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Technology That Breaks the Car Industry Mold

As the auto industry faces tougher fuel-economy standards, engineers are working on longer-term fixes for what ails today's models: too much weight, inefficient engines, a troubled fuel source for gasoline-powered cars and recalcitrant batteries in electric ones. Here's a look at four technologies that could make cars more environmentally friendly.

Carbon Fibers to Trim Vehicle Weigh

Cutting a car's weight is one of the best ways to boost fuel economy. And one way to reduce weight is to replace some of the steel in a car's body with a material called carbon fiber.

But carbon fiber is too expensive for widespread use—it costs at least four times as much as steel by weight. That's why its use has been limited to luxury vehicles such as the Audi R8 and racing cars, along with some airplanes and golf clubs.

Now, researchers hope to make automotive-grade carbon fiber using a process similar to how knitting yarn is created. The development could lower the price of carbon fiber by as much as 25%.

And reducing weight in one vehicle part can cut weigh elsewhere by allowing the use of lighter-weight supporting parts. "For every pound you take out of a vehicle, there is usually a corresponding 30% reduction in the need for weight in other areas of the vehicle," said Jay Baron, the director of the Center for Automotive Research in Ann Arbor, Mich., who is a materials expertCarbon fiber is a thin strand of repeating carbon molecules lined up in parallel, an arrangement that makes them incredibly strong. T hese tiny filaments are wound into strands that are subsequently turned into a fabric. The fabric is then combined with a glue-like chemical and hardened into the final shape of a car part, such as a hood or trunk lid.

The knitting-yarn breakthrough was developed at Oak Ridge National Laboratory in Tennessee. Researchers later persuaded a yarn factory in L isbon, Portugal, to set up a portion of its plant to produce the product, said David Warren, the manager of transportation materials at Oak Ridge Lab.

Carbon fiber and acrylic yarn both are made from a chemical called polyacrilinitrile. The chemical is treated and screened into strands that are used to make fiber. Mr. Warren's team found that auto-grade carbon fiber could be made by altering the process at the knitting-yarn factory by adding additional screening and chemicals, but not at a great expense, he said.

Meanwhile, another part of the cost is turning the carbon fiber into fabric. Much of that comes in energy use and the length of time needed to treat the materiald in a sort of baking process, Mr. Warren said. BMW AG is trying to overcome the

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issue by producing carbon fiber at plant near Spokane, Wash., where inexpensive electricity is created by hydropower. BMW has a contract to buy power at three cents per kilowatt hour, about a third the going rate across the U.S. and much cheaper than in Europe.

The carbon fiber fabric made there is shipped to Germany to be formed into car parts. BMW is doing the work in a partnership with SGL Carbon SE of Germany.

Ultracapacitors Aim at Batteries' Shortfalls

The first electric vehicles now on the road are limited by the immense cost and weight of their giant battery packs, which are needed to store huge amounts of energy. Scientists working to improve batteries face the fundamental limitations of battery chemistry.

But there is another energy-storage device that could radically cut the cost of electric and hybrid vehicles while improving their performance.

AFP/Getty Images

Battery technology curbs driving range in electrics such as Nissan's Leaf

The device is called an ultracapacitor. Related to the tiny capacitors long used in electronic products such as TV sets, they can absorb large amounts of electricity quickly, and then discharge it just as fast.

Ultracapacitors function in very cold or very hot air without the temperature-related problems batteries can experience. They also can be recharged millions of times before failing, compared with a few thousand times before a battery goes bad.

On top of that, ultracapacitors are made of inert and abundant materials such as carbon, compared with the rarer metals like cobalt and lithium used in batteries. There's also no chance an ultracapacitor could overheat and cause a fire, as some batteries have done.

The devices work by capturing electrons in a field between carbon-coated metal plates contained in an electrolyte solution. Batteries, in contrast, rely on a chemical process that builds up electrons between an anode and cathode.

The big limitations in using ultracapacitors in cars have been their cost and limited amount of energy storage by weight compared with batteries. But that's changing.

"Five years ago, they were considered too expensive and there were questions about our ability to mass-produce them," said Mike Sund, vice president of investor relations for ultracapacitor maker Maxwell Technologies of San Diego. "Our manufacturing costs have been reduced by two-thirds over the past three years."

Researchers believe ultracapacitors could replace batteries entirely in hybrid vehicles and be paired with much smaller batteries in all-electric vehicles, cutting costs while improving the driving range.

Already, a few vehicle makers use ultracapacitors. PSA Peugeot Citroën SA of France has begun deploying Maxwell's ultracapacitors instead of batteries in its diesel cars in Europe, where they run the car's electronics as part of a fuel-saving "start-stop" system that shuts off the engine at stop lights. Chinese bus companies also are putting ultracapacitors in some hybrid buses.

Toyota Motor Corp., the largest maker of hybrid vehicles with the Prius, has been investigating ultracapacitors and found them too expensive and difficult to manage with the electronic system that controls the flow of current into and out of the car's batteries, said spokesman John Hanson. But Panasonic Corp., which works closely with Toyota

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on batteries, is one of the leading producers of the technology and is making advances.

Anu Cherian, a power and energy analyst with research firm Frost & Sullivan, said ultracapacitor technology is tantalizing. "But it has to be shown that it can work with batteries, because they can't be used by themselves" in pure electric cars, she said.

Research at the U.S. Department of Energy's Argonne National Laboratory aims to show that pairing ultracapacitors with batteries could allow electric-car makers to cut the size of batteries in half and lengthen their lives.

BMW aims to mass-produce a carbon fiber interior shell for its MegaCity electric vehicle that will lower the car's weight by about 772 pounds, or roughly 20%. Lighter electric vehicles can use smaller batteries, and batteries are even more expensive than carbon fiber.."The processing cost of manufacturing carbon fiber is very high," said Tom Kowaleski, a BMW spokesman. "We've taken on the task to try to break that."

Start-Ups Make Gasoline From Wood

There are reasons why gasoline has been the dominant motor-vehicle fuel for a century: It's packed with energy, noncorrosive, easily transported and readily available.

As the world looks for alternatives to counteract global-warming gasses and other pollution, as well as boost energy security, almost all the proposals require major tradeoffs or an entire new infrastructure, such as charging stations for electric vehicles.

But what if you could make gasoline out of readily available plants? Not ethanol, which requires huge amounts of water and energy to produce and is corrosive. Real, actual, gasoline.

It's not science fiction. A number of start-ups are working on technologies that produce oil substitutes or the base products of gasoline from wood chips or other so-called biomass through a process called pyrolysis.

One firm, KiOR Inc., has pledged to build five plants in Mississippi to create "Re-Crude," a crude-oil substitute that can be refined into diesel fuel or gasoline. Another, Annellotech, is working to build a demonstration plant to make gasoline compounds directly from biomass.

KiOR declined to comment. The company already has a small plant that it previously said produces 15 barrels of crude oil a day. The factory uses a reactor that breaks down the biomass plant materials using a chemical called a catalyst.

Annellotech, meantime, uses a similar process to make biomass into the base chemicals of gasoline. Its system is based on research from the University of Massachusetts Amherst.

The technology is intriguing because it creates oil and other petrochemicals like benzene, from cellulose—but without most of the troubling drawbacks that other biofuels have.

"We're making gasoline. The molecules we make are exactly the same as what is made in petroleum today," said George Huber, the UMass chemist who created the process used by Annellotech.

Most plant material can be used, but wood chips or sawdust are best. This material is first dried and ground up, then fed into a device called a fluidized bed reactor, where it is heated and put under vacuum.

An inexpensive chemical catalyst called a zeolite is introduced to the mixture, which turns it into a hydrocarbon gas. The gas, in turn, can be transformed into gasoline.

Meantime, the catalyst is recycled and fed back into the reactor to process more.

One of the reasons the technology is so intriguing is that other biofuels, such as cellulosic ethanol, require a time-consuming fermentation process to break down the molecules in plant material. Then, a huge amount of heat and water are required to make alcohol from the results, and more heat to distill it into ethanol.

Most biofuel companies envision building plants

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in rural areas near large supplies of biomass, like wood chips, corn stalks or other wood waste that is often burned or composted today. For Annellotech, the process produces about 85 to 100 gallons of liquid from each ton of biomass.

Annellotech says the process is so inexpensive that a plant should be able to make a profit on the gasoline as long as crude oil sells for $30 a barrel or more—it was above $90 Wednesday.

"We have to be competitive with oil on a dollar for dollar basis," said David Sudolsky, the CEO of Annellotech. "We know we can't count on this business working as just a 'green' business."

KiOR has pledged to build five plants in Mississippi with state aid, including a $75 million loan. The plants don't need to be large or expensive to make money, the company says. It says it will invest $500 million in Mississippi for three of the five plants in the next five years.

The technology has limits, however. The raw biomass is so heavy it can't be transported efficiently, capping the size of any plant.

A typical oil refinery can produce two million gallons of petroleum products a day. Annellotech is proposing a plant that could make up to about 250,000 gallons a day.

Chevron Corp. is researching various forms of creating fuels from biomass, but the oil giant casts doubt on how well it can be cost-effectively scaled up to large volumes and how sustainable using wood feedstock is.

"This is a very good idea—similar research was conducted in the 1980s and early 1990s, but there was not that much interest because of the price of crude oil," said Stefan Czernik, a researcher at the National Renewable Energy Laboratory in Golden, Colo.

Still, he said, "I'm not that optimistic that it would be implemented very soon" because of the need to make the process work on a large scale.

New Engine Seeks 50% Economy Boost

The auto landscape is littered with variations on the internal combustion engine that fell by the roadside. But one is gaining notice with its promise of a 50% boost in fuel economy.

The technology makes what seems like a minute change in when the gasoline ignites inside an engine. But that split-second twist has a big impact on how efficiently the engine operates.

Nearly every gas engine today shoots a mist of fuel into the engine's cylinder and, as the piston squeezes the fuel and oxygen into a hot, high-pressure environment, a spark is created and…KABOOM! The piston is sent the other direction and drives gears that eventually move the wheels. But the explosion actually happens a moment before the piston comes all the way to the top of the cylinder.

A start-up called Scuderi Group has developed an engine that causes combustion to occur after the piston reaches the top of the cylinder. That change could result in a 50% fuel economy improvement when the engine is paired with a turbocharger and a small air-tank, Scuderi says.

Scuderi Group, founded by a thermodynamics engineer and his family, is nearly finished testing the engine design to see how it performs under thousands of scenarios. The tiny company in West Springfield, Mass., says its design may be the fastest route for vehicle makers to meet tough new U.S. fuel economy standards.

Car makers must get their corporate average fuel economy to 35.5 miles per gallon by 2016. To reach that they are counting on using high-compression engines that are turbocharged or supercharged—two existing ways of getting more power out of a small, fuel-thrifty motor.

But the Scuderi method changes the mousetrap. Scuderi splits the compression and fuel intake into one cylinder and the combustion and exhaust into another. Existing engines use the same cylinder to do all the work, but combustion only occurs every other revolution of the piston.

The split-cycle engine isn't a new idea and, by itself, in lab testing shows only a modest

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improvement in fuel use. But with the small air tank that effectively stores energy and helps to maintain high compression, the engine produces large improvements in fuel economy.

The engine has received interest from Honda Motor Co. and Daimler AG, among others, and the company expects to license the technology to its first auto maker in the first half of 2011, said Sal Scuderi, son of the founder and president of the company. Representatives from both companies declined to comment.

Mr. Scuderi, the son of Carmelo Scuderi, who died in 2002, said the company has signed nondisclosure agreements with nine auto makers that have expressed interest, though the agreements prevent him from naming them. The company also has been able to raise $65 million in private investment capital, he said.

Some experts say the Scuderi design has merit. "It's a promising technology in theory," said Larry Rinek, a senior power train and technology analyst for Frost & Sullivan. But he said that until the engine is put in a vehicle and tested it is difficult to know how it performs.

Mr. Rinek said the Southwest Research Institute in San Antonio, which is assisting Scuderi in designing and testing the engine, is a respected engine-testing facility. If their results show the engine can perform as advertised it will add a new level of legitimacy.

Southwest Research Institute has built a 1-liter, two-cylinder test Scuderi engine and has been testing it for nearly a year. Among its findings is that it generates 135 horsepower at 6,000 RPM, Mr. Scuderi said. That's similar to the output of Honda's bigger and presumably more fuel-hungry 1.8-liter, four-cylinder engine, which generates 140 horsepower at 6,300 RPM. The third-party testing facility doesn't comment on its projects other than to verify things that its customers report.

"They've shown real progress," said Lindsay Brooke, senior technology editor for the Society of Automotive Engineering magazine. "But it becomes very difficult to convince the world that has billions of dollars invested" in one technology "to turn to something else."