Research groups around the world are working to develop artificial photosynthesis, which could greatly reduce our dependence on crude oil and make use of the growing amount of manmade carbon dioxide emissions. (Darren Staples-Reuters)

CAN HIGH-TECH PHOTOSYNTHESIS TURN CO_2 INTO FUEL FOR YOUR CAR?

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Imagine having a fuel pump in your driveway that uses photosynthesis, the same process plants use to feed themselves, to turn carbon dioxide into fuel for your car.

It's not science fiction: research groups all over the world have been working to develop artificial photosynthesis, which could greatly reduce our dependence on crude oil and make use of the growing amount of manmade carbon dioxide emissions that contribute to climate change. The concept received a nod from US President Barack Obama when he mentioned "turning sunlight into liquid fuel" in his State of the Union speech in January.

Despite carmakers' efforts to roll out electric cars, liquid fuels aren't likely to disappear any time soon. First of all, drivers are comfortable with – and accustomed to – their internal combustion engine vehicles and the process of finding gas stations and filling up a tank. And even if everyone decided to

switch to electric cars tomorrow, they wouldn't be likely to get rid of their conventional cars right away, given that cars often last 10-15 years.

Battery technology also isn't ready to replace all fuel tanks: batteries are heavier than gasoline and take up more space to deliver the equivalent power. The battery needed to power a jumbo jet over long distances, for instance, would be so large that it would leave no room for passengers. Electric powertrains also are unfeasible today for big ships.

Here's how artificial photosynthesis works: solar energy is used to split water and carbon dioxide into hydrogen, oxygen and carbon. A catalyst then recombines the molecules to create liquid fuels, such as methanol. Methanol is the simplest hydrocarbon that works in internal combustion engines. China already has already blended it into gasoline at low levels (15% or less) at retail pumps, and has taxi and bus fleets running on high-level blends of 85% methanol or more.

"When we develop a way to economically mimic photosynthesis, the impact on everything from global warming to our global economies is world changing," says Tim Young, chief executive officer of HyperSolar, a Santa Barbara, California-based company working to produce low cost hydrogen fuel from solar energy.

After 30 years of research, scientists have made significant progress over the past five years in bringing artificial photosynthesis to the market. Scientists at the California Institute of Technology have created a lab-scale device that converts 10% of the sunlight that reaches it into fuel, according to research published earlier this year. This compares with plants' ability to convert 1% to 2% of sunlight into sugars and other carbohydrates.

Speed bumps ahead

However, there's still a long way to go before the technology is ready for mass production. For one thing, it's still too expensive.

One of the biggest challenges has been figuring out how to split hydrogen and CO2 from water without using fossil fuels, which would undermine the environmental benefits, in a way that isn't cost-prohibitive.

To reduce the cost, significantly higher efficiency than 10% is needed, researchers say, as well as a cheaper catalyst. One of the most efficient and stable catalysts for splitting water is platinum, which – at about $1,100 an ounce – is too costly to be commercially viable for artificial photosynthesis, says Syed Mubeen Jawahar Hussaini, assistant professor of chemical and biochemical engineering at the University of Iowa and the main researcher at HyperSolar.

Making a device that's long-lasting will also be key to driving costs down, researchers say, and then there's the challenge of developing manufacturing equipment around the device that can mass produce fuels at a comparable production cost to gasoline.

"The real challenge is going to be how do you make something like [artificial photosynthesis] at a reasonable scale and have it work in the real environment," says Kathy Ayers, vice president for research and development for Proton Onsite, which is developing equipment to produce hydrogen gas for industrial applications.

In addition, while researchers have figured out how to split water and CO2 in separate processes, they have yet to come up with a single, long-lasting device that can do both, according to Dick Co, managing director at the Solar Fuels Institute at Northwestern University.

Solar Fuels Institute researchers are taking a modular approach: they plan to put the existing technologies for splitting water and CO2 together, building block style. They aim to complete a $250,000 prototype by the end of this year, says Kimberly Williams, the institute's managing director.

"These technologies have never been integrated in this way," Co says. "We want to find out what are the challenges, what are the integration risks. More importantly, let's have this in front of people, so they can see it from soup to nuts, from solar to fuel."

Myriad possibilities

The institute aims to bring its technology to the market within five years, targeting high end consumers that might currently be considering electric cars like the Tesla.

But it's unclear what the end products will actually be. Researchers are thinking broadly, and say they could be anything from consumer products that make fuel at home, such as a mobile carbon-capture device to regulate oxygen levels in classrooms in order to improve learning, to a commercial factory like a solar-based vodka distillery. The institute plans to either license the technology or partner with other firms to commercialize it, Co says.

Finding multiple markets for solar fuels will be critical to reducing their production cost, he adds. If that happens, then solar fuels could become as cheap as conventional fuels like gasoline in 10 years, he predicts.

Researchers at Northwestern's solar institute worry about whether they'll be able to secure enough government funding to even complete the work on the prototype, however. They hope to raise at least $100,000 in a Kickstarter campaign later this year.

“A pain point for researchers is the cycle of funding – it’s high, it’s low,” Co says. “It’s really difficult to manage. Ideas come and go. You can’t just sit and wait 15 years.” The Kickstarter campaign’s success or failure will also indicate consumers’ interest in alternative fuels, he claims.

Meanwhile, last month the US energy department announced it was renewing its five-year $75m grant to Caltech’s Joint Center for Artificial Photosynthesis, the US’s largest research program dedicated to developing artificial solar fuel generation technology.

The institute, a global research consortium that includes the Joint Center for Artificial Photosynthesis, Sweden’s Uppsala University and French energy company Total France, also aims to speed up artificial photosynthesis research by creating a database of academic papers, newspaper articles and other materials on the subject. It has developed algorithms to help its scientists search for information quickly and find collaborators. The database already contains about 50,000 pieces of data.

The institute isn’t the only one working to develop artificial photosynthesis technology. Panasonic is working to create formic acid, a fuel that, like methanol, can be synthesized from CO2 and can be used in hydrogen fuel cells. A European team of researchers is developing solar jet fuel. And the New CO2 Fuels program at Israel’s Weizmann Institute of Science seeks to convert CO2 into fuel.

Harry Atwater, director of Caltech’s Joint Center for Artificial Photosynthesis, said solar fuels research is about where the solar energy industry was about 30 years ago, and it’s just starting to create a new industry.

“We are powerfully inspired that we have a photovoltaic industry that is worldwide, multi-scaled with integrated manufacturing,” he said. “We’re laying the foundations that could produce [an artificial photosynthesis] industry in the future.”