Microsoft makes a 'crazy' bet on fuel cells to feed power-hungry data centers

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In an industrial space tucked off a side street in Seattle's Sodo District, Microsoft is trying to reinvent the data center.

Twenty racks of servers sit in a stark, white, well-lit room - a familiar setup for anyone who's visited one of the data centers that make up the humming infrastructure powering the internet.

To see what's special about this one, look up: Sitting on a steel frame above each stack of computer hardware is an electrical cabinet the size of a mini-fridge. Inside is a natural-gas-powered fuel cell.

That technology, Microsoft engineer Sean James says, could allow future data centers to someday unplug from the power grid entirely.

By generating electricity close by - literally on top of the computing hardware - Microsoft's new design eliminates the inefficiency of producing electricity at a distant power plant and transporting it long distances to data centers. That could trim the energy footprint of the fast-growing data-center business, eliminating a portion of the carbon emissions that fuel global warming, and, in the process, save Microsoft a lot of cash.

The company's Seattle trial is preliminary. But if Microsoft's estimates hold up - and, a big if, the cost of fuel cells comes down - the savings of a fuel-cell-based design spread across the company's fleet of facilities could total hundreds of millions of dollars.

James sums up the prevailing view of the plan among the rest of the industry, a group that includes many conservative engineers content to tweak existing designs on the margins: "They think I'm crazy."

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As long as there have been computers, there have been data centers.

The corporate backrooms that housed mainframe computers in the 1970s and 1980s evolved into cavernous spaces full of the servers that underpin the modern internet, storing emails, videos, business tools and the content of websites.

With demand for those services surging along with high-speed internet use, web giants Amazon, Microsoft and Google, as well as specialists like Digital Realty and Equinix, are scrambling to build warehouse-size data centers across the globe.

That business is a massive, and growing, consumer of energy.

Data centers account for about 2 percent of U.S. electricity use, the Department of Energy's Lawrence Berkeley National Laboratory estimates, up from 0.8 percent in 2000. To cut their costs, companies like Microsoft have designed their newer facilities with energy efficiency in mind.

They've also reduced their dependence on fossil fuels by buying renewable energy or building their own wind or solar farms.

But Lucas Beran, who tracks data-center energy economics for IHS Markit, says the industry's efficiency improvements have started to stall.

"In the next few years we're going to be at a crossroads," he says. "We'll

have to change what we're doing to maintain those energy gains."

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James and the team of data-center engineers at Microsoft think they're set to take the next jump forward.

Understanding their thinking requires a tour of a typical data center.

Modern facilities run like small, virtually unpopulated cities, sprawling sometimes across more than 100 acres.

A few dozen technicians manage things from a control room, supplemented by contractors when something goes wrong. Inside central rooms are neat rows of metal cages that hold racks of humming servers. Those stacks churn out a lot of heat, requiring industrial-scale air circulation and cooling systems to keep things from overheating.

Powering all of that is a maze of electrical equipment.

Big data centers typically require their own substation-sized link to the power grid. From there, transformers and switchgear convert incoming electrical current to a lower voltage and regulate its flow with backups, surge protectors and miles of bundled copper wiring.

Because a sudden loss of power could cripple the facility and erase data, backup batteries are also plugged into the grid. As a last line of defense, diesel generators the size of shipping containers sit ready to go from cold and quiet to roaring full power in a few seconds.

Microsoft's fuel-cell concept would eliminate most of that equipment.

No generators, no stacks of batteries, no transformers, no bundles of

electrical cable.

Christian Belady, a longtime data-center engineer who manages Microsoft's data-center design and research, has hyperbole at the ready to describe the company's push to resist traditional thinking.

"I want the data center to disappear," he says. "And I want energy for free."

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Microsoft's fuel-cell concept stems from years of experimentation.

A project under construction outside Cheyenne, Wyoming, will place natural-gas turbines in an expanded Microsoft data-center facility. During periods of strain on the power grid, those turbines can power on and feed electricity back to the grid to prevent brownouts.

Back at home, in the corner of a loading dock behind Microsoft's conference center on its campus outside Seattle, the company is testing whether large batteries could someday let data centers unplug from the power grid for a few hours when prices are higher or the grid is overburdened, and then recharge at night when people are using less electricity.

"We just need something that can store an enormous amount of energy," James says. "The future is, if I've got a data center in the city, we could take our load off the grid and give back that power."

James is an accidental Microsoft employee.

Originally from Olympia, Wash., he joined the Navy out of high school, serving on submarines. Afterward, he earned a computer-science degree

while working full time as an electrician.

When he applied for a job at a data center, he wasn't sure what he was in for: "I didn't know what a data center was."

The company he joined was struggling, and eventually Microsoft came in and bought the whole operation.

Today, James is charged with finding ways to improve data-center design.

One of Microsoft's early ideas relied on modular components - in some cases, literal shipping containers full of computing hardware - designed for efficiency and easy replacement if something failed.

That line of thinking later combined James' two career paths.

He worked on Microsoft's Project Natik, a continuing research effort that, in 2015, dropped a data-center module into the ocean to test whether cold subsea temperatures could save on cooling costs and enable quicker build out of cloud computing in remote areas.

Over the last two years, James has spent much of his time on the fuel-cell project.

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Microsoft isn't the only technology giant dabbling in fuel cells.

Apple and eBay have used fuel cells to power data centers from a centralized location, essentially replacing the backup generators or grid connections in a typical data-center design with fuel-cell clusters.

Amazon uses fuel-cell-powered forklifts to move goods around its warehouses. (The company also operates Amazon Web Services, the biggest, and perhaps most secretive player in cloud computing. Amazon rarely discusses data-center design for fear of disclosing trade secrets.)

Microsoft's $3.4 million fuel-cell project is funded, in part, by a $674,000 grant from a Washington state program that aims to stimulate the development of clean-energy technology. It's awaiting approval from Seattle building inspectors.

With that clearance, McKinstry, the Seattle-based contractor that built and is hosting Microsoft's experiment in a formerly vacant space attached to its headquarters, will link the mock data center to the municipal natural-gas grid.

Gas will be piped to the 20 fuel cells, starting an electrochemical reaction that extracts hydrogen atoms and sends a current of negatively charged electrons to power the servers below.

Waste products - water vapor and a small amount of carbon dioxide - will be vented out of the building along with the excess heat from the servers.

In a real data center, the servers would be processing Bing web searches or storing customers' email. For the purposes of the trial, the 20 racks in Sodo will be filled with dummy data meant to simulate actual workload.

Microsoft will add methane detectors to guard against potential gas leaks, and airflow monitoring to see how the design deals with exhaust.

Microsoft researchers, in tests a few years ago with the University of California at Irvine, estimated that when plugged into the power grid, the average data center reaped about 17 percent of the potential energy of

the fuel used to generate that electricity.

The in-rack fuel-cell concept can pull off 29 percent efficiency, Microsoft estimates, because no energy is lost through the long haul from power plant to conversion and consumption, and because the fuel cell's chemical reaction is more efficient than some industrial-scale power generation.

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There is a problem, though. Fuel cells are expensive. Current models cost about twice as much as Microsoft needs to make the concept pay off.

But the company is optimistic. Fuel-cell manufacturing is a relatively new industry, with most fuel cells bound for relatively niche applications like backup power, cranes and industrial equipment, and specialty vehicles. If big buyers such as Microsoft start lining up for many thousands of them, their costs may come down.

In that case, the savings would be significant. Microsoft researchers estimate that mass-produced fuel cells would cut the cost of installing a new data-center rack by at least 10 percent, and the costs of operating that rack by 21 percent.

Those savings pencil out, conservatively, to about $80 per rack, per month. With more than 1 million servers in Microsoft's worldwide data-center fleet, the potential savings could stretch into the hundreds of millions of dollars a year if the design were rolled out across the board.

Fuel cells raise other questions. While Microsoft's project is built around the idea of simplicity and removing electrical components that might fail, it's unclear how the generators will hold up in Microsoft's

distributed model. And if one goes down, how easy will it be to replace or repair?

Microsoft is hoping to start testing the concept next month, once it gets the city's clearance.

Dan Ronco, the McKinstry manager overseeing the project, says city officials have never had to vet a commercial fuel-cell deployment. Both sides ended up consulting a massive technical tome of safety standards to make sure the project checked out.

It wasn't the first time Microsoft waded into uncharted waters with its project.

"That's the fun part, when someone says, 'No, that won't work,'" James says. "And we say, 'No, that doesn't violate the laws of physics or anything. Let's make it work.'"

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