



Race for Renewables' Game-changers Heats Up

By Elisa Wood, Contributor

April 16, 2012 | 2 Comments

'Innovation economics' is propelling a global hunt for inventions that can extend the frontiers of renewable generation.

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Virginia, U.S.A. -- First comes invention then comes prosperity. That's the theory of 'innovation economics,' a relatively new doctrine that underlies today's worldwide race to discover energy's next game changer and is triggering some intriguing tinkering in renewable energy. Will one of these new technologies lead us out of our economic malaise?

'Hurry up with your work.' That was the message delivered to energy innovators by Arun Majumdar, director of the U.S. government's [Advanced Research Projects Agency-Energy \(ARPA-E\)](#) at a Washington, D.C. gathering in November. 'Let there be no illusion that speed is of the essence right now,' Majumdar said at the energy innovation conference sponsored by the Information Technology and Innovation Foundation, a public policy think tank.

Why the haste? The last 100 years brought us electricity, air travel, nuclear technology, fibre optics, wireless communication and more. Now the world needs the equivalent breadth and depth of innovation from the energy sector, but this time we don't have a century to make the transformation. Dependent on a single fuel for transportation, the US is vulnerable from both a security and an economic perspective, particularly since it imports half of its oil - as does China. India also is an importer, as are Germany and Japan. 'This is a global problem and people are looking for technological leadership in trying to solve it,' Majumdar said.

At the same time, prosperity is arriving for large swathes of the undeveloped world, which creates new pressures and opportunities for energy innovators. Rural outposts have no transmission or distribution infrastructure, but they want electric lighting now, and they want it to be clean and affordable. Energy innovators are being called upon for quick solutions, and the victory will go to the swift, according to Majumdar.

Clean energy represents the 'biggest business opportunity' of the twenty-first century, Majumdar said, one that Bloomberg New Energy Finance expects to amount to a US\$7 trillion investment by 2030. 'The question is: Are we going to stand on the sidelines and buy all that stuff? Or are we going to innovate and make it and sell it to the rest of the world? That is the battle. That's the fight.'

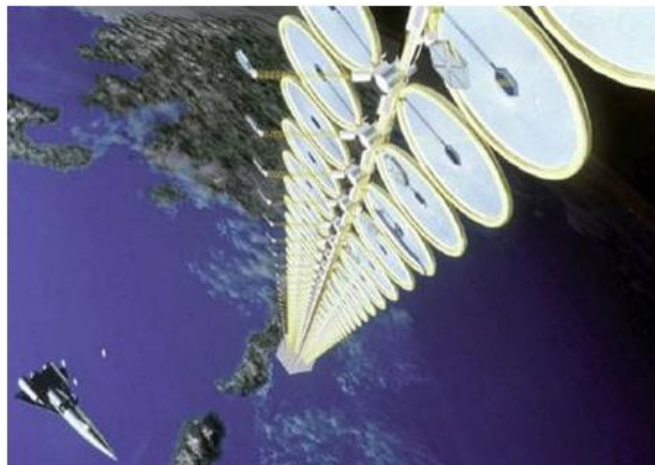
So how is it going on the battlefield? Are the energy innovators advancing? And will they prove that innovation economics is correct? Can we innovate our way out of today's economic slowdown?

Towards the Heavens

Some are casting their gaze upward for the answer, very high upward — about 6700 metres where potential exists for space-based solar power or satellite solar. Not so long ago it seemed far-fetched that orbiting satellites could collect solar energy and beam it to earth. But now, the chase is on to master the technology by researchers in the U.S., U.K., Japan, India and China. If they succeed, solar satellites could become one of the most disruptive energy technologies yet. In theory they could collect solar energy 24 hours per day, with no interruption from weather or darkness, and provide the world with much of the baseload electricity it needs. Because there is nothing to block the sun's rays in space, satellite solar panels could collect up to 25 times more power than those on earth, according to U.K.-based developer Orbital Power. Equipped with solar panels, the satellites would collect the sun's energy, convert it to radio waves and then beam the energy to a collector on the earth's surface where it would be converted to electricity and shipped to homes and businesses over existing transmission and distribution lines.

The concept has been around since the 1960s, but until recently has largely been dismissed because of technology hurdles and expense, estimated to be about five times that of conventional solar.

Roger Rosendahl, a partner at international business law firm DLA Piper, was among the early doubters. 'Several years ago a client asked me to assist in trying to procure an agreement with Pacific Gas & Electric (PG&E) for a 5-10 MW power purchase agreement for an innovative satellite solar power project. I admit to being fairly sceptical. I dubbed the project "Death Star", which didn't help on the marketing side. It didn't go forward,' he said. Rosendahl, who has represented several wind, biofuel and other energy projects, was particularly concerned that microwaves beamed to earth would evoke protests from California residents, despite assurances that the technology is safe. (California is notorious for its anti-development sentiment and has been a centre of protest against smart meters by those who believe radio waves cause health problems.)



Space-based solar is now widely considered to be a realistic prospect for the coming decades (Source: NASA/DOE)

Many people began looking at the technology more seriously after PG&E signed a contract in 2009 to buy 200 MW of satellite solar starting in 2016 from California-based Solaren. More recently, the International Academy of Astronautics boosted the credibility of satellite solar in the first international study on the technology. Published in August, the report says we'll have the technology to build large-scale satellite solar in 10-20 years.

But cost remains a stumbling block. It is doubtful that private capital will materialise without significant government backing, the report said. The projects need low cost earth-to-satellite transportation, which is not currently available. The report envisions the technology becoming commercially viable in a step-by-step fashion, rather than all at once, first capturing funding to make space transportation economical before mastering a cost-effective way to operate a solar power plant in space.

Space solar also faces political and legal challenges, Rosendahl said. Enemy nations could potentially cripple any high-tech economy that is heavily dependent on satellite solar by shooting down satellites. Governments also need to consider what to do with the space junk once the solar satellites became too old to operate.

Given the obstacles, Rosendahl is sceptical that PG&E will be using satellite solar as quickly as it expects, by 2016. He believes it will be closer to 20-30 years before the technology is affordable. But he admits he's become a believer: 'I have to say, as science fiction and Star Wars as all these things sound, it is probably going to happen. When technology focuses, it tends to find solution,' he said. 'If it does become commercially successful, look out oil, gas and coal.'

Back on Earth

Solar satellites may become a reality, but not soon enough to have a near-term effect on economic development. Closer to home, the microgrid gets the vote as biggest near-term game changer by Al Malouf, a scientist and project manager at NineSigma, a company which helps industry innovate. NineSigma uses an 'open innovation' approach, meaning it taps into a network of about two million 'solvers' worldwide that might help a company in its technology pursuit. African utility Eskom is one of its clients. NineSigma is also assisting [LAUNCH: Energy Challenge](#), an effort by NASA, USAID, the U.S. Department of State, and NIKE to find and develop 10 sustainable energy game changers. NineSigma works with distributed generation and microgrids, self-contained mini-versions of the larger electric grid that produce small amounts of electricity to serve nearby consumers.

Why does Malouf like microgrid? 'The big grid is expensive and slow. If we look at the microgrid, it is a little more affordable, faster, and a little less risky for homeowners, office complex owners or neighbourhoods to install.'

Microgrid operations also avoid the problem of building large transmission lines to carry electricity vast distances, which is not only costly, but also evokes protests from landowners who believe the lines are unsightly and devalue property.

Malouf is looking at some new, small scale forms of generation. As [REW](#) goes to press, LAUNCH has yet to announce its winners. But Malouf provided a sneak peak. One winner is a small aluminium device that paddles in water and generates electricity for low-demand targeted purposes. The device is well-suited for irrigation canals and sewer plants; in fact, Malouf calls it a kind of windmill for a sewer line. It is scalable, may be up to 2 metres long and generates enough power to supply pumps for a sewer plant.

Another is a fuel cell-like generator that is especially well-suited for rural Africa, where people typically are not connected to an electric grid. About 80% of Africans now own cell phones. Charging the phones is difficult and sometimes requires day-long walks to an electrified village. The fuel-cell device, which looks like little more than a small box, takes advantage of the biomass ovens that many African households use to heat and cook. The box is placed in the oven, where the heat causes it to produce power, enough to charge a cell phone or lights.

The industrial countries of the US and Europe do not need such products, but the developing world's vast population does. These inventions, if successful, could become a new profit centre for the developed world, which would act as creator, manufacturer and supplier for the vast unmet electricity needs of the developing world, gaining much-needed jobs in the process.

In the Garden

But getting the technology right represents only half the equation when it comes to creating game changers. Innovation in financing can be equally important. In fact, it was creation of the solar lease or solar power purchase agreement (SPPA) that spurred rapid U.S. growth in commercial solar during the last decade.

Such contracts do not address a larger problem in solar expansion. Not everyone owns good roof space or land for solar. Moreover, those who own property with strong solar potential don't necessarily have an incentive to develop it fully. As a result, a lot of solar potential goes to waste. Building owners can only use so much energy on their property. Why invest in more panels than they need?

'This isn't a technology problem. It's a financial problem, and underlying that is a policy issue,' said Lee Barken, a certified public accountant and practice leader for energy and clean tech at California accounting and consulting firm Haskell & White.

Virtual net metering or 'solar gardens,' now underway in about a dozen U.S. states, aims to correct the problem. Net metering allows utility customers to capture bill credits when their solar panels produce more power than the home or business uses. The utility, in essence, pays the customer for any excess energy their solar panels pump into the grid. The newer incarnation, virtual net metering, lets utility customers share those credits with others who may not have solar panels.

Typically solar gardens work by allowing people to pool their resources to install solar, much the way they might plant a community garden. The garden, or in this case solar panels, may not be in your own back yard, but it is communal. While members may not be physically connected to the panels, they benefit from them by receiving credits that lower their electricity bills.



*Innovative financial models such as virtual net metering can maximise solar potential
(Source: University Park Solar)*

Solar garden programmes vary depending on state rules. Massachusetts, which is trying to increase its solar installations from the current 67 MW to 250 MW, allows solar gardens only between customers who are served by the same utility. In Colorado, members must be within the same county. Other states limit the kinds of customers that can participate. Connecticut, for example, only lets government entities take advantage of virtual net metering.

Why might solar gardens be a game changer? They give property owners a financial incentive to install solar panels that exceed the capacity of their building's needs, encouraging maximum use of roofs or land with good sun exposure.

Proponents see store chains, municipalities, school districts and others that own multiple buildings as early adopters of virtual net metering, since they can use a solar installation on one building to help offset electric bills for their other facilities. In California, the first adopters have been apartment buildings, where tenants can all jointly share the benefits of solar.

The concept could also open up 'urban infill' to solar development, says Barken. These are parcels of land already disturbed in cities, but not usable for significant development.

But the vision for solar gardens is much larger. If states experience success with the small solar gardens now underway, they may allow more types of consumers to participate and expand the gardens' geographic footprint. If rules eventually allow, building owners in solar-rich states might transfer or sell solar garden credits to those in less favourable locations.

Another approach may be to treat solar gardens like a subscription service; you might live in California and subscribe to a garden. Then when you move to another state, you could sell your subscription, and buy another in your new location, Barken adds.

While many solar advocates champion the garden idea, they also point out hurdles. Barken calls this 'Prius effect': people drive highly efficient cars or install solar panels in part to show the world they are green, but if you are part of a solar garden, your roof has no panels to display. 'I think a lot of people will buy solar gardens because they can save money. But a segment wants to wave the flag. We're going to have to think of a creative mechanism for them,' he says.

Even so, such hurdles are surmountable, and the solar garden's potential is enormous. 'The solar garden can do in the US what the feed-in tariff (FIT) did for Germany. It could unleash a massive amount of entrepreneurial effort that opens solar for everyone, creates jobs and just explodes renewable energy opportunities,' he concludes.

Innovation Everywhere

Innovators are exploring a wide range of other renewable resources, many with promise. Biofuel developers are increasingly refining farming and harvesting methods to reduce water use and bring down the cost of non-petroleum transport fuels. Many are exploring algae as a feedstock because it is 'a petroleum that is being made fresh instead of fossilised', said Riggs Eckelberry, president and CEO of California-based OriginOil. The company helps algae growers extract oil in a single step that both de-waters and breaks down the algae for its useful products.

Others are trying to increase solar panels' efficiency. For example, U.S. company Magnolia Solar is doing so with thin film and nanostructures. Solar cells now absorb less than half of potential energy and the rest goes to waste, according to Ashok Sood, president and CEO. Magnolia Solar's technology attempts to improve this by absorbing more wavelengths of solar radiation.


Meanwhile, high-tech companies are working on analytics to improve our understanding of how, when and where renewable energy performs best. For example, IBM is analysing the environmental impact of wave technology in Galway Bay in partnership with the Sustainable Energy Authority Ireland. New Jersey-based Petra Solar is a technology company focusing on ways to make distributed solar more reliable through smart grid, demand response and energy storage.

Others are looking at dye-sensitised solar cells; bacteria to produce biofuels with electricity and carbon dioxide; batteries that use high-energy fluids to store wind and solar power; and, increasingly, technologies that replace rare earth materials from China used in the permanent magnets found in electric vehicles and wind turbines.

The energy innovators are busier than ever. Will they spur a new round of international economic growth? The answer will probably come in hindsight, as it did with computers, the internet, cell phones and other technologies that we can now say were game changers.



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