

RESEARCHING ALTERNATE FUELS

GLASS ENGINE POWERS AUDI'S VIEW OF RENEWABLE E-FUELS

BY **JAMES E. GUYETTE** | NEWS CORRESPONDENT

Seeking to wean the world's motorcar fleet off petroleum and the accompanying political turmoil and environmental hazards, Germany's Audi is developing e-fuels that include a product line consisting of microorganisms that are combined with non-potable water – brackish, salt or wastewater – sunlight and carbon dioxide to create high-purity, non-fossil fuels suitable for powering automotive engines.

"We're taking another step closer to carbon-neutral mobility," says Reiner Mangold, the automaker's chief of sustainable product development.

TRENDS & MARKET ANALYSIS

"We are supporting an innovative technology here which can be used to produce renewable fuel," he reports, adding that the research into e-gasoline, e-diesel, e-methanol and e-(natural) gas is poised to eliminate a controversial dependency on edible crops. "This process does not create competition with food production and farmland."

A special glass engine allows Audi's engineers and scientists to view and analyze an assortment of combustion scenarios.

"This test setup reveals the processes that are otherwise hidden by the metal walls of the cylinders," Mangold points out. "A small window made of quartz glass enables the experts to observe the fuel's behavior in the cylinder and how it interacts with the airflow in the combustion chamber. During each of up to 3,000 revolutions per minute in the research engine, a minute amount of fuel shoots into the glass cylinder, is compressed and ignited, and the exhaust gas then expelled," he explains.

"Unlike fossil fuels, the composition of which varies depending on their place of origin, synthetic Audi e-fuels are absolutely pure fuels," according to Mangold. "Thanks to their chemical properties, fewer emissions are generated when they are burned. They do not contain any olefines or aromatic hydrocarbons. As a result, the synthetic fuels assure a more effective mixture preparation process, cleaner combustion and lower emissions."

The extensive e-fuels strategy includes working on an e-gas fuel at a laboratory in Werlte, Germany. "It demonstrates how large amounts of green power can be stored efficiently and independently of location by transforming it into methane gas and storing it in the natural gas network," says Mangold.

In January Audi announced a col-

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Q&A

TIMOTHY G. NASH
Northwood University
professor



Q

HOW WELL IS THE AFTERMARKET PREPARED TO EMBRACE REPAIRS FOR ALTERNATIVE FUEL SYSTEMS?

A

Editor's Note: Northwood University Professor Timothy G. Nash will be among the expert speakers

at the Automotive Aftermarket Products Expo (AAPEX) in Las Vegas as he takes part in conducting a Nov. 4 seminar entitled Aftermarket Dynamics and the Road Ahead: 2015.

A: Generally speaking, this question begs for a free market answer. The beauty of the aftermarket is that it is well suited to adapt to whatever the market throws at it if it is profitable to do so.

Q: How would you rate the ongoing pattern of acceptance for electric vehicles? Is a network of charging stations and EVs something that the industry should be preparing for in earnest?

A: Certainly there are more and more electric vehicles on the road. From an aftermarket perspective, we are less concerned about charging stations and more concerned about the readiness of aftermarket service dealers to provide the service and repair of these vehicles.



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“UNLIKE FOSSIL FUELS, THE COMPOSITION OF WHICH VARIES DEPENDING ON THEIR PLACE OF ORIGIN, SYNTHETIC AUDI E-FUELS ARE ABSOLUTELY PURE FUELS. THANKS TO THEIR CHEMICAL PROPERTIES, FEWER EMISSIONS ARE GENERATED WHEN THEY ARE BURNED. THEY DO NOT CONTAIN ANY OLEFINES OR AROMATIC HYDROCARBONS.”

- REINER MANGOLD, AUDI

laborative project with France’s Global Bioenergies to develop isobutene-derived isooctane, a high performance biofuel for gasoline engines.

“As a 100 percent drop-in fuel, it can be used in any blending ratio with all standard fuels for gasoline motors. It does not present the drawbacks associated with alcohol-based biofuels such as ethanol or isobutanol, which lead to limited blending ratios and lower mileage,” says Thomas Buhl, Global Bioenergies’ senior business development manager.

“Audi is a frontrunner at implementing sustainable solutions for all aspects directly linked to its products,”

he notes. “Three parameters are key to Audi in pushing forward the development of new biofuels: The quality of the fuel to ensure optimal compatibility with its engines, the environmental footprint in particular regarding CO2 emissions, and the requirement to use feedstock not in competition with eatable resources,” says Buhl.

The project to utilize microorganisms, wastewater, sunlight and carbon dioxide to produce e-ethanol and e-diesel is taking place at an Audi research facility in Hobbs, N.M. Joining with Bedford, Mass.-based Joule, scientists report that they have achieved a near-100 percent increase

in photosynthetic efficiency.

“With our American partner Joule, we have been able to modify and optimize the process to make the microorganisms directly produce either ethanol or long-chain alkanes for diesel,” explains Audi project manager Sandra Novak.

At the end of this photosynthesis process, the ethanol or the synthetic diesel fuel is separated from the water and cleaned. “The characteristics of Audi e-ethanol are exactly the same as those of regular bio-ethanol and can be used immediately as the basis for E85 fuel (85 percent ethanol, 15 percent gasoline). Audi e-diesel, too, can



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Is the aftermarket distribution channel prepared to source and stock a new range of products? Are technicians trained to service these vehicles? The last thing the aftermarket wants is for the motoring public to take their electric vehicles to the dealer because the aftermarket cannot service these vehicles.

Q: Do you think the industry and motoring public will ever fully accept a substitute for fossil fuels?

A: Absolutely! The U.S. carbon footprint has declined in recent years largely due to better technology and the realization that pollution at its core is waste and inefficiency. LED lighting sales are skyrocketing because they provide more candle power and cost a fraction to operate relative to their predecessors. The same type of breakthrough innovation needs to drive alternative fuels and sales will follow. We have no doubt that entrepreneurs will make this happen within 10 to 15 years.

Q: Implementation of alternative fuel sources tends to be hampered by the “chicken or egg” issue. OEMs are reluctant to produce mass quantities of vehicles that people are reluctant to buy because fueling stations are scant, and fuel providers are reluctant to construct filling/charging facilities because they may have a paucity of people using them. What can be done to remedy this situation?

A: In the early- to mid-1800s the primary mode of transportation in the U.S. was the horse and buggy/wagon or the canal. Major inventions from the train to the automobile were initially opposed or deemed unsafe. Once they gained acceptance, roads, fueling stations, train stations, tracks, etc. emerged over time, not overnight. A successful market-driven technology will be the catalyst to wide-scale use of alternative fuels and logical government policy and partnerships – just as it was with the automobile and the train.

Q: Numerous alternative fuels are being developed; is there any one system that stands out as being both practical and acceptable to mainstream motorists?

A: According to the 2014 U.S. Annual Energy Outlook, there were just under 14 million alternative fuel vehicles on U.S. highways out of roughly 253 million in 2012, or 5.4 percent of all vehicles on the road. This is good progress over the last decade, yet

data indicates growth is slowing as it has been driven by government subsidies and/or tax incentives, which often come into question during challenging economic times and the political philosophy of the U.S. Congress and/or White House.

Q: How would you assess the nation’s willingness to wean itself off fossil fuels? Do you anticipate significant strides regarding this within the decade or so?

A: The market is not purchasing alternative fuel vehicles in mass quantities because the prices of said vehicles are too high relative to pure fossil fuel powered vehicles. The U.S. should not increase fuel taxes on gasoline to drive people to purchase higher priced alternative fuel vehicles and take highly subsidized public transportation in the U.S. like is done in Europe, as most Americans do not have, nor want, such a system as it limits freedom of mobility and job opportunity outside of major urban areas. Also, high taxes on fuel disproportionately limit a poor person’s ability to purchase a car and their mobility. Competition, investors and innovation must make these technologies and alternative fuels more affordable.

Q: How do you rate the near-term prospect of success for ethanol?

A: Eighty-two percent of the alternative fuel vehicles are powered by engines that can run on gasoline or a gasoline/ethanol blend called E85; most owners do not use E85 fuel. Eighteen percent are hybrid gasoline, natural gas, hydrogen, diesel and/or electric vehicles. As you can see, the true percent of the U.S. market embracing alternative fuels today is well below 5 percent, yet ethanol is the clear leader.

Q: Audi, Joule and Global Bioenergies are working on a synthetic e-fuel that involves microorganisms using water (brackish, salt or wastewater), sunlight and carbon dioxide to produce high-purity fuels. How would you assess the practicality and timeframe of e-fuels replacing fossil fuels?

A: It is impossible to say. The replacement of something as well established as fossil fuels will take more than just a good idea. There are many other things to take into consideration beyond the technology. From an aftermarket perspective, we are a reactive industry and we will accommodate whatever technologies the OEMs throw our way.

be mixed without restriction with fossil diesel,” she says.

“Audi e-ethanol and Audi e-diesel do not need biomass for their production and can be made in regions unsuited to agriculture,” Novak continues. “This finally puts to end discussions about ‘food or fuel,’” she asserts.

“Obviously they, too, produce CO₂ when burned. However, our Audi e-fuels are climate neutral, as the microorganisms consume the same amount of CO₂ from the atmosphere. The bottom line is that a car powered by e-fuels has a similarly good carbon footprint to that of a battery-powered car driven by electricity from renewable sources,” says Novak.

“By effectively taking photosynthesis out of nature and into a controlled system, we have been able to realize its industrial potential,” says Joule chief scientific officer Dan Robertson.

“Our biocatalyst, reactor and process have been developed in parallel to solve a natural mismatch between the photosynthetic conversion of energy and the metabolic processes which use that energy,” he elaborates. “As a result, we have demonstrated a production platform unlike any other – capable of producing liquid fuels directly from sunlight and CO₂ with efficiencies previously thought unattainable,” says Robertson.

“Audi chose to align with Joule in support of its ambitious vision for CO₂-neutral mobility. This vision, in part, calls for increasing levels of renewable fuels to supplant petroleum-derived fuels and reduce related CO₂ emissions. The strategic partnership will directly enable Audi’s e-ethanol and e-diesel programs,” he notes. “For Audi, the agreement fits with its stated objective to become a carbon-neutral personal transportation provider for generations to come.”

By selecting a particular catalyst, Joule’s CO₂-to-liquids platform can be tailored to produce multiple products. “Each of our catalysts is engineered to convert CO₂ to a specific molecule of interest, including ethanol and hydrocarbons that comprise diesel, jet fuel and gasoline,” according to Robertson. “Our first commercial products will include Joule Sunflow-E, solar-derived

ethanol, and Joule Sunflow-D, the world's first hydrocarbon diesel fuel produced directly from sunlight and waste CO₂. We have also demonstrated the capability to produce a number of valuable chemicals that are typically derived from petroleum."

Fueling biofuel's growth

According to a recent report from Navigant Research, worldwide revenue from biofuels for road transportation is expected to grow from \$166.5 billion annually in 2014 to \$337.8 billion by 2022.

"Over the last 10 years, growth in the biofuels sector has been driven by the increase in ethanol production capacity in the United States and Brazil, and in biodiesel in Europe," says Scott Shepard, a Navigant research analyst. "Today, the industry is on the verge of entering a new phase of development focused on advanced and drop-in biofuels."

Citing the report, entitled, Biofuels for Transportation Markets, Shepard says "commercial-scale production of cellulosic feedstock biofuels is just getting underway." He goes on to observe that "recent developments in drop-in biofuels propelled by the aviation industry and the U.S. Department of Defense are driving down the costs of these advanced biofuels, enabling commercial-scale drop-in biofuels production. Meanwhile, large oil-consuming nations concerned about energy security, climate change and economic stagnation are driving global biofuels markets through a number of policy platforms, principally biofuels mandates."

In July the U.S. Department of Energy announced that up to \$4.5 million is being made available to the Clean Cities program to further expand public acceptance of alternative fueled vehicles, including plug-in electric, natural gas, propane and flexible fuel systems.

The funding is geared to support seven to 15 deployment projects in on-the-road demonstrations, safety-related training and emergency preparedness.

The first area of funding focuses on increasing the number of drivers that can experience alternative fuel vehicles first-hand. "Projects in this area will help potential buyers drive these vehicles for extended periods of time and gather data about their experiences. By increasing access to these vehicles through car-sharing, rental car and commercial fleet leasing programs, more drivers will understand their benefits and be more likely to purchase them," according to a position paper issued by the agency.

Projects under the second area of funding will develop and/or deliver training on alternative fuel vehicles to emergency first responders, public safety officials and automotive technicians. "This area may fund in-person workshops and online training courses to educate these vital personnel on safely handling and responding to incidents involving alternative fuel vehicles."

The third area of funding will support efforts to incorporate alternative fuels into city, state and regional emergency management plans. "Because natural disasters often interrupt gasoline and diesel fuel supplies, alternative fuel vehicles and infrastructure can be valuable resources for disaster relief and emergency response teams," the department notes. □

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