



Co-Optimization of Fuels & Engines FOR TOMORROW'S ENERGY-EFFICIENT VEHICLES

CO-OPTIMIZATION FOR NEAR- AND LONG-TERM TRANSPORTATION SOLUTIONS

A new U.S. Department of Energy (DOE) initiative is accelerating the introduction of affordable, scalable, and sustainable biofuels and high-efficiency, low-emission vehicle engines. The simultaneous fuels and vehicles research and development (R&D) is designed to deliver maximum energy savings, emissions reduction, and on-road vehicle performance. Although improvements over the years based on either fuel or engine advancements have made vehicles cleaner and more fuel efficient, transportation still accounts for 70% of overall U.S. petroleum consumption and 27% of the country's greenhouse gas (GHG) emissions. This project's ambitious, first-of-its-kind approach simultaneously tackles fuel and engine innovation to co-optimize performance of both elements and provide dramatic and rapid cuts in fuel use and emissions.

National laboratories and other institutions are developing breakthrough technologies to address energy and emissions issues, advancing a range of clean, energy-efficient solutions that include improvements to the types of fuels and engines that are found in most vehicles currently on the road. Given the considerable amount of time required to develop and bring new automotive technologies to the marketplace and the high energy density offered by liquid fuels, vehicles with internal combustion engines (ICEs) will continue to comprise a significant portion of the nation's vehicle fleet for the next several decades.



CO-OPTIMIZATION GOALS

The project will provide U.S. industry with the R&D needed to:

- ▶ Reduce petroleum consumption by billions of barrels a year
- ▶ Improve passenger vehicle fuel economy by 50% — 15%–20% beyond the projected results of existing R&D efforts
- ▶ Deliver tens of billions of dollars in cost savings annually via improved fuel economy
- ▶ Dramatically decrease criteria pollutants and GHG emissions from the transportation sector
- ▶ Accelerate the rate of advanced biofuels deployment
- ▶ Enhance energy security through more effective use of diverse domestic energy sources
- ▶ Spur U.S. economic and technological vitality.

The initiative's integrated approach combines the previously independent areas of biofuels and combustion R&D, bringing together two DOE Office of Energy Efficiency & Renewable Energy research offices, nine national laboratories, and numerous industry and academic partners to more rapidly identify commercially viable solutions. This multi-year project will provide industry with the scientific underpinnings required to move new biofuels and advanced engine systems to market faster while identifying and addressing barriers to their commercialization.

This coordinated R&D effort complements established initiatives and partnerships. In addition to exploring synergies among the fuels, engines, and powertrains found in today's traditional light-duty ICE vehicles, the initiative is also examining opportunities related to hybrid and plug-in hybrid technologies, as well as advanced compression ignition solutions that will benefit medium- and heavy-duty vehicles.

INTEGRATED EXPLORATION OF NEW FUELS AND ENGINE TECHNOLOGIES

The co-optimization initiative draws on the combined expertise of the country's leading researchers across multiple disciplines and institutions. It taps into the strengths of the national labs to identify solutions that deliver maximum internal combustion performance and efficiency. Parallel R&D tracks focus on identification and co-development of fuel and engine technologies that, when used in tandem, offer the greatest combination of efficiency, GHG reduction, and performance.

The R&D approach integrates experimental testing with computational modeling and multi-scale simulation studies to enable prediction of performance and guide the optimization process. In addition to analyzing technologies from environmental and economic perspectives across the supply chain, researchers are working to identify potential market barriers and devise mitigation strategies.

Researchers are exploring synergies among new bio-based fuels, engines, powertrains, and fueling infrastructure.
Image by Loren Stacks, Sandia National Laboratories.



CONCURRENT TRACKS OF FUELS, ENGINES, AND MARKET-FOCUSED RESEARCH

Co-optimization researchers are collaborating with partners on three concurrent phases of R&D. One body of research focuses on improving near-term spark-ignition (SI) engine efficiency through identification of fuel properties and engine design parameters that maximize efficiency and performance. Simultaneously, teams are developing advanced compression ignition technologies needed for revolutionary low-temperature combustion (LTC) engine platforms, along with the supporting fuel technologies needed to produce a longer-term, higher-impact series of solutions.

Throughout the project, analysts are evaluating proposed solutions from environmental and economic perspectives, in addition to examining market viability. This perspective will inform the project team's research agenda, as well as deployment options eventually considered by industry.

Near-Term Solutions: Maximum Spark-Ignition Engine Efficiency

Near-term SI engine R&D will:

- › Identify molecules and pathways to enable fuels of the future
- › Characterize the auto-ignition behavior of new candidate fuels, bridging fuel composition and fuel performance metrics
- › Examine the impact of fuel properties and engine design on one another in terms of performance, energy efficiency, and emissions
- › Identify spray and mixture formation characteristics vital to the design of energy-efficient, emissions-compliant engines enabled by the new fuels.

Long-Term Solutions: Revolutionary Engine and Fuel Technologies

Longer-term engine R&D will:

- › Assess the fuels identified for compatibility with LTC engines
- › Quantify the interactions among fuel properties, engine design, and operating strategies to enable high-efficiency engine operation
- › Provide the scientific underpinnings needed for industry to develop advanced, highly efficient, clean-burning vehicle engines
- › Develop strategies that utilize today's trillion dollars of fuel infrastructure, but with a significantly smaller GHG footprint.

Overarching Strategies: Market Viability

Lifecycle, techno-economic, and market analyses will:

- › Evaluate potential solutions based on factors including sustainability, scale, economics, risk, and trade
- › Assess market viability based on criteria such as cost, GHG reduction, feedstock supply, scalability, and infrastructure compatibility
- › Identify possible barriers to widespread deployment and develop market-driven solutions
- › Identify the value proposition for consumers and the potential for U.S. job creation and energy security.



The new DOE initiative takes a first-of-its-kind approach, simultaneously exploring fuel and engine innovations to maximize performance and provide dramatic cuts in fuel use and emissions. Photos courtesy of iStock (left) and Shutterstock (right).

COLLABORATION ACROSS NATIONAL LABORATORIES, INDUSTRY SECTORS, AND GOVERNMENT AGENCIES

The broad range of fuel and engine innovations necessary for the project's success cannot be achieved by any single institution, but relies on the combined expertise of the country's leading researchers from multiple national labs, universities, and industries working collaboratively toward integrated near- and long-term goals. These partners will enhance the commercial impact of federally funded research aimed at creating a sustainable transportation future.

Project partners include:

DOE Office of Energy Efficiency & Renewable Energy

- › Vehicle Technologies Office
- › Bioenergy Technologies Office.

National Laboratories

- › Argonne National Laboratory
- › Idaho National Laboratory
- › Lawrence Berkeley National Laboratory
- › Lawrence Livermore National Laboratory
- › Los Alamos National Laboratory
- › National Renewable Energy Laboratory
- › Oak Ridge National Laboratory
- › Pacific Northwest National Laboratory
- › Sandia National Laboratories.

Strategic Engagement

- › Vehicle original equipment manufacturers
- › Energy companies and refiners
- › Fuel producers, renewable energy producers, distributors, and retailers
- › Universities and other research institutions
- › Other government agencies.

Learn more about the initiative:

www.energy.gov/fuel-engine-co-optimization