approach those decisions. "There's nothing in her background to suggest that she knows anything about fusion, or particle physics, or nuclear physics, or atomic physics," he says.

Most past office directors have had a mixture of training in physics, experience running large organizations, and work history with DOE. But that background is not a prerequisite for success, says Raymond Orbach, a theoretical physicist and former chancellor of UC Irvine who directed the office from 2002 to 2009. Orbach won plaudits for, among other things, developing a 20-year to-do list of major projects that DOE has largely followed. But he notes that he, too, was a newcomer to DOE. "One never knows how someone with no prior formal government service (e.g. me) will turn out," he wrote in an email. The office's most recent director, Christopher Fall, has a doctorate in neuroscience and had prior management experience at DOE and the Office of Naval Research.

Some directors with traditional credentials have struggled with the job. William Brinkman, a theoretical physicist who led the office from 2009 to 2013 under former President Barack Obama, came to DOE with 14 years of experience as a director at the storied private Bell Labs. But the scholarly and cerebral Brinkman found it difficult to communicate with Congress, Lubell says. During one hearing, a legislator pressed Brinkman for a plan to deal with a particular issue. To lawmakers' dismay, Lubell recalls, "Brinkman pointed to his head and said, 'It's in here.'"

No director has to do it all on her own, notes physicist Cherry Murray of the University of Arizona, who was director from 2015 to 2017. DOE has a corps of staffers who are "incredibly competent" and can help keep the agency humming, she says. "I'm not worried at all about physics research dropping by the wayside" under Berhe, she says. "That will continue, just as under me biology research continued." Murray says she is curious to see where Berhe will head in setting policy.

If Berhe is confirmed, her success will largely rest with budgetmakers in Congress. For example, even though former President Donald Trump repeatedly tried to slash the office's budget, Congress increased it by 31% over 4 years. That boost spared Fall from having to make unpopular cuts. If the budget keeps growing, Berhe may enjoy a long honeymoon with DOE-sponsored researchers.

Should budgets tighten, she could face the challenge of retaining the support of the community while picking winners and losers. Berhe has the leadership skills to meet that potential challenge, Harte says. "I would call her steadfast with good humor and an extraordinary thoughtfulness," he says. "She will gather the respect of others because of her intense intelligence." ■

MATERIALS SCIENCE

Zinc aims to beat lithium batteries at storing energy

Rechargeable batteries based on zinc promise to be cheaper and safer for grid storage

By **Robert F. Service**

If necessity is the mother of invention, potential profit has to be the father. Both incentives are driving an effort to transform zinc batteries from small, throwaway cells often used in hearing aids into rechargeable behemoths that could be attached to the power grid, storing solar or wind power for nighttime or when the wind is calm. With startups proliferating and lab studies coming thick and fast, "Zinc batteries are a very hot field," says Chunsheng Wang, a battery expert at the University of Maryland, College Park.

Lithium-ion batteries—giant versions of those found in electric vehicles—are the current front-runners for storing renewable energy, but their components can be expensive. Zinc batteries are easier on the wallet and the planet—and lab experiments are now pointing to ways around their primary drawback: They can't be recharged over and over for decades.

The need for grid-scale battery storage is growing as increasing amounts of solar, wind, and other renewable energy come online. This year, President Joe Biden committed to making the U.S. electricity grid carbon free by 2035. To even out dips in supply, much of that renewable power will have to be stored for hours or days, and then fed back into the grid. In California alone, the public utilities commission envisions deploying more than 8800 megawatts of rechargeable batteries by 2026, and last week, California Governor Gavin Newsom proposed $350 million in state funding to develop long-duration energy storage technologies. "That trend will not go down. It will only continue to grow," says Mark Baggio, vice president for business development at Zinc8 Energy Solutions, a zinc battery producer.

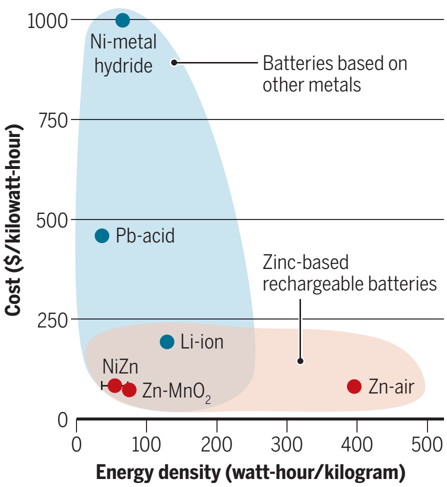
For power storage, "Lithium-ion is the 800-pound gorilla," says Michael Burz, CEO of EnZinc, a zinc battery startup. But lithium, a relatively rare metal that's only mined in a handful of countries, is too scarce and expensive to back up the world's utility grids. (It's also in demand from automakers for electric vehicles.) Lithium-ion batteries also typically use a flammable liquid electrolyte. That means megawatt-scale batteries must have pricey cooling and fire-suppression technology. "We need an alternative to lithium," says Debra Rolison, who heads advanced electrochemical materials research at the Naval Research Laboratory (NRL).

Enter zinc, a silvery, nontoxic, cheap, abundant metal. Nonrechargeable zinc batteries have been on the market for decades. More recently, some zinc rechargeables have also been commercialized, but they tend to have limited energy storage capacity. Another technology—zinc flow cell batteries—is also making strides. But it requires more complex valves, pumps, and tanks to operate. So, researchers are now working to improve another variety, zinc-air cells.

In these batteries, a water-based electrolyte spiked with potassium hydroxide or another alkaline material separates a zinc anode and a cathode made of other conductive materials, often porous carbon. During discharge, oxygen from the air reacts with water at the cathode to form hydroxide ions, which migrate to the anode, where they react with zinc to eventually produce zinc oxide. The reaction releases electrons that flow from anode to cathode through an external circuit. Recharging the batteries

A better battery

Zinc is cheaper than many battery metals and could store more energy.



GRAPHIC: B. HOPKINS *ET AL.*, *SUSTAINABLE ENERGY & FUELS*, 4, 3363 (2020), ADAPTED BY C. BICKEL/*SCIENCE*

This energy storage facility under construction in southeast England uses lithium-ion batteries.

means reversing the flow of current, causing zinc metal to re-form on the anode.

But zinc batteries don't like to run in reverse. Irregularities across the anode's surface cause the electric field to intensify at certain spots, which causes zinc to deposit there, further enhancing the electric field. As the cycle repeats, tiny spikes called dendrites grow, eventually perforating and shorting out the battery. Equally troublesome, water in the electrolyte can react at the anode, splitting into oxygen and hydrogen gas, which can burst the cells apart.

Researchers have begun to deal with these downsides, churning out nearly 1000 papers per year. In 2017, for example, Rolison and colleagues reported in *Science* that they reengineered the anode as a 3D network of zinc metal pocked with tiny voids. The electrode's vast surface area reduced the local electric field, which prevented the buildup of dendrites and reduced the likelihood of splitting water molecules. NRL licensed the technology to EnZinc.

This month, Wang and his colleagues reported in *Nature Nanotechnology* that when they added a fluorine-containing salt to their electrolyte, it reacted with zinc to form a solid zinc fluoride barrier around the anode. Ions could still wriggle through during charging and discharging. But the barrier prevented dendrites from growing and repelled water molecules, blocking them from reaching the anode.

"It's a great development," says Wei Wang, who directs the Energy Storage Materials Initiative at the Pacific Northwest National Laboratory. Still, Chunsheng Wang notes his device is somewhat slow to discharge. To improve that, his team wants to add catalysts at the cathode to speed up the reaction between oxygen and water.

The same strategy features in work by researchers led by Jung-Ho Lee from Hanyang University. In *Nature Energy* on 12 April, they reported creating a fibrous and conductive cathode from a mix of copper, phosphorus, and sulfur that also served as a catalyst, dramatically speeding up oxygen's reaction with water. That and other advances produced batteries that could be charged and discharged quickly and had high capacity, 460 watt-hours per kilogram (compared with about 75 Wh/kg for standard zinc cells with manganese oxide cathodes and 120 Wh/kg for scaled-up lithium-ion systems). The batteries were stable for thousands of cycles of charge and discharge. The result "looks like another important step," Chunsheng Wang says.

Such advances are injecting new hope that rechargeable zinc-air batteries will one day be able to take on lithium. Because of the low cost of their materials, grid-scale zinc-air batteries could cost $100 per kilowatt-hour, less than half the cost of today's cheapest lithium-ion versions. "There is a lot of promise here," Burz says. But researchers still need to scale up their production from small button cells and cellphone-size pouches to shipping container–size systems, all while maintaining their performance, a process that will likely take years. Burz also notes electric utilities and other companies looking to buy cheap large-scale batteries want to see years of steady operation first. "These customers need to see that it works in the real environment," he says. ■

PUBLIC HEALTH

Studies test lifestyle changes to avert dementia

"Multidomain" trials look for brain benefits from multiple, simultaneous alterations

By **Mitch Leslie**

For the past 3 years, about 6000 middle-aged and elderly Australians have pumped iron, loaded up on greens and whole grains, strived to quell stress, and challenged their wits with computer exercises, all in an effort to preserve their cognition. They're part of a clinical trial called Maintain Your Brain, one of about 30 current or planned studies that eschew pharmaceutical interventions and test whether altering multiple aspects of participants' lives improves brain health. Such multidomain studies may finally reveal whether modifying diet, exercise, and other factors can slow cognitive decline as people age—or even prevent dementia.

"There's a lot of hope for multidomain trials," says psychologist Kaarin Anstey of the University of New South Wales, Sydney, one of the principal investigators of the Maintain Your Brain trial, which will finish by the end of this year.

Although people can't escape some mental decline as they get older, lifestyle exerts a powerful influence over the risk of developing dementia—the type of severe cognitive impairment seen in conditions such as Alzheimer's disease. Last year, an international committee of scientists and psychiatrists known as the Lancet Commission on dementia prevention, intervention, and care estimated that so-called modifiable factors account for 40% of dementia risk. Their report highlighted a dozen factors, including many familiar villains—diabetes, high blood pressure, smoking, obesity, and lack of exercise.

Researchers are still probing exactly how these risk factors steal people's faculties, but they've identified some likely mechanisms. Lack of physical activity may impair cognition, for instance, because

Science

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