Plus leaders you meet on the way

On the Road to A Low-Carbon Future

At the imaginary intersection of Climate Boulevard and Energy Security Avenue is the Center for Green Transportation Opportunities, a place where the needs of our country and our planet intersect and money can be made. Our transport fleets are the mechanical beasts of burden that no modern society can exist without. Whether commuting to work or taking the kids to soccer practice, liquid fuels are essential for our way of life and commerce.

But there is no free lunch. Engines need fuel, and fuel carries geopolitical and environmental costs. The market is immense: There are more than 235 million motor vehicles on the road in the U.S. today, including cars, trucks, buses, big rigs, and motorcycles. Nearly 26,000 trains operate on America's 120,000 miles of railroads. According to the Federal Aviation Administration, 7,626 aircraft fly our skies, requiring 20 billion gallons of jet fuel a year. Purely fossil-based transportation fuels generate 28% of our greenhouse gas (GHG) emissions. Globally, the International Energy Agency predicts that the transportation sector will contribute 22% of GHG emissions by 2020.

Since 2001, discussion has intensified about alternatives to the current fuel and drive-train system. "The future is not one fuel. It is a panoply of fuels—in different applications, in different parts of the country where it makes the most sense to use each fuel," says Richard R. Kolodziej, president of NGVAmerica, in Washington, D.C. Options range from corn ethanol to biobutanol, biodiesel to hydrogen fuel cells, and electric hybrid technologies (including plug-ins) to ultra-low-sulfur diesel. "We're going to see alternative engine designs, engineered fuels, and more fuel choices coming on line," says Philip New, president of BP Biofuels, a division of global energy giant BP.

Options Galore

The excitement surrounding renewable fuels has been brewing for more than 30 years in the U.S. and Brazil. About half the gasoline in the U.S. today is blended with ethanol, the nation's most rapidly growing fuel. The blend is most common at the 10% level, but blends of up to 85%, otherwise known as E85, are becoming more common at the retail level. Availability has grown from 400 fueling stations in 2005 to more than 1,200 in the U.S. today. About 95% of U.S. ethanol comes from corn, while in Brazil sugar cane is used. More than 6 billion gallons of fuel ethanol will be produced in the U.S. in 2007, and continued federal incentives are luring more farmers, distillers, and distributors into the market.

Many policy makers, environmentalists, and business people see the future in "cellulosic" ethanol—a fuel that can be made from biomass, including plant wastes such as straws and leaves, paper or post-process items such as shells or rinds, or fast-growing plants like switchgrass.

Since early 2006, the Department of Energy has awarded $500 million to pilot projects. While fewer than 50 demonstration plants exist today, many more are expected to be built in the years to come.

In addition, diesel fuel has long been the poor cousin to gasoline in the U.S., but ultra-low-sulfur diesel (ULSD), which contains less than 5% of the sulfur of conventional diesel, was mandated by law in the U.S. beginning in 2006. But for those looking to leave petroleum-based fuels in the dust, diesel engines aren't an option, unless drivers can choose biodiesel, one of the fuels that Rudolf Diesel originally considered for his engine—in the form of vegetable oil.

Grass, Grease, or Flowers

Whether called grassolene, greasegas, or flowerpower, biodiesel is coming on strong. It can be manufactured in-country from vegetable oils, animal fats, or recycled restaurant grease. It is biodegradable and can reduce vehicle emissions of particulates, carbon monoxide, and hydrocarbons. The biodiesel market is growing rapidly in the U.S. Low-level blends—known as B5—can be employed in all diesel engines. B20 can also be used, though currently in fewer makes. Cars that run on B80 emit fewer greenhouse gases than hybrid electric vehicles.

"The future is not one fuel. It is a panoply of fuels – in different applications, in different parts of the country where it makes the most sense to use each fuel."

—Richard R. Kolodziej, president of NGVAmerica

So little of the fuel was produced in 1997 that it is hard to find reliable statistics. In 2005, 75 million gallons were produced, most from soybean oil. Ten years ago, no public fueling stations existed; today there are nearly 1,500.

Innovative to many in the energy field is BP's move toward biobutanol, a biogasoline the company believes will get us to the level of scale we need. BP and DuPont are working together to create a liquid, bio-based transportation fuel with a high energy density. While biobutanol and ethanol are produced from the same renewable feedstock, biobutanol is nearly as efficient as gasoline. "You're going to see biofuels evolving, using biotechnology to make more sophisticated fuels that go beyond ethanol," says BP's New. With the future development of cellulosic technology, both ethanol and biobutanol will be produced without reliance upon food-based plants.

Hydrogen fuel cells may be a long-term, high-tech future transportation option. Vehicles powered by hydrogen use fuel cells to convert the energy in hydrogen into electricity. The fuel cells enable an electrochemical reaction, producing an electrical current from hydrogen combining with oxygen within the cell. Fuel cells power many small vehicles today, such as forklifts, with zero tailpipe emissions. If hydrogen is made from renewable resources (giving it a low-carbon lifecycle) and made domestically, it is a very attractive option, but the complexity of production, storage, distribution, and on-vehicle use means that commercial hydrogen vehicles may not be available in large numbers until at least 2020. Hydrogen advocates, however, like to

Amyris Biotechnologies Based in Emeryville, Calif., this innovative company has a technology platform to make renewable cost-competitive hydrocarbon biofuels. Its products include a high-performance and scalable bio-diesel; a bio-jet with significantly lower freezing point than Jet A; and a bio-gasoline with more energy content than ethanol.

DEKA This Manchester, N.H., company, founded by inventor Dean Kamen, is working to develop stirling engines for use in a number of applications including electric vehicles. Stirlings can use virtually any fuel source to produce electricity. These small, clean, quiet, and efficient power sources are attracting the attention of alternative vehicle companies.

DuPont Dupont is leading the way in developing and applying biotechnology to the challenges of materials and energy and demonstrating a capacity to do this at scale. It is a company that is willing to collaborate with others to find answers, as it has done with such companies as BP, Tate and Lyle, and Broin.

IndyCar Series Racing Beginning with the 2007 racing season, all cars are fueled with 100% fuel-grade ethanol. As an early proponent of renewable fuels and an innovation leader, the IndyCar Series is the only major racing series to take this position. The use of ethanol to power the cars at more than 200 MPH has showcased the fuel.

The State of Oregon In June 2007, the Oregon Senate passed a renewable fuels standard for the state that establishes minimum thresholds for in-state ethanol and biodiesel (or other renewable diesel) production and consumer tax credits for biofuel use. Currently, about 1 million gallons of biofuels are produced annually in Oregon.

Range Fuels This Broomfield, Colo., company is working to build the first commercial cellulosic ethanol plant in the U.S. Recently awarded up to $76 million by the U.S. Department of Energy, Range Fuels is developing a plant that will produce ethanol from wood chips from "unmerchantable" Georgia pine trees and forest residues.

Solena Group This global company, based in Washington, D.C., created a triple-patented application of plasma technology called plasma gasification vitrification. This process produces much-needed clean, renewable bio-energy in the form of bio-power and aviation bio-fuel, at the same time it addresses the complex biomass and waste management needs of industrial society.

The companies above were selected by independent consultants and the Energy Series 2007 Board of Advisors. The selection process did not involve BusinessWeek editors or staff.

BP Biofuels
Doing the Right Thing is Good Business

Global energy demand seems insatiable, but relying on fossil fuels alone to feed the beast would be a risky plan. Biofuels have a critical role to play, both in diversifying the energy mix and reducing the world's dependence on conventional fuels such as gasoline and diesel. In fact, energy experts predict that biofuels may represent as much as 30% of the planet's transportation fuels by the year 2030.

Ethanol and biodiesel are good first steps in this shift, but they are not enough. To help develop the next generation of biofuels, BP is using its leadership in the energy market to drive change.

"We are confident that responsible, rational, and progressive players can deliver the technology and market mechanisms necessary to support these developments," says Philip New, president of BP Biofuels. "We believe that firms like BP have a role to play."

To support this goal, BP is partnering with DuPont to facilitate the introduction of next-generation biofuels into gasoline. The first, biobutanol, offers several advantages. It can be easily added to conventional gasoline, employs the existing supply infrastructure, and can be blended at higher concentrations than ethanol for use in standard vehicle engines without compromising fuel economy. Additionally, biobutanol can be produced from the same renewable feedstocks that produce ethanol.

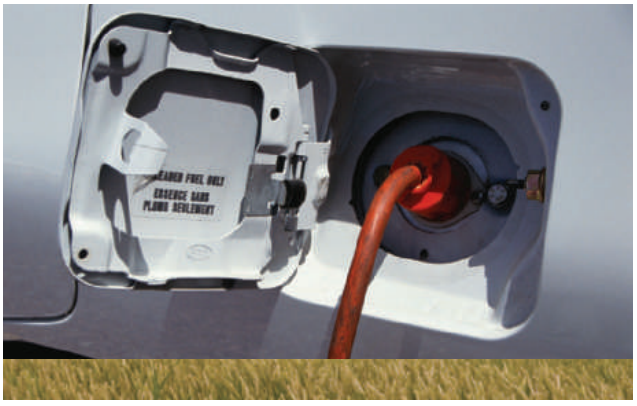
Engine testing for the exciting potential of biobutanol at BP's research center in Bochum, Germany.

In partnership with DuPont and Associated British Foods, BP is building a $400 million biofuels plant, initially for the production of ethanol, but with plans for conversion to the production of biobutanol.

BP is also making a major investment in the science of applying biotechnology to energy through its $500 million commitment to establish the Energy Biosciences Institute (EBI) with the University of California, Berkeley, the University of Illinois, and the Lawrence Berkeley National Laboratory. The EBI will perform groundbreaking research aimed at producing new and cleaner energy, with an initial focus on new biofuels crops and processes.

Further, to make more sustainable biodiesel feedstock available on a larger scale, BP is forming a venture to accelerate the planting of jatropha curcas, a drought-resistant tree that does not compete with food crops for agricultural land or adversely affect the rainforest.

"We can contribute to building the market in a way that's progressive and positive," says New. "By developing relationships with like-minded players, and developing and marketing innovative technologies and solutions, we can play a role in meeting the challenge of a growing global demand for energy."



Plugging into the Future Vehicles based on plug-in technology are on their way.

say that other transport options are "bridging technologies," mere stepping stones to a hydrogen economy.

One of the bridges available today is the hybrid drive train, in which internal combustion engines are matched with electric motors. The electric motors, charged by the turning wheels of the vehicle while braking, run the cars at low speeds and during acceleration. Hybrid cars, such as the Toyota Prius and Honda Civic, emit around 30% less carbon dioxide than gasoline vehicles. With hybrid cars reaching nearly 60 miles per gallon, the efficiency of

"We're thinking through how engines and energy can both develop in ways that are convergent – rather than divergent – to increase fuel economy and reduce carbon emissions."

—Philip New, president of BP Biofuels

gas-electric hybrids is resonating with consumers looking for higher fuel economy. Though today's hybrids still depend on fossil fuels for most of their power, hybrids are fast becoming a common sight on U.S. roads.

But for those looking to unchain themselves from fossil fuels as completely as possible, electricity is the fuel of choice. Electric vehicles use motors powered by rechargeable batteries, which can be plugged into standard outlets to charge over as few as three hours. Plug-in hybrids may be right around the corner. Like today's hybrids, plug-ins have a gasoline/electric drive train, but they have better batteries that enable the car to be plugged into the grid and run more fully on electricity alone, with gasoline as a backup. Engineers predict 100-mile ranges within a few years.

The hitch with plug-ins, according to Robert Shaw, president of the venture management firm Aretê Corp., is when and where you put in the plug. "If you recharge during peak loads from a utility, then all you're doing is forcing an increase of usage that will ultimately lead to greater CO_2 emissions. The trick is to provide an incentive to drivers to only recharge during 'base-load' periods, such as nighttime, or to find solar arrays to power their batteries."

Partnering for the Future

The transportation sector may offer opportunities for change because of the commonality of vehicle design and fuel characteristics. "There's quite a bit of cooperation between companies like ours and the vehicle manufacturers," says New. "Together, we're thinking through how engines and energy can both develop in ways that are convergent – rather than divergent – to increase fuel economy and reduce carbon emissions."

Rapid success is far from assured and depends on its own mix of technological advances and regulatory support. Many see biofuels and corresponding engine designs as the best supply-side option. But the existence of significant barriers means government and industry need to work together. Barriers to growth in the U.S. include feedstock limits, distribution constraints (from lack of trucking to a shortage of barges), and increased resource prices (corn, for instance, in regard to ethanol).

Where to start, what bets to make, and how to get it all done are all variables in a laughably complex equation. Energy is at the heart of the world economy, and the world's population continues to grow. Failure isn't an option. Yet this situation hasn't been seen before, and getting it right means a mix of trial and error, at the government, corporate, and consumer levels.

The global system of energy is like a Rubik's Cube: Change one thing and you change the whole formula. But the players are moving forward nonetheless. BP's New is optimistic: "It may be complicated, but through a mixture of market mechanisms, thoughtful regulation, and technology innovation, things will get smoothed out."

ENERGY SERIES 2007

Web Directory

BP
ww.bp.com/us
www.bp.com/biofuels

U.S. Department of Energy
www.eere.energy.gov

Produced by Carey Publishing Group, www.careypublishing.com
Written by Henry Gentenaar, Reluminati LLC, www.reluminati.com
Designed by Segal Savad, www.segalsavad.com
Visit: www.businessweek.com/adsections
Photos: Cover (from left to right): © Getty Images, © iStockphoto;
This page: © Getty Images