Amory's Angle: Ramping Up Renewable Electricity

By Amory B. Lovins

AS GRID OPERATORS COMBINE VARIOUS TECHNIQUES, HIGH-PERCENTAGE RENEWABLES PROVE THEY CAN PROVIDE RELIABLE POWER

Many people in the electricity industry long thought that the two renewable sources of electricity that vary widely over time—windpower and solar photovoltaics (PVs) —could provide only a few percent of total generation without endangering reliability. Those who still believe this now face increasingly severe reality tests.

As we'll see, Germany and other countries are successfully powering their grids with astonishingly high fractions of renewable generation by combining five techniques: a) leveraging diverse generation sources across interconnected regional and national grids, b) improving renewables' forecasting and predictability, c) integrating dispatchable renewables, d) adding distributed storage, and e) leveraging demand response.

GENERATION DIVERSITY AND INTERCONNECTED GRIDS

In Germany, renewables contributed 23 percent of total electricity generation for 2012. In Denmark, renewables produced an even more impressive 41 percent—windpower alone produced 33 percent for all of 2013 and 54.8 percent for December. These two countries had Europe's most reliable electricity, about ten times more reliable than America's.

Both countries swap electricity with neighbors on two or more sides, helping to balance windfarms' and PVs' variable output. Denmark, for example, exports windpower when the country’s turbines are generating a surplus, and imports hydropower from the Scandinavian grid when it needs to. But such interconnections may be less important than many think.

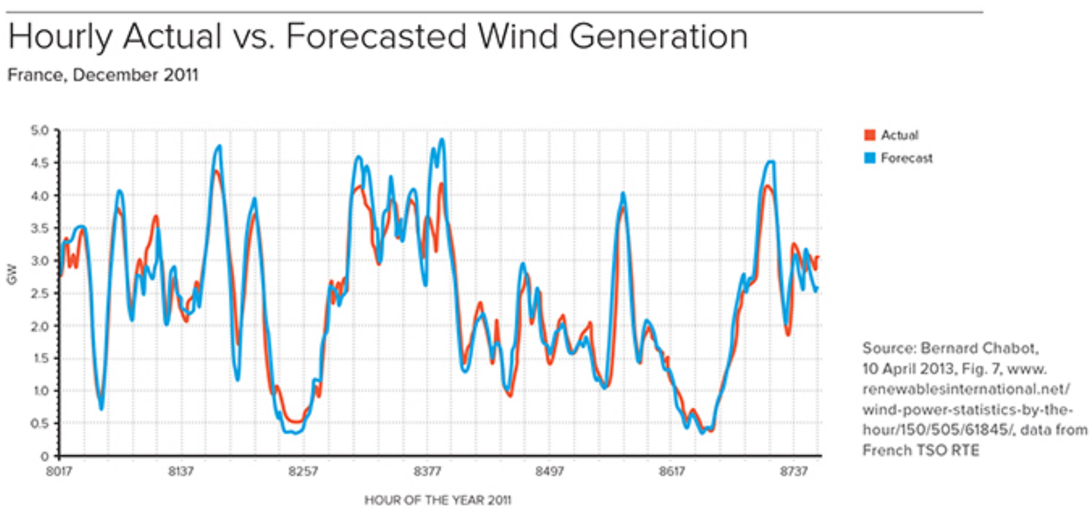
Out on the edge of the European grid, Spain generated 49 percent renewable electricity in the first half of 2013, and Portugal, interconnected only with Spain, an astonishing 70 percent (respectively 29 and 30 percent excluding hydropower). For all of 2013, Spain’s electrical generation was 32 percent renewable (30 without hydro), Portugal’s 47 (44). Similarly, Scotland, a net exporter linked only to England and Wales, generated electricity 40 percent renewably (36 without hydro).

For brief periods, the first four of these high-renewables countries have respectively achieved 70, 136, 61,and 100 percent renewable generation, just as Xcel Energy in Colorado briefly surpassed 60 percent from windpower last year.

IMPROVED FORECASTING AND PREDICTABILITY

Modern PVs and windpower are among the most reliable known generating technologies (typically 98–99 percent technically available), but their output varies strongly with time and weather. Fortunately, one generator doesn’t serve one load; all generators together serve the grid, which melds them to serve all loads. Thus the giant German utility RWE, working with Siemens, “synthesizes” steady output from a diverse portfolio of varying renewables.

Such stable and reliable power comes from choreographing many shifting resources, so variable outputs must be accurately forecast. Though still improving, forecasting is already so good that PV and windpower are often more predictable than electricity demand. For example, throughout a stormy winter month, the French grid operator reported actual national windpower generation very close to its forecast one day ahead (see graph below). The small remaining errors disappeared in the hours before actual dispatch.



INTEGRATING DISPATCHABLE RENEWABLES

Modern grid operators are also melding an even broader slate of resources. They start with wind and PV power, diversified by location (so they don’t all see the same weather at the same time) and by type (so they don’t all react in the same way). Operators next add the other, “dispatchable,” kinds of renewables that can operate whenever they’re needed and in good working order: big and small hydropower, several emerging kinds of marine energy, solar-thermal-electric plants whose stored heat can stretch their operation into or through the night, geothermal, and burning biomass, biogas, or wastes (often in combined-heat-and-power plants of various sizes, including “green gas” or natural gas in fuel cells, or cogeneration from waste heat).

ADDING DISTRIBUTED STORAGE

Another key flexibility resource is distributed electricity storage—as heat (such as ice-storage air conditioning) or as electricity (such as smart charging of electric vehicles or battery backups for solar PV systems). With smarter grids, car charging can be bidirectional, drawing some peak power back from the car when it's exceptionally valuable—of course, without compromising driving. Tesla, other automakers, and several solar developers are developing such capabilities. Tesla, now the world's largest battery manufacturer, is also piggybacking on its world-class battery and inverter production for cars to offer very efficient, reliable, and economical distributed storage modules for buildings and factories. And firms like Sunverge, SolarCity, Solar Grid Storage, Stem, and a growing list of others are starting to (or already) offer distributed storage to complement solar PV.

LEVERAGING DEMAND RESPONSE

Operators can also integrate with "demand response," which controls or influences when customers use electricity for particular tasks. Your utility may pay you to allow your electric water heater to be turned off occasionally for a quarter-hour; you'll never notice such "load management." Many building services and industrial processes can use smart controls unobtrusively to make demand surprisingly flexible to make the grid agile. Modern telecommunications, distributed control intelligence, transparent pricing (especially if it reflects real-time production and delivery costs), and integration with efficient energy use combine to make demand response a bigger and more versatile resource than had long been thought.

New forms of demand response are continually emerging. For example, my electric car charger adjusts its charge rate between zero and 7 kW every second according to the frequency of the grid. Such "fast regulation" is worth enough (if the grid paid me for it as FERC says it should) for me to make a few bucks' profit every night by charging my car.

ADDING IT ALL UP

All this is a big slate of options. But what if it's not enough? The next and costlier options would include bulk electricity storage (via compressed air in underground caverns, pumped hydroelectric storage, hydrogen, or conventional or flow batteries). But the five European countries mentioned earlier have needed no new storage or backup capacity. Indeed, emerging evidence seems consistent with my longstanding hypothesis that a largely or wholly renewable power system may need less storage and backup than utilities have already bought to manage the intermittence of their big coal and nuclear plants. For example, many utility analyses find major windpower installations need only about five percent or less in "balancing reserves," while big thermal power stations require three times that reserve.

As more countries build more renewables, any limits of this strategy will increasingly be tested. So far, practice is confirming analysis. The National Renewable Energy Laboratory's 2011 REFS study showed how to run an 80–90 percent renewable U.S. grid in 2050 with only 136 GW (about 10 percent of the total renewable capacity) of added bulk storage. RMI's 80-percent-renewable Transform scenario in Reinventing Fire added less bulk storage—67 GW (6.3 percent)—mainly because its renewables were half-distributed.

The more we let all options compete—demand-side resources can now bid into power auctions in about three-fifths of the U.S.—the more we can discover in the marketplace how far customer-centric, distributed supply- and demand-side resources can deliver reliable and resilient electrical services at least cost. But already, it's clear that the long-claimed low limits to renewable power supply were imaginary.

With only about six percent of the world's electricity now coming from non-hydro renewables, we're a long way globally from the average renewable fractions now achieved in five European countries and two U.S. states. But every year, these sources are getting a quarter-trillion dollars of private investment worldwide and adding over 80 GW, both promising trends. Global clean-energy investment fell 11 percent in nominal terms during 2013, but in 2012, despite a similar 10 percent nominal investment drop, capacity additions rose 6 percent because costs fell even faster. Soon we'll know whether the same recurred in 2013.

After all, half the world's new generating capacity added each year starting in 2008 has been renewable; solar cells are scaling faster than cellphones, probably surpassing windpower's 2013 additions; and Bloomberg New Energy Finance expects solar power to compete with retail grid power in three-fourths of world markets in another year or two. The first part of the renewable power revolution—scaling production—is already well underway. Next comes the interesting part: ensuring that all the moving parts mesh properly.

Amory B. Lovins is the cofounder, chief scientist, and chairman emeritus of RMI.

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