

Hotbed

By [Michael Fitzgerald](#)

Iceland is an anomalous place. First, thanks to the Gulf Stream, it isn't all that icy. That would be Greenland, named by Erik the Red, the inventor of travel marketing. That's not to say Iceland doesn't have weather -- I experienced four seasons in 30 minutes on a visit to the Gullfoss waterfall. There is an elemental war going on here: The clouds blot out every bit of light, then the sun stabs through in displays of horrible beauty; the postcard-perfect mountains look impermeable, but up close, it's clear they've been raked by watery claws of snow and rain; the ubiquitous lava fields wrestle with hummocks of grass and moss.

Depending on your point of view, Iceland was either the last part of Europe to be settled or the first part of North America to see Europeans. It sits on both continents, astride the Mid-Atlantic Ridge, where the earth's plates are gradually pulling apart, making Iceland a bubbling vessel of magma-heated water. Since its settlement by Vikings in AD 874, the country has remained remarkably isolated. The people -- all 300,000 of them, roughly the population of Aurora, Colorado -- are as homogeneous as the weather and the terrain are not. Iceland is Appalachia with different rocks.

Their remoteness, however, seems to have made Icelanders particularly resourceful. Faced with essentially no arable land, they built greenhouse farms to raise cucumbers and tomatoes and even bananas. In the fish-rich but almost uninhabitable north, Icelandic fishermen needed special clothing, which spawned 66° North high-tech outerwear, now sold in 15 countries. Icelanders have even managed to turn their own lack of diversity into an advantage: [deCODE Genetics](#), based in the capital, Reykjavik, has built the largest DNA database of its kind (on a per capita basis) to spot disease-causing mutations and use them to develop biotech drugs.

But Iceland's primary innovation, the one that puts it on the map for some of the world's largest companies, centers on renewable energy. The country has no coal, no petroleum reserves, and no trees. (The Vikings leveled the timber centuries ago, leading to this bit of local wit: "What do you do if you're lost in an Icelandic forest? Stand up.") Rather than continue to import every calorie of fuel, Icelanders figured out how to heat their homes with their copious geothermal supply; before long, they were generating geothermal electricity as well. Today, Iceland imports essentially no coal or oil for heat and power: 70% of its energy is renewable. Reykjavik is at the center of this energy vanguard, filling all of its needs from green sources, either geothermal or hydroelectric.

It is here that Iceland's ambition becomes clear. Having shown that it knows what it takes to move from one fuel source to another, this rocky little outpost is ready for something bigger. "We would like to be the world's laboratory for exploring a carbon-neutral future," says Ingibjörg Sólrún Gísladóttir, the country's foreign minister and former mayor of Reykjavik. Reykjavik Power, the world's largest geothermal heating company, and other local firms already export expertise to markets including China and the United States (which is the world's largest consumer of geothermal power and which hopes to

boost that usage exponentially). The next step: Proving that cars can run on something other than gasoline. That they can run, in fact, on hydrogen.

Energy Island

On my trip to Iceland last November, I became the first person in the world to rent a hydrogen-powered car. That I could do so was testament to the sheer force of will exerted over 30 years by people like Bragi Árnason. A now-retired chemist at the University of Iceland, Árnason started arguing back in the 1970s that hydrogen could power cars. People mocked him, but he weathered the barbs and slowly won converts, including a wisecracking energy physicist named Thorsteinn Sigfusson, who took the hydrogen-fuel concept out of the faculty club and into the market. Sigfusson helped found Icelandic New Energy (INE), a consortium of energy companies, and was its chairman until recently, when he was asked to run the Icelandic Innovation Institute.

At 6 feet, 4 inches and weighing something like 300 pounds, Sigfusson is part offensive tackle, part Katie Couric. "I'm a people whisperer," he says. Which means he likes to suggest ideas to others and then get out of their way, letting them make it happen. His affable nature has made him Iceland's unofficial ambassador of energy, and he greets groups interested in the country's green-energy prowess with gigantic air bear hugs. "Welcome, friends," he intones in his friendly baritone. "Welcome to Energy Island." During a serious presentation about energy physics, he'll slip in a playful slide on the diet of an energy society, comparing renewables, oil, and coal to proteins, carbs, and fat.

Sigfusson has done as much as anyone to push hydrogen fuel forward, enough that last year he was named a winner of Russia's Global Energy Prize, which rivals the Nobel in payout. He has a book coming out this spring called *Planet Hydrogen: The Taming of the Proton*.

Hydrogen is a paradoxical fuel, he says. But since it is the most plentiful substance in the universe and throws off only water when burned, it has been hailed as the answer to earth's dual fossil-fuel problems: dwindling supply and the ballooning greenhouse effect. So far, though, most hydrogen fuel is still produced either as a by-product of making fossil fuels or by burning them. In other words, it isn't much greener than oil.

Thanks largely to the persistence of Árnason, Sigfusson, and their colleagues, Iceland has begun making clean hydrogen fuel on a proto-commercial scale. As it turns out, that's a simple enough proposition given one thing: electricity derived from clean sources such as geothermal, hydroelectric, solar, or wind. The Shell station off Reykjavik's Miklabraut road has been producing hydrogen for almost five years, using green electricity to electrolyze water, splitting off the hydrogen atoms and then storing them at high pressure. It's a zero-emissions process.

So if Iceland can make clean hydrogen (locals pronounce it with a hard *G*), why can't the rest of us? The United States produces enough hydrogen to power 34 million cars, according to the Department of Energy, but 95% of it starts as natural gas and then is reformed in a nongreen process using steam and high pressure. (This hydrogen is used largely in refining petroleum and in creating ammonia used in fertilizer.) Since 1999, Daimler, Royal Dutch Shell, and Norsk Hydro, the \$31 billion Norwegian aluminum and energy company (it spun off its energy business in 2007), have been trying to replicate the Icelandic model. All three companies are part of INE, which built Shell's hydrogen station and sparked a 10-city hydrogen bus project funded by the European Union and later expanded to Beijing and Perth, Australia. David Haberman, a longtime investor in hydrogen fuel cells and an early partner in INE, explains that the consortium has already proved three things: Hydrogen is safer than oil or gasoline; people are willing and even eager to use hydrogen to fuel their vehicles; and governments can effectively educate their citizens about an alternative fuel. None of that was clear in 1999. Now the challenge is to

roll out this new blueprint to the rest of the world.

Iceland's neighbors are already paying attention. Iceland has been "an important learning project for us," says Per Øyvind Hjerpaasen, VP of hydrogen at [StatoilHydro](#), which was formed in October 2007, when the Norwegian state oil company, Statoil, bought Norsk Hydro's energy operations and in effect formed the world's largest offshore oil-and-gas company. Hjerpaasen says StatoilHydro and others are adapting those lessons as they build HyNor, Norway's hydrogen highway, a string of five or six hydrogen filling stations on the road along the country's southern coast. StatoilHydro will use wind and solar power to produce green hydrogen for these stations; it's also testing a station that uses hydrogen produced from fossil fuels and buries the carbon dioxide -- a process that might make hydrogen an option even in places dependent on coal-fired power plants. Once the Oslo station is built, in 2009, the hydrogen highway will go on through Sweden and Denmark to Germany, thanks to a project that's in the works among the four governments and a dozen major industrial firms, including StatoilHydro.

Meanwhile, INE forges ahead. Late last year, it helped the local [Hertz](#) to start importing Toyota Priuses, including the one I rented, that had been converted to run on hydrogen. INE will bring up to 40 hydrogen-powered cars to Iceland over the next two years for consumer testing. And in April, it will launch a whale-watching boat that uses hydrogen to run its auxiliary power system, the first time hydrogen has been used aboard a ship.

Hydrogen's Bill Gates

My first trip in the hydrogen Prius -- known in the business as an H Prius -- was to see one of Sigfusson's protégés, Hallmar Halldórs, who runs his new company, Icelandic Hydrogen, in a suburb of Reykjavik. I set off during rush hour, my heart racing at every rotary for fear of being the first person to crash a hydrogen car. (They don't blow up like the *Hindenburg* in a collision, but at \$100,000 a pop, my terror was justified.)

It was just a decade ago that hydrogen cars had room for only a driver -- the rest was given over to storing the fuel. Today, the only visible difference between my H Prius and the regular version is that the spare tire has to sit in the trunk.

After Halldórs checks out my car, he shows off his company. "We have a little work to do," he says with a grin, ushering me through a door in the machine shop owned by his business partner. Across the threshold, I find myself standing on a recently poured concrete slab -- under a rainy Icelandic night sky.

The 37-year-old Halldórs -- he repaired ship engines before starting his PhD in physics and getting hooked on hydrogen -- is well aware of the distance yet to travel. Still, he may just be hydrogen fuel's Bill Gates, circa 1977: His dream is a refueling station in every garage. He even has a working prototype, adapted from laboratory equipment, which looks like a PC server, only with tubing and a container for water. Right now, it can make about 1.5 kilograms of pressurized hydrogen fuel in a day, good for about two-thirds of the capacity of my Prius's tanks.

Halldórs's four-person company is pursuing a number of other ideas, including the possibility of small-scale filling stations that generate enough hydrogen to fuel three or four cars a day, about one-twentieth the capacity of the Shell station on the other side of Reykjavik. His partner has built a stainless-steel dispenser prototype. And Halldórs says he has already sold some related technology to two customers abroad, though he won't name them.

Like any good visionary, Halldórs thinks hydrogen fuel is coming fast. In fact, he expects there will be a substantial market by 2015, and not just in Iceland: "We like to say we will make it happen."

Winning investment and interest from outside the country has been perhaps the biggest hurdle. But there are plenty of others. H cars still need better fuel cells and a network of filling stations at least as extensive as diesel's. Then there's the distribution and storage problem: At high pressure, hydrogen simply seeps through the molecules of conventional steel, so traditional trucks and tanks are useless. (Scientists are experimenting with things like composite materials, bonding hydrogen to vehicle frames, or using nanoscale storage devices, to get around this problem.)

But as Bill Reinert, national manager in the advanced technologies group for Toyota Motor Sales, points out, hydrogen cars have been seriously researched for only 15 years. It took Toyota more than 10 years just to sell a million copies of the hybrid Prius -- and that's for a car that slides right into today's fuel infrastructure. Reinert figures the U.S. government spends \$16 billion to \$20 billion, including subsidies, on ethanol. Toyota alone, he says, spends more on hydrogen research than does the entire U.S. government.

Coming to America

Hydrogen's appeal in the quest to replace oil is not simply that there's so much of it but that it works so well. "Hydrogen fuel cells are the only way to get vehicles that perform like a gasoline vehicle," says Britta K. Gross, General Motors' manager of hydrogen and electrical infrastructure commercialization. H cars refuel quickly, and they can match gas-powered cars for range. But -- once more for emphasis -- there are no emissions.

Oil approached \$99 a barrel while I was in Iceland. Back home, the news seems full of hydrogen. Honda says it will begin a controlled leasing program this year in Southern California for its FCX Clarity fuel-cell car. GM, desperate to recover its mojo, has rolled out the first phase of Project Driveway, a 100-car pilot in Los Angeles and New York, which will move on to Washington, D.C., and eventually Europe and Asia; select drivers will get a hydrogen-powered SUV, the Equinox, for periods ranging from three months to several years. To fuel those cars, GM, along with Shell Hydrogen and another large energy company it won't yet identify, is building 10 hydrogen filling stations across the country, including one in the Bronx, not far from Yankee Stadium. While none of the stations will produce its own hydrogen (some will come from a green facility in Niagara, New York), all are seen as part of a proof of concept.

Gross says that H cars have become far more than an experiment for GM. While the company plans one more prototype model to succeed the Equinox, it is already gearing up to bring H cars to a dealer near you at a price that won't leave you gasping. Like Honda, GM has pushed the hydrogen car well past the R&D phase: While it doesn't quite have a hydrogen-car division, Gross says H cars are now part of GM's mainstream organization, with an engineering chief, a vehicle line director, and a manufacturing and marketing staff. GM plans to be ready to produce them commercially in 2013.

Gross has been to Iceland twice. "It's absolutely shaped my thinking on how you do this," she says. She calls the will of the country "eye-opening," and marvels at its ability to get government and industry focused on the same goal, something the United States has failed to do. The hydrogen economy cannot happen here without such coordination, she says. INE's general manager, Jón Björn Skúlason, agrees, pointing out that one reason Iceland has made such progress is that his outfit manages every aspect of Iceland's hydrogen economy, a degree of command and control the United States hasn't even attempted. Now, says Gross, an ad hoc "H gang" of five automakers (including GM), as well as oil companies, hydrogen merchants, and government officials, have started meeting to talk about how America can follow Iceland's lead.

Project Driveway's focus on just three cities, she explains, is a way of proving the possible. "You have to

break it apart for anyone who says it's a \$400 billion exercise," she insists, "or you will never get 1 million vehicles out there. You have to demonstrate what you can do."

Even if hydrogen does end up the long-term replacement for oil, there will be bridge fuels along the way. In fact, the post-oil economy may be a patchwork of local solutions, says Barbara Heydorn, director of the Center of Excellence in Energy at SRI, a California-based research nonprofit. Heydorn points out that localized markets exist even now, Brazil's sugarcane ethanol being a prime example. Similarly, more than a quarter of the cars in Bangladesh run on natural gas, as do 1.6 million cars in Argentina and almost 500,000 in Italy. "Just as there are regional variations for what cars are available," she says, "fuel will be one more piece of the puzzle automakers will have to accommodate."

Where, exactly, hydrogen will fit isn't yet clear. But governments, automakers, and people worldwide are increasingly motivated to figure it out.

In Reykjavik, over a horse-meat lunch at the iconic Hotel Holt, Thorsteinn Sigfusson reflects on what he has wrought so far. To him, it's clear that oil is doomed. "Hydrocarbons are a mishap, a sigh in time," he says. "We provided the scenario for testing hydrogen. We've shown that it is the ultimate fuel. Nobody doubts that now."

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