Optima: Co-Optimization of Fuels and Engines

ACCELERATING THE PATH TO ECONOMIC AND SUSTAINABLE FUELS AND VEHICLES

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

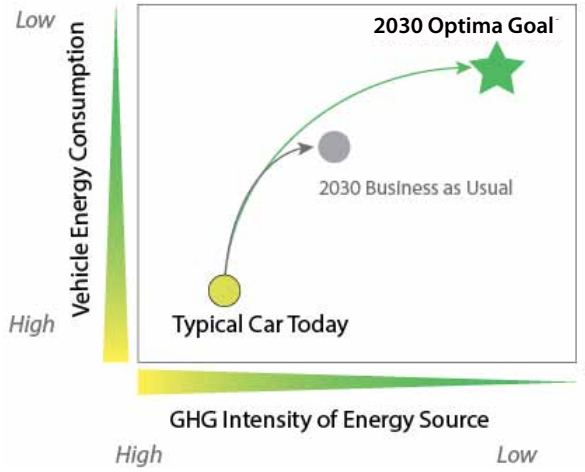
The Challenge

Although crucial to our economy and quality of life, transportation presents drawbacks: it requires an abundant supply of petroleum and is a significant source of greenhouse gas (GHG) emissions. Internal combustion engines (ICEs) will continue to dominate the vehicle fleet for the next several decades—as either prime movers or range extenders for the increasing number of electric vehicle (EV) drive systems expected. Therefore, it is critical to develop and deploy significantly more-efficient ICEs and low carbon intensity transportation fuels to power them. But a business-as-usual approach, driven by current CAFE standards based on today's fuels and engines, will not provide sufficient gains to solve the problems our nation faces and will not meet Climate Action Plan goals. Rather, the nation requires new low carbon fuels and advanced engines that are *co-optimized*—designed in tandem to work for maximum performance and carbon efficiency.

Given the considerable time required to introduce new engine and fuel technologies, aggressive action is needed now to develop advanced fuels and ICEs that are economically viable, environmentally sustainable, massively scalable, and rapidly deployable.

Opportunity

The Co-Optimization of Fuels and Engines (Optima) initiative—an unprecedented collaboration between industry stakeholders and Department of Energy (DOE) national laboratories—seeks to transform the fuels and vehicles that provide mobility for our country's people, goods, and services.



Optima will build on decades of remarkable advances in both fuels and engines. Ground-breaking research over the past 10 years has identified new combustion engine strategies that—especially if optimized to run on new fuels—would offer significantly higher efficiency and produce less engine-out pollutants than current engines. At the same time, research is advancing low carbon fuel options that can blend with petroleum-based feedstocks to significantly reduce GHG emissions and enable engine performance gains.

The confluence of these developments provides a rare opportunity to introduce co-optimized new fuels and engines that can achieve dramatic performance improvements at the enterprise level. Specifically, Optima targets a 30% reduction in per-vehicle petroleum consumption beyond the levels to be provided by the expected evolutionary, policy-driven improvements to today's fuels and engines. This revolutionary transition will yield a range of benefits:

- Enhanced energy security through more effective use of diverse domestic energy sources
- Increased US technology vitality, including a direct economic benefit of improved fuels, a regeneration of the US bio-economy, and increases in US jobs
- A sound technical basis for a comprehensive national transportation energy strategy

Approach

Changing the fuel and engine options for every vehicle on the road will be a considerable undertaking. Optima initiates a focused and coordinated research, development, and demonstration (RD&D) program centered on providing stakeholder and consumer value. The initiative will accelerate the widespread deployment of significantly improved fuels and vehicles (passenger to light truck to heavy-duty commercial vehicles) by 2030.

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To yield better solutions with faster time-to-market, Optima is already engaging with vehicle manufacturers, fuel producers, and regulators regarding an RD&D plan that encompasses two concurrent phases:

- An initial phase focused on introducing new fuel/vehicle combinations by 2025, building on current gasoline and diesel engines
- A parallel, more ambitious phase focused on kinetically controlled combustion technologies with fuels that enable maximum engine performance

For each of these engine classes, the RD&D co-optimization approach involves simultaneously determining the fuel properties that maximize engine performance, and identifying the low carbon fuel and petroleum blendstocks that can best provide those properties at the lowest cost and environmental impact. Lifecycle and techno-economic analyses will guide selection of new fuel candidates that can be scaled up and deployed rapidly, economically, and sustainably at the required scale of tens of billions of gallons per year.

The only way to achieve these goals is through coordination across a broad range of disciplines at multiple national labs. Active involvement with industry at all stages of RD&D will provide market stakeholders the confidence needed to start producing new fuels and vehicles and the assurance that the new designs will demonstrate market superiority.

2030 to 2040 Benefits	Impact
Reduction in petroleum consumption	4-4.5 Billion Barrels
Cost savings from improved fuel economy	$30-50 Billion
Reduction in transportation sector GHG emissions	9-14%

Metrics of Success

By developing new fuels and vehicles with higher performance that can be produced affordably, sustainably, and at scale, Optima aims to achieve these targets:

- Reduce per-vehicle petroleum consumption by 30% vs. the 2030 base case, which is constrained to using today's fuels. This goal reflects contributions from both improved engines (7–14% reduction in fuel consumption) and improved fuels (with substitution of up to 30% low-GHG biofuel blend stocks).
- Accelerate the deployment of advanced biofuels to meet the Renewable Fuel Standard Program 2030 goal of 15 billion gallons/year of advanced biofuel—a sharp contrast to the low volumes currently predicted by the International Energy Agency for the US in 2030.
- Produce an additional 9–14% fleet GHG reduction by 2040.

Given current gasoline and diesel fuel definitions, these goals cannot be achieved through evolutionary improvements—including engine advances, lightweighting and aerodynamics, and use of advanced biofuels—to today's vehicles. Rather bold action, such as that possible with Optima, is required.

DOE's Essential Role

Introduction of new fuels and vehicles by 2030 will require the buy-in and active participation of a wide range of stakeholders; opposition from even one sector could delay progress by years. Replicating past successes, DOE and other federal agencies will play several essential roles:

- Convene key stakeholder groups.
- Identify and inform regulatory and policy actions needed to coordinate and incentivize the marketplace, including establishing national fuels targets crucial to managing investment risk for both fuel producers and vehicle manufacturers.
- Build on the long-established capabilities of DOE national labs to attain the needed R&D momentum; the absence of for-profit motives and decades of capability investment make the national labs the right place to do much of the needed work.

Key Stakeholders

Success is dependent on the active engagement of many key stakeholders: light- and heavy-duty original equipment manufacturers (OEMs), energy companies and refiners, biofuel producers, federal and state agencies, fuel distributors and retailers, consumers, and ultimately, society.

Timeline

With Big-Idea funding levels, Optima expects to complete R&D on gasoline and diesel fuels/engines by 2020 and kinetically controlled combustion and advanced fuels by the middle of 2025. Approximately five years are required to introduce new engines into the market. New fuel deployment timelines will depend on the nature and extent of changes needed in biorefinery and conventional refinery operations.

Current and Anticipated Funding

The President's FY16 budget request includes $27M for Optima—sufficient to ramp up this activity. This initiative is envisioned to be an enduring research effort through the early 2020s to achieve the aggressive Optima targets.