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The Challenge of Storing Energy on a Large Scale

By ERICA GIES

SAN FRANCISCO — Renewable energy sources like solar power and wind have been in the spotlight lately, as have ways to improve control of the power distribution system through information technology. But another crucial component of developing a climate-friendly, secure and affordable supply of electricity — large-scale storage — has received little attention.

Now storage is stepping into the light. In the United States, incentives from the Energy Department, increased interest from venture capitalists and policy shifts at the state level, where utilities are regulated, are laying the groundwork for bringing energy storage capability to the electricity grid.

“Energy storage is the killer app for taking our grid to the next level,” said Matt Rogers, a senior adviser to the U.S. energy secretary, Steven Chu.

Stored energy is part of daily life: batteries power cellphones and laptops, for example. But now the focus is on building grid-scale storage technologies. Possibilities include pumped hydroelectric energy; air compression systems; flywheels; and even superlarge batteries. These technologies can perform several desirable tasks in the energy system.

Grid operators must keep power flowing reliably to users, a task known as frequency regulation that has been complicated by the addition of unpredictable generating resources like solar and wind power. Those sources can change output rapidly if external conditions shift: a cloud crossing the sun or a drop in the wind.

Aside from these minute-to-minute changes in output, solar and wind also have larger production discrepancies: the sun does not shine at night, and in many places, wind is calm during the day. Energy experts call this “intermittency.”

Utilities have generally used the more controllable output from fossil fuel power plants to

compensate for intermittency. But if renewable sources are to contribute a greater share of the energy mix — California has a target of 33 percent by 2020 — the declining proportion of fossil fuel power available to smooth out the peaks and troughs of output will make storage technology essential.

“Well-meaning voters and legislators come up with things like 33 percent renewables in California by 2020,” said Maurice Gunderson, senior partner at the venture capital firm CMEA Capital in San Francisco. “Well, it sounds like a good idea, but you really have to be a utility geek to get into the details and realize that it simply cannot be done without storage.”

Mike Gravely, an energy research manager at the California Energy Commission, agreed. “There may be a point in the future where the policy requires renewables to bring storage along with them,” he said.

Recent research suggests that storage technology could respond faster to supply and demand shifts than fossil fuel plants. Utility managers could address intermittency, Mr. Gravely explained, “with maybe half the amount of energy, if you have storage,” than they would require using traditional generation.

Utilities must also build systems capable of meeting peak demand, which arises at different times of the day, week and year. For this purpose, utilities have traditionally relied on bringing additional fossil fuel generating plants into action.

But fossil fuel plants run most efficiently at full power. And the marginal plants turned on to meet peak demand are often less efficient and more polluting than the power generators that run around the clock.

Using stored energy to meet peak demand could eliminate the need to switch on dirtier, more expensive plants.

Depending on where storage is sited, it could also reduce the need for transmission lines, according to Jim Eyer, a senior analyst at the consulting company Distributed Utility Associates and a lead author of a report this year by Sandia National Laboratories on energy storage. That would be a boon because utilities often struggle to get rights of way to build transmission lines. As a result, they usually overbuild after they get permission.

“That’s a waste of capital for something that might not be utilized for 20 to 30 years,” said David MacMillan, president and co-founder of MegaWatt Storage Farms, an energy storage developer and adviser. “If you deploy storage, you don’t have to add more transmission.”

Storage can also help utilities get the best price for the energy they generate, using a strategy called “time shifting.” Energy managers can store lower-cost energy produced at night, then release it to the grid during peak demand when it is more valuable. With both traditional power plants and wind farms, much more energy is produced at night than can be used.

“In West Texas, there is so much wind that, at night, they effectively have to let the things turn but dump the power because there’s no demand for it,” said Mr. Rogers of the U.S. Energy Department.

The Energy Department is supporting a variety of storage projects, using money from the economic stimulus funds approved by Congress.

“Today a storage solution costs about $1,000 per kilowatt-hour,” Mr. Rogers said. “We’re trying to drive it down to somewhere between $100 to $200 per kilowatt-hour.”

The venture capital world has taken note. “Right now there’s a big flock forming of grid-scale storage proposals, and that indicates that the entrepreneurs of America are responding to a very big opportunity,” said Mr. Gunderson of CMEA Capital.

The most common technology already in use for grid storage is pumped storage hydroelectricity, in which managers use electricity to pump water up into higher elevation reservoirs at night, then release it at times of peak demand to recapture the energy. This technique proliferated in the United States during the heyday of nuclear plant construction in the 1960s and 1970s to absorb unused nighttime energy from reactors that produce a constant flow of power around the clock.

In 2009, the United States had 21.5 gigawatts of pumped storage generating capacity, according to the Energy Information Agency. Wider deployment, however, is limited by geography and environmental concerns similar to those associated with dams. The E.I.A. projects no change in capacity through 2030.

Another large storage option is compressed air. There is just one site operating in the United States at the moment, built in Alabama in 1991. But four new projects are in the works.

Electricity is used to force air under pressure into a cavern. To extract it, operators heat the compressed air with natural gas, then push it through turbines to generate electricity. Like pumped hydroelectricity, this method is limited by geography. And its use of natural gas produces emissions that undermine some of the benefits of turning to renewable sources.

A new flywheel project in New York will be used for frequency regulation because current models can store energy for only about 15 minutes. Flywheel systems use electricity to drive a motor, which accelerates a massive disc, storing electricity in the increased momentum. When the stored power is needed, the flywheel is used to drive the motor in reverse, generating electricity.

Batteries have not yet reached grid scale for the most part, although a village in Japan has assembled a bank of them to serve that purpose. Many experts think batteries hold the most promise because they are scalable and can be used anywhere.

“I’ve been deeply impressed by the new science in this space,” Mr. Rogers said. With many battery technologies in development, he said he was confident that something economical would emerge.

New policies are also promoting energy storage in a drive to overcome barriers to its deployment. Those are needed because markets and regulators currently recognize just three types of businesses on the grid: generation, transmission and distribution.

“Storage is a peculiar animal; it’s this funny, amorphous thing with some aspects of each entity,” said Mr. MacMillan, the energy storage developer. “But market and regulatory structures have to adapt to take advantage of it.”

That might happen soon. The Federal Energy Regulatory Commission is now considering ways in which it would set regulations for cost recovery for energy storage, perhaps by creating a separate asset class for storage.

A federal investment tax credit could also help compensate for the difficulties until the need for storage is more accepted, said Jason Makansi, executive director of the Coalition to Advance Renewable Energy through Bulk Storage, an advocacy group. Senator Ron Wyden, a Democrat from Oregon, sponsored such a provision in 2009 that, like most energy proposals, is currently languishing in Congress.

Some states have also introduced policies to promote storage.

The New York Independent System Operator has defined short-term energy storage devices like flywheels and batteries as frequency regulators, allowing them to participate in regulated markets. Independent system operators in Texas, California, and the Midwest, Mr. Makansi said, “have been progressively laying in policy, procedures, pricing, and other mechanisms that support deployment of storage services.”

The California legislature recently passed an energy storage bill requiring the Public Utilities Commission to set storage targets. The bill is expected to be signed by Gov. Arnold Schwarzenegger by the end of September.

But advances are likely to be slow because of the inherent conservatism of the electric utility business.

“It’s a business built on providing reliable service to customers,” Mr. Makansi said.

“People will vote you out of office, as Gray Davis found, if you screw up the electricity system,” he added, referring to the California governor who was ousted in 2003 after an energy deregulation scheme failed.