The Biggest, Strangest 'Batteries'

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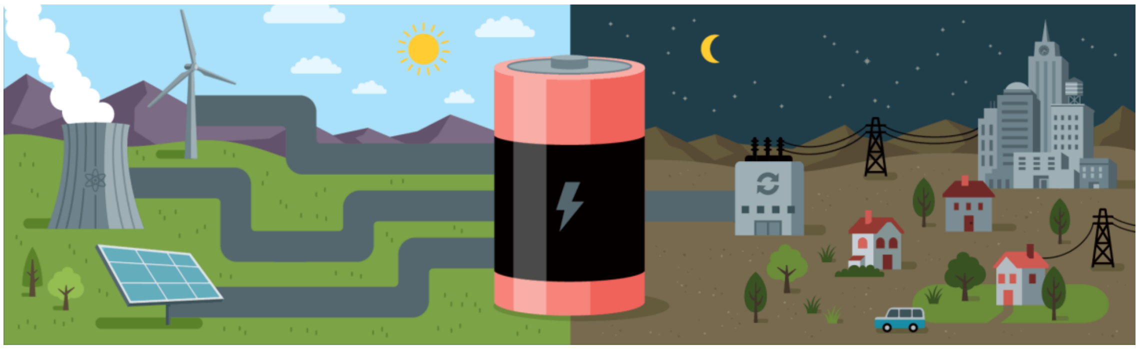
What if you need a battery? A really big one — big enough to run a city?



By Diane Cardwell and Andrew Roberts

It's a question that inventors have been tackling for decades. No one wants the fridge, or the hospital, going on the blink when demand surges or the power plant needs repairs.

It turns out to be a surprisingly tricky question to answer. Today, with the rise of green energy sources like solar and wind, the need for industrial-scale energy storage is becoming ever more vital to make sure there's power even after the sun sets or the breeze dies down.

It's usually (but not always) still too impractical to string together enough traditional batteries — those powered by chemical reactions, like the ones in smoke alarms and Teslas — to do the job. Instead, with remarkable ingenuity, technicians have relied on a host of physical forces and states such as temperature, friction, gravity and inertia to keep energy locked up for later release.

That's why in Wales a power company engineered a special lake on a mountaintop. And in Germany a utility pumps underground caverns full of compressed air. Here's how those and other systems — all in use today — work

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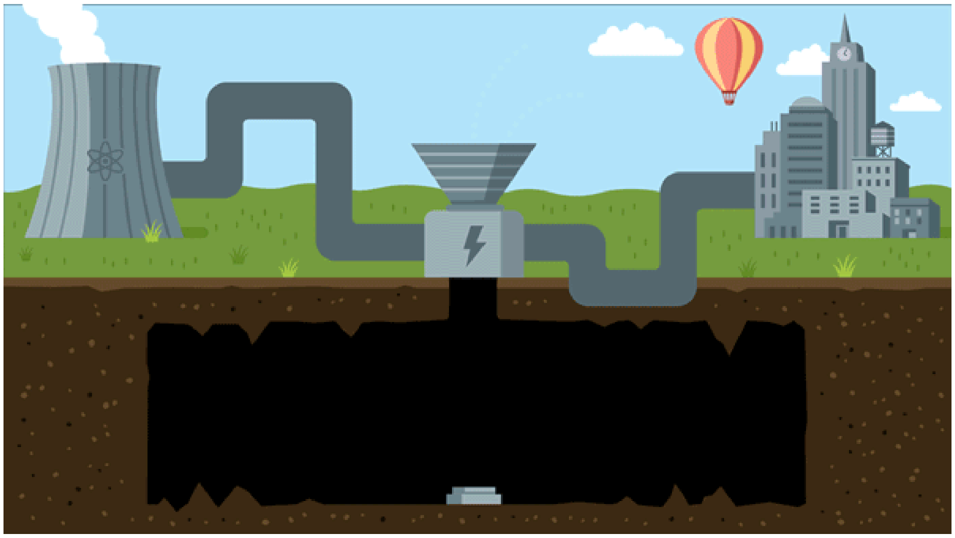

Compressed Air in a Cavern

Back in the 1970s, a German utility wanted to build a flexible storage plant that could respond to sudden peaks in electricity demand, since its conventional plants — mainly coal — weren't designed to dial up or down quickly.

It didn't have the hilly terrain needed for a hydroelectric plant, which can start operating much more quickly when demand surges. But here's what it did have: ancient, underground salt deposits.

Borrowing a technique commonly used to store natural gas and oil deep underground, it piped water into the salt beds to dissolve the salt and create two caverns roughly a half-mile below the grassy fields in Huntorf. The plant, which opened in 1978, uses electricity from the grid, when it's cheap because demand is low, to compress and store air in the salt caves.

Then, when electricity demand surges, a motor pushes the air to the surface and into a combustion system, where it burns natural gas that spins a turbine to produce electricity. Compressing the air allows it to deliver more oxygen to the turbines, making them more efficient.

A similar plant opened in 1991 in McIntosh, Ala. Several energy companies, mainly in the United States and Europe, are exploring mining their salt deposits for storage as well.

Molten Salt to Stockpile the Sun's Rays

Out in the desert of Tonopah, Nev., about 200 miles northwest of Las Vegas, an enormous spiral of mirrors surrounds a concrete tower roughly 55 stories tall. Topped with a 100-foot heat exchanger formed of tubes, it's not a relic of some mystical pagan rite, but the Crescent Dunes Solar Energy Facility.

It is the world's first utility-scale concentrating solar power plant that uses extremely hot salt to extend the use of solar energy way past sundown.

Rather than using solar panels to produce electricity, the plant has more than 10,300 billboard-size mirrors that focus the sun's heat on the heat exchanger, melting the salt into millions of gallons of 1,050-degree liquid that is stored until electricity is needed. The salt, which can stay liquid at higher temperatures than some other fluids like water, then flows through a steam-generating system that drives a turbine, producing enough electricity for 75,000 homes for as long as 10 hours past sundown — in essence, allowing the sun to shine at night.

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Spinning Wheels That Power a Crane

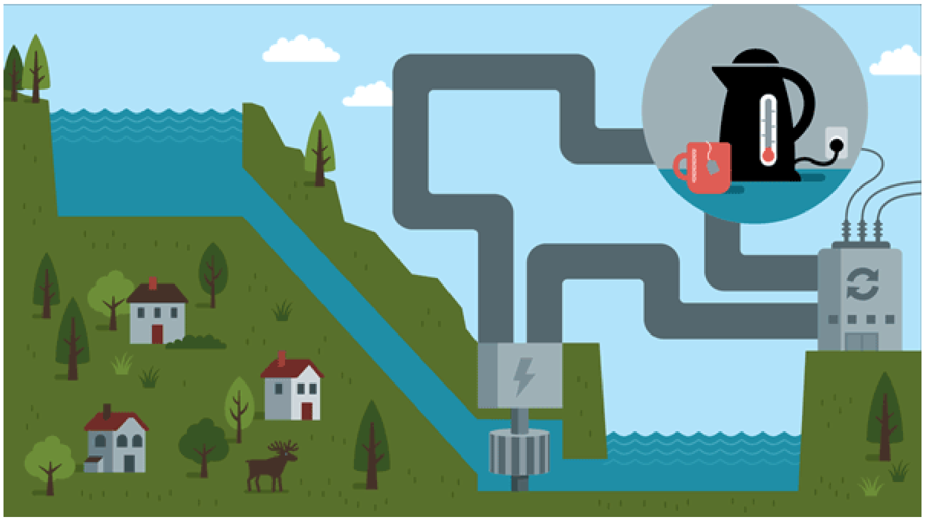
On Kodiak Island in Alaska, the local electric cooperative got an unusual request from the shipping company that operates the port: Could it install an electric crane?

The company wanted to replace its aging diesel-powered crane with a new, and faster, electric one. It would be able to service larger ships and higher container stacks, making the shipping operations more efficient.

At first, the utility balked. The powerful crane would need to suck up tremendous amounts of electricity in short bursts. The local grid wasn't really set up to handle that.

But after studying the proposal and potential solutions, it settled on the flywheel, which uses a rotor spinning in a vacuum to act as both a motor and a generator. Operating since 2015, the system uses grid electricity to accelerate the flywheels, which maintain their speed through inertia. When the crane lifts, the system converts the momentum of the rotors to electricity. And when the crane lowers, it recharges the flywheels, feeding power back to speed them up again.

The installation also helps the electric company balance energy fluctuations on the grid from its wind turbines, which provide about a quarter of the island's electricity.



Two Lakes and One Big Hill

In the 1950s, Britain's need for electricity — and the facilities to store it — was rising. Energy officials had an idea: pumped hydro.

In other words, you build two lakes, one on top of a hill, and one at the bottom. Off-peak electricity (read: cheaper) would pump water from low to high. Then, when the grid needed power, the upstairs pool would open, sending the water down through turbines to make electricity.

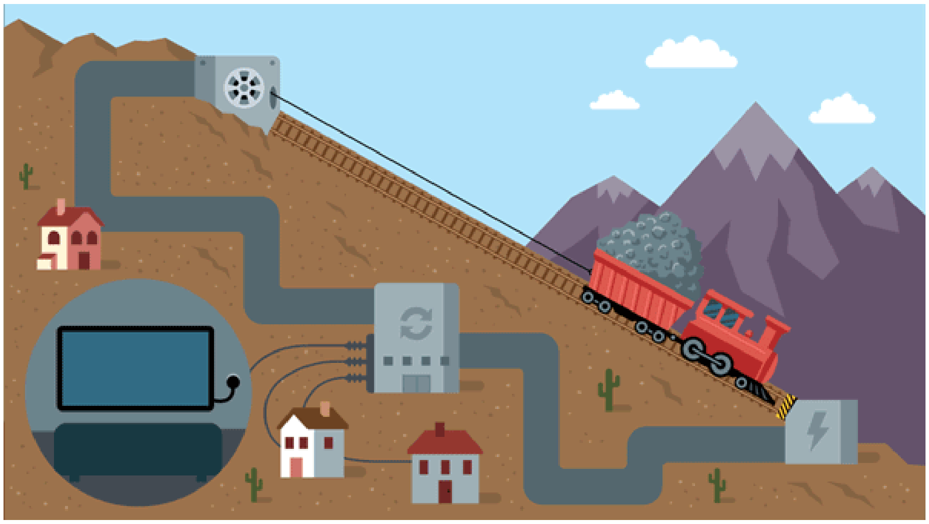
Officials made plans to build these contraptions. But demand for electricity kept soaring, so they decided an enormous one was in order.

After searching for the perfect location for two years, they settled on Elidir Mountain, on the edge of Snowdonia National Park in North Wales. Though the idea of putting a power plant in a wilderness area raised some hackles, the location was in many ways ideal. It had one lake, Marchlyn Mawr, near its peak, and another, Peris, at the bottom.

It also happened to contain the guts of an abandoned slate quarry, making it easier to hide the Dinorwig Power Station inside. Still, it took 10 years of construction to complete, which included expanding both lakes and excavating huge caverns and miles of tunnels.

Opened in 1984, it is among the world's largest plants of its kind and can generate enough energy to run all of Wales for six hours.

But it isn't really used that way. Instead, it has become crucial in meeting a very British need: the sharp spike in electricity demand when popular television shows end — and millions of people simultaneously plug in their electric kettles to brew some tea.



A Train Laden With Rubble

Almost a decade ago, the founders of a small start-up based in Santa Barbara, Calif., set out to build a green approach to storing renewable energy that could mimic pumped hydro but without the water.

Their solution? Load a string of rail cars with rocks and concrete and let gravity do the work.

The company, Advanced Rail Energy Storage, proved that concept in Tehachapi, Calif., using electricity from a diesel generator to shuttle a roughly five-ton train up a steep hill. On cue, the train rolled back down, generating electricity from the turning wheels, a technology similar to the regenerative braking common in electric vehicles such as the Prius.

The company recently won approval from the Bureau of Land Management for its first commercial-scale project in Pahrump, Nev., about 30 miles east of Death Valley. That installation, to include seven much heavier trains, is designed to reach full capacity within 15 seconds and to produce enough energy to run 14 average homes for a month.

An Ice Maker That Chills a Building

As night falls over 1 Bryant Park, the gleaming office tower at 42nd Street and Avenue of the Americas in New York City, employees shut down their computers, grab their cellphones and flood out of the building as the workday ends.

But in the basement, the action is just getting started. Using cheaper overnight electricity from the grid, a large refrigerator chills water mixed with glycol (a component of antifreeze) below the freezing point. The system then pumps the mixture into roughly two miles of tubing coiled inside each of nearly four dozen 750-gallon tanks full of water. Hovering around 27 degrees, the glycol solution freezes the water, effectively storing energy in the form of ice.

The next day, the glycol mix flows out of the coils and into a closed-loop air-conditioning system. Combining with water and air, it helps to chill the building's 2.35 million square feet for as many as 10 hours during the day — when power is typically pricier.

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