Hydrogen milestone moves energy independence one step forward

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Pure hydrogen produced in INL's high-temperature electrolysis laboratory could provide a more efficient means for upgrading low-quality crude oils into petroleum.

(PhysOrg.com) -- Big things often come in small packages. That's certainly the case with the potential created by recent successes in hydrogen research at Idaho National Laboratory.

Steve Herring, technical director of the High Temperature Electrolysis Nuclear Hydrogen Initiative, holds in his hand a solid-oxide electrolysis cell no larger than a standard CD. However, the two electrodes and electrolyte that make up the cell are almost eight times thinner than a CD at a mere 150 microns.

"That's where we get into the physics and chemistry of what's going on here," said Herring. In that tiny arena, he and his team have been laboring for six years to create options for the U.S. and world to defend against looming problems in world energy supplies.

During the 1973 oil crisis, cars lined up for miles waiting to fill up with gasoline on even or odd days while prices skyrocketed and the broader economy suffered.

Now, an increasing number of scientists are predicting that similar conditions could exist with the peaking of world oil production. That peak, they project, could come within a generation or so. A 2007 report by the Government Accountability Office compiled studies to produce a conservative estimate that oil production would peak by 2040.

A world after oil production peaks will be inherently different from what happened in the 1973 crisis, though. Instead of slowly rebounding, oil production would instead slowly taper off, according to the study, and require global restructuring on a phenomenal scale.

But the researchers at INL think they may have at least part of the solution. The first thing that comes to the minds of many when they hear "hydrogen" is fuel-cell-powered vehicles. However, INL's team is focused on a more strategic priority.

Currently, "gasoline and diesel fuel actually have a lot of hydrogen that has been added to them, and that's one thing that a lot of people don't recognize," said Herring. "Next to a refinery, there's often a plant making hydrogen that is used for upgrading the petroleum."

In the near future, those refineries will likely begin to require more and more hydrogen as oil producers are forced to turn to lower quality sources for petroleum. "Particularly," said Herring, "what are called heavy crude oils, that have a lot of sulfur or that are tar-like."

Hydrogen, when added to petroleum, breaks apart the long chains of hydrocarbon molecules, creating a more flammable substance. Experts say that upgrading these reserves of lower-grade petroleum could prove to be one of the best defenses against cataclysmic economic implications brought on by peaking oil production.

But producing hydrogen requires large amounts of electricity to power the electrolysis process that splits water into its hydrogen and oxygen components, which is precisely why the work of Herring and his team is so promising.

By improving the efficiency and increasing the life span of the electrolytic cells, Herring and team aim to make the use of oil sands, biomass and other sources a viable option for transportation fuel.

And with recent successes, they have reason to be hopeful. The latest batch of electrolytic cells tested included modified electrodes that were designed to resist internal separation caused by oxygen bubble formation that had degraded performance in previous tests.

It worked. The new cells more than doubled the lifetime of their predecessors by lasting 2,583 hours with an average degredation rate of 8.2 percent for 1,000 hours, more than twice the previous best performance of 21 percent degredation per 1,000 hours.

The 10-cell stack just prior to the start of the test.

"It means that they're closer to commercial viability," said Herring. But even before the test had cooled down from its 800-degree Celsius operating temperature, the team was already planning on making the cells even better.

"I'm very much encouraged that it will be able to operate for longer periods of time," said Herring. "We'll have to take these cells apart and investigate what has happened inside them, and then change the way that they're fabricated so they can last longer."

That analysis will involve splitting up the work with partners like the Massachusetts Institute of Technology (MIT) researchers who will examine the edges of the cell using "Auger spectroscopy." They'll also use scanning tunneling and transmission electron microscopes that allow them to identify the electric fields surrounding individual atoms in the cell. In this way, they can identify what elements are building up in certain areas of the cell and begin to engineer electrolytic cell adjustments to further increase efficiency and longevity.

"It's been a lot of work by a number of people here, particularly Carl Stoots, Jim O'Brien, Keith Condie and Lisa Moore-McTeer," Herring said. "They've really worked hard in putting this all together over the last five or six years. And then keeping it running, that's always a real challenge."

Speaking of the progress that's been made since research began in 2003, Herring said, "It's the same sort of physics that occurs in electronics. That, too, was a process that took many years and a lot of trial and error to get devices that would last for a long time."

The lab is also taking other steps to advance hydrogen research, including building an experiment that will allow them to produce hydrogen and carbon monoxide for the synthesis of hydrocarbons. The idea, with electrolytic cells creating hydrogen on one end of the lab and a fuel synthesizer on the other, is to model the embryo of a future fuel synthesizing plant.

In cooperation with several manufacturers of ceramic cells, including Ceramatec and Materials and Systems Research Inc. of Salt Lake City, the NASA Glenn Research Center and the French firm St. Gobain, INL is also investigating new, thinner cell designs. Some of the new designs have electrolytes only 10 microns thick, or a quarter the thickness of a common human hair.

All these efforts, Herring hopes, can help the U.S. avoid the precarious cliff of peaking world oil production. "That's why we're doing this research," he said.

Provided by Idaho National Laboratory (by Brett Stone)