after treatment, and cost savings for the customer while using low carbon, renewable liquid fuels. The engine technology accomplishes these goals by using a unique high temperature combustion system that easily ignites clean-burning fuels such as methanol, ethanol, and DME. These low-carbon, renewable liquid fuels are easy to store and transport.

The ClearFlame Engines solution leverages several combustion technologies that have just reached the readiness level where their incremental improvements can be combined in a novel way to enable far greater gains in performance and emission reduction.

Through the U.S. Department of Energy's Chain Reaction Innovations program, ClearFlame Engines has gained access to multi-million dollar engine testing lab space, as well as world-class computational modeling, and engineering experts. This will greatly accelerate the development and validation timescales, and result in the ability to build a demonstration engine within two to three years.

INVEST IN THE HEAVY-DUTY ENGINE OF THE FUTURE

Increasingly stringent emissions standards are driving a market shift towards non-diesel-fueled alternatives for engines and generators. Get in on this growing market opportunity by investing in ClearFlame Engines or licensing the engine technology.

The heavy-duty transportation market includes approximately $70 billion in global engine sales annually. It is projected to grow by 60 percent by 2030.[3]

The distributed power generation market is a $150 billion and expected to grow by 30 percent by 2020.

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[1] Clear Flame estimates; http://papers.sae.org/2014-01-1194/

[2] Clear Flame estimates; http://papers.sae.org/2014-01-1194/

[3] http://www.npc.org/reports/FTF-report-080112/Chapter_3-Heavy_Duty_Vehicles.pdf

CLEAR FLAME ENGINES

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