ALTERNATIVE TRANSPORTATION FUELS AND ENERGY EFFICIENCY

Western States Petroleum Association

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PETROLEUM COMPANIES - ALTERNATIVE TRANSPORTATION FUELS AND ENERGY EFFICIENCY

Future energy demand will make it likely, if not certain, that petroleum-based energy supplies will continue to play an important role for many decades. Nevertheless, WSPA companies recognize that alternative sources of energy are a growing part of the world energy mix. They are investing dollars and manpower to help make that happen.

Much of their current activity is directed towards stationary power generation – such as the development of new, more efficient and/or cleaner ways to generate electricity (e.g., solar, wind, geothermal).

This report focuses on the petroleum industry's work on the development and commercialization of alternative transportation fuels. Many WSPA companies have created and staffed new organizations to spearhead these efforts. There are a few areas of special emphasis: hydrogen, biofuels, research, and energy efficiency.

HYDROGEN

Some consider hydrogen an ideal future transportation fuel. It can be used to power conventional, internal combustion engines, promising water as the only vehicle emission. But, its use in fuel-cell powered electric vehicles promises to be much more efficient. Two disadvantages are that hydrogen is difficult to distribute from a centralized production facility, and it is difficult to store, especially on-board a vehicle.

Many WSPA company efforts involve participating in programs to evaluate the viability of fuel-cell powered vehicles. Some companies provide refueling stations where hydrogen is produced from natural gas on-site, often using technology developed in-house. Some company projects involve technology to produce hydrogen from liquid fuels on board the vehicle itself.

Shell has built hydrogen refueling infrastructure for fuel-cell powered vehicle demonstration projects in Washington DC, Amsterdam, Reykjavik, Tokyo, Shanghai, New York, and California.

Shell also recently announced a 5-year agreement with Virent Energy Systems Inc. to further develop and commercialize Virent's BioForming technology for renewable hydrogen production. Joint development will be targeted for fueling station applications at Virent's facilities in Madison, Wisconsin and at the Shell Westhollow Technology Center in Houston, Texas.

BP has partnered with Ford, General Motors, and Daimler Chrysler to provide hydrogen for fuel-cell powered demonstration vehicles in London, Barcelona, Oporto, Sydney, Beijing, Michigan, Florida, and California. They also plan to provide hydrogen refueling facilities for fuel cell buses operating in public service in the cities of London, Hamburg, Barcelona, Oporto, and Perth.

BP also has a joint project with BMW to demonstrate the use of hydrogen in specially modified internal combustion engines.

Chevron is currently operating five hydrogen demonstration refueling stations across the U.S.; three stations in California, one in Michigan, and one in Florida. Each is demonstrating and evaluating a different technology for on-site production of hydrogen.

- Two of the California stations are located in Southern California and were designed to support a fleet of Hyundai-Kia fuel cell vehicles.
- In Northern California, Chevron has built a prototype hydrogen refueling station as part of the Bay Area HyRoad project. The station will provide fuel for small fleets of fuel-cell powered buses and automobiles operated by the Alameda-Contra Costa Transit District (AC Transit).
- In Florida, Chevron is collaborating with Ford and the State of Florida on the evaluation of hydrogen-fueled internal combustion engine buses.
- In Michigan, Chevron is collaborating with the Air National Guard to demonstrate and evaluate Chevron's advanced steam methane reforming and pressure swing adsorption technologies to convert natural gas into purified hydrogen.

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As part of a collaboration with the U.S. Department of Energy, Chevron has partnered with the Gas Technology Institute on a pilot-scale partial oxidation gas turbine project to evaluate the simultaneous production of hydrogen and power.

ExxonMobil is active in the Department of Energy's Freedom Car and Fuel Partnership activities. The company has also announced that it is carrying out R&D on a new process for generating hydrogen from hydrocarbon fuels. If successful, they believe it could impact future use of fuel-cell powered vehicles via improved ways to generate hydrogen, either at retail refueling stations or on-board the vehicle.

ConocoPhillips is working with a number of California companies to develop a hydrogen refueling infrastructure in the state. The company plans to test several approaches for producing hydrogen and providing infrastructure at twenty-four refueling stations throughout the state.

Several WSPA member companies, including BP, Chevron, and Shell are also members of the California Fuel Cell Partnership, a private-public consortium targeted at addressing the technological challenges that are presented by hydrogen fuel cells when used as transportation power sources.

ETHANOL

Many petroleum companies are blending more and more ethanol into gasoline. Some are also investing to reduce the cost and increase the benefits of ethanol production, and to investigate its more widespread use in gasoline.

BP, for example, is partnered with Dupont and Associated British Foods to construct a world-scale bioethanol plant in Hull, England. The plant will use locally grown wheat as feedstock.

Shell is investing in new methods of producing ethanol through the use of 2nd generation enzymatic technology for converting cellulose into sugars which can then be fermented into ethanol. They and their partner Iogen Energy are at present operating a pilot plant in Ottawa, Canada, with plans to build the first commercial plant in Canada.

Shell and Iogen Energy are also working with Volkswagen to assess the economic feasibility of building a commercial cellulosic ethanol facility in Germany.

ConocoPhillips is conducting R&D on the production of ethanol from coal via intermediate synthesis gas produced using ConocoPhillips' EGAS technology. That work is being done in collaboration with the Department of Energy, Oak Ridge National Laboratory, and the universities of Louisiana State and Clemson.

Chevron collaborated with the state of California, General Motors, and Pacific Ethanol to evaluate the use of E-85 as a vehicle fuel. Over a one-year period, Chevron provided E-85 (a mixture containing 85% ethanol and 15% gasoline) at two refueling sites to refuel a fleet of 50-100 vehicles owned by the state of California.

BIODIESEL

In 2006, ConocoPhillips began commercial production (1000 bpd) of biodiesel produced from soybean oil at their Whitegate refinery in Cork, Ireland. They have also formed a strategic alliance with Tyson Foods to produce in their refineries and market next-generation biodiesel, or renewable diesel, derived from processed animal fats.

BP has announced that its Bulwer refinery in Queensland, Australia will produce commercial quantities of biodiesel from tallow feedstock.

Shell has partnered with CHOREN Industries in the development of a new process for producing diesel fuel from wood chips, straw, and other sources of biomass. The biomass is first used to produce synthesis gas, which is then converted to biodiesel using Shell's GTL process for converting gas to liquids. Following successful pilot production, CHOREN industries is building a demonstration plant and planning a commercial plant.

OTHER BIOFUELS

BP has entered an alliance with Dupont to commercialize the production of biobutanol for use as a gasoline component. The partners will begin infrastructure and vehicle testing this year.

In June of this year, BP announced the formation of a 50/50 joint venture with D1 Oils to accelerate the development of Jatropha plantations in South East Asia, Southern Africa, India, as well as Central and South America. Jatropha is an inedible, oil-bearing crop that can be grown successfully on marginal land, unsuitable for food crops. Jatropha oil produced from the plantations will be used to meet local biodiesel requirements and for export to European markets.

Previously, BP had announced that it was funding studies in India to explore using products derived from Jatropha as components of biofuels.

Chevron has entered into a partnership with the National Renewable Energy Laboratory (NREL) to explore the production of liquid fuels from algae.

In February 2008, Chevron and the Weyerhaeuser Company created a 50-50 joint venture company that will focus on developing the next generation of renewable transportation fuels from nonfood sources. The joint venture, Catchlight Energy LLC, will research and develop technology for converting cellulose-based biomass into economical, low-carbon biofuels. The formation of Catchlight Energy is the first milestone of a biofuels alliance announced by

Chevron and Weyerhaeuser in April 2007, and reflects the companies' shared view that nonfood biofuels will play an important role in diversifying the nation's energy supply.

ConocoPhillips and Archer Daniels Midland Company have announced they will collaborate on developing renewable transportation fuels from biomass. The alliance will research and seek to commercialize the conversion of crops, wood or switchgrass into biocrude, which would then be converted into fuels.

UNIVERSITY RESEARCH

The biofuel production technologies in widest use today require feedstocks that are also food crops (e.g., corn, sugar cane and soybeans). These feedstocks may be comparatively expensive and their use sets up competition between the food and energy markets for the same agricultural resources.

Economic processes able to produce biofuels from cellulose (biomass) on a commercial scale would be a major step forward. Scientific breakthroughs are needed to make this a reality. For this reason, a substantial part of petroleum industry attention is focused on appropriate University R&D. Examples include the items below.

BP founded the BP Energy Biosciences Institute combining the efforts of UC Berkeley, the Lawrence Berkeley National Laboratory, and the University of Illinois. Funding is expected to be in the hundreds of millions of dollars, and up to fifty BP scientific staff will locate at the two university campuses.

BP is also helping fund unique research at Arizona State University which is aimed at producing biofuels from containers filled with bacteria.

ExxonMobil founded the Global Climate and Energy Project at Stanford University in 2002. Funding is also expected to be in the hundreds of millions of dollars.

ConocoPhillips began an 8-year program at Iowa State University to develop new biofuel technologies. They are focusing on converting biomass to oil through pyrolysis, a process that uses heat in the absence of oxygen to decompose biomass into a liquid product. This “bio-oil” can be converted to transportation fuels at petroleum refineries.

ConocoPhillips and the US DOE are co-funding a $2.9 million research effort on the conversion of coal-derived synthesis gas to ethanol. The research involves the universities of Clemson and Louisiana State, as well

as the Oak Ridge National Laboratory. The study will use ConocoPhillips EGAS technology to produce synthesis gas from coal.

Chevron and the Georgia Institute of Technology formed a strategic research alliance to pursue advanced technology aimed at making cellulosic biofuels and hydrogen viable transportation fuels. The alliance is focusing its research on four areas: production of cellulosic biofuels; understanding the characteristics of biofuel feedstocks; developing regenerative sorbents; and, improving sorbents used to produce high-purity hydrogen.

Chevron and UC Davis executed a research agreement directed at the development of technology for production of liquid transportation fuels from biomass feedstocks. The objective of the Chevron-UC Davis research is to develop commercially viable processes for the production of transportation fuels from renewable resources such as new energy crops, forest and agricultural residues, and municipal solid waste.

The collaboration is expected to focus its research on four areas: understanding the characteristics of current California biofuel feedstocks; developing additional feedstocks optimized for features such as drought tolerance, minimal land requirements, and harvesting technology; production of cellulosic biofuels; and, design and construction of a demonstration facility for biochemical, and thermo chemical production processes.

Chevron and Texas A&M University executed a strategic research agreement to accelerate the production and conversion of crops for manufacturing ethanol and other biofuels from cellulose.

Chevron will support research initiatives that will focus on several technology advancements to produce biofuels including: identifying, assessing, cultivating, and optimizing production of second-generation energy feedstocks for cellulose and bio-oils with a focus on non-food crops; characterizing and optimizing the design of dedicated bioenergy crops through advances in genomic sciences and plant breeding; developing integrated logistics systems associated with the harvest, transport, storage, and conversion of bioenergy crops; and, developing advanced biofuels processing technologies.

Chevron, ConocoPhillips, and Shell are founding members of the recently formed Colorado Center for Biorefining and Biofuels. Other participants include the University of Colorado, Colorado State University, the Colorado School of Mines and the National Renewable Energy Laboratory. The mission of C2B2 is to improve fundamental understanding and develop new technologies in areas relevant to the

future commercialization of integrated, sustainable biorefining and biofuels processes.

ELECTRIC AND ENERGY EFFICIENCY

ExxonMobil has developed a battery separator film technology to allow lithium-ion batteries to be used to power drivetrains of all electric or hybrid vehicles. This may result in increased safety, power, efficiency, and reliability of next generation battery technology for vehicles. ExxonMobil has signed an agreement with an all-electric auto manufacturer to apply the technology in actual commercial operations.

Valero is implementing advanced control technologies to improve combustion efficiency at refineries nationally. That new technology is expected to reduce CO2 emissions by 1.8 million tons per year by approximately 2008. Project upgrades at its Benicia and Wilmington refineries are planned to decrease C02 emissions by more than 140,000 tons per year.

Tesoro installed two state-of-the-art flare gas compressors at its Golden Eagle Refinery in Concord, CA. This equipment takes flare gases – hydrogen, nitrogen, methane and other hydrocarbons – compresses them and returns them to the refinery for use as fuel. The project reduced flaring by 90 percent, which in turn reduced flare emissions by 94 percent.

At its Salt Lake City Refinery, Tesoro's cogeneration operation (using natural gas to generate both electricity and steam), reduces emissions at that facility by more than 500 tons each year.

SOURCES

The activities described in this report were found on the public web sites of the individual companies. Most were found in recent, publicly available press releases archived by each company.

Chevron:

www.chevron.com/news/press contains a search function. Entering “biofuels”, “hydrogen”, and “alternative fuels” led to the information cited.

www.chevron.com/globalissues/climatechange/actionplan was also useful.

ConocoPhillips:

www.conocophillips.com/newsroom/news_releases provided most information.

The home page also has a major heading called “Technology & Innovation”, with a subsection “Emerging Technologies” which was helpful.

ExxonMobil:

www.exxonmobil.com/corporate/files/corporate/tomorrows_energy.pdf leads to a report in which pp. 14-17 contain the information cited.

BP:

www.bp.com provides a search function. Entering “biofuels” and “hydrogen” led to all the information used.

Shell:

www.shell.com

Selecting the major heading “Technology and Innovation”, then the subsection “New Energy Sources” leads to sections on hydrogen and biofuels.