Power play: Envisioning a wind, water and solar world

By Pat Brennan,
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Placing planet Earth on a strict diet—100 percent renewable energy—can be done by 2050, without the need for radically new technology, contends Stanford University Professor Mark Z. Jacobson.

Stanford University Professor Mark Jacobson

The path to a world powered by wind, water and sunlight is, in fact, decidedly low tech, Jacobson says. Storing heat in underground rocks. Making mounds of ice at night, when electricity is cheaper, and melting it for air conditioning during the day. Building wind turbines on and offshore.
But Jacobson's team in Stanford's Atmosphere/Energy program is moving far beyond this simple vision of a clean power world. His research group uses sophisticated modeling to develop tailored energy plans that would allow a smooth transition to renewables in all 50 U.S. states, as well as 139 countries, by 2050. He helped co-found a non-profit, "The Solutions Project," that disseminates these plans and educates the public and policy makers about them.

On a break during a recent visit to NASA's Jet Propulsion Laboratory in Pasadena, Jacobson described his initiative.

How would you describe the research?

The research has two components. The first is to develop roadmaps to change the energy infrastructure of countries, states and cities, for all purposes: electricity, transportation, heating and cooling, industry. The second is to educate the public and policy makers through social media, video media, and storytelling. The state and country plans are publicly available for anyone, including policymakers, to examine and start implementing them.

Have some of these cities or nations begun doing that?
The places where these roadmaps have been implemented the most so far are in California and New York. In the case of New York, the governor first asked us for five first steps. They ended up adopting three of them. They subsequently adopted a 50 percent goal for renewables by 2030. We'd asked for 80 percent. In California, we met with the governor's office in October, 2014, to talk about plans. In January, 2015, the governor announced a goal of 50 percent.

Are there certain features common to all these plans?
They are all based on similar methodology: trying to project the current energy (trend) to 2050, electrify every sector and then see what the resulting electricity demand is, then satisfy that demand, in each state or country, into wind, water or solar supply.

How do they differ from other renewable energy plans?
There is nothing really comparable—no other set of plans state-by-state or country-by-country exists. Other plans that have been developed are either not 100 percent, they're 80 percent or less or they weren't necessarily all sectors. They might have included just electricity, or they didn't treat all states or many countries. And other plans include things like nuclear power, coal with carbon capture, biofuels.

What are the biggest innovations in your plans?
I think the whole idea—electrification of all sectors—and satisfying the electricity demand with clean, renewable generators plus low-cost storage—is novel. Electrifying all sectors makes it easier to match the power demand on the grid. We had a paper published last November in PNAS (Proceedings of the National Academy of Sciences), a grid integration paper. That paper was fortunate to win a Cozzarelli prize from PNAS due to the innovative ideas.

The storage options are low tech. You can produce ice with low-cost electricity (at night), and use that cold for air conditioning during the day. Using it for air conditioning avoids the need for electricity during the afternoon. A lot of places, including Stanford, use this already.

There's also seasonal heat storage with rocks. You collect sunlight during the summer on the roof of a building in a collector that contains a glycol solution. The solution gets passed through to water; the heated water is piped underground to heat rocks. The rocks can stay hot because they're insulated. In the wintertime the whole system can be run in reverse and supply 100 percent of wintertime building heat when snow is on the ground. One example of this can be found in Okotoks, Canada.

Then there's direct electrical storage—concentrated solar power storage, pumped hydroelectric power storage and existing conventional hydroelectric power, which is a form of storage.

Since wind and solar power fluctuate, how do you keep the power grid stable?
Wind and solar are complementary in nature. When the wind is not blowing, the sun is often shining during the day. But really you have to match peaks in demand. The way to do that is to use low-cost electricity, heat

storage and cold storage. Electricity storage includes concentrated solar power storage, pumped hydroelectric power and existing hydroelectric power. Heat/cold storage includes hot and cold water, ice and underground rock. In addition, some energy is stored in hydrogen for use in transportation. Finally, we combine these features with demand-response management.

Why the focus on solar and wind?

Because they're the only two forms of energy that theoretically can supply the entire world for all purposes, many times over. We can use geothermal, hydro, tidal wave. Geothermal would be in more limited locations, but it's a good resource. Hydro (electric) is not going to grow. There's opposition to it; we wouldn't add any new hydropower dams, just increase the efficiency of the existing ones. Tidal wave is more expensive, so there's probably lesser penetration. Also it's a limited resource.