Vast amounts of solar energy radiate to the Earth, but tapping it cost-effectively remains a challenge

October 26 2011, by David L. Chandler

With the world's energy needs growing rapidly, can zero-carbon energy options be scaled up enough to make a significant difference? How much of a dent can these alternatives make in the world's total energy usage over the next half-century? As the MIT Energy Initiative approaches its fifth anniversary next month, this five-part series takes a broad view of the likely scalable energy candidates.

The sunlight that reaches Earth every day dwarfs all the planet's other

energy sources. This solar energy is clearly sufficient in scale to meet all of mankind's energy needs — if it can be harnessed and stored in a cost-effective way.

Unfortunately, that's where the technology lags: Except in certain specific cases, solar energy is still too expensive to compete. But that could change if new technologies can tip the balance of solar economics.

The potential is enormous, says MIT physics professor Washington Taylor, who co-teaches a course on the physics of energy. A total of 173,000 terawatts (trillions of watts) of solar energy strikes the Earth continuously. That's more than 10,000 times the world's total energy use. And that energy is completely renewable — at least, for the lifetime of the sun. "It's finite, but we're talking billions of years," Taylor says.

Since solar energy is, at least in theory, sufficient to meet all of humanity's energy needs, the question becomes: "How big is the engineering challenge to get all our energy from solar?" Taylor says.

Solar thermal systems covering 10 percent of the world's deserts — about 1.5 percent of the planet's total land area — could generate about 15 terawatts of energy, given a total efficiency of 2 percent. This amount is roughly equal to the projected growth in worldwide energy demand over the next half-century.

Such grand-scale installations have been seriously proposed. For example, there are suggestions for solar installations in the Sahara, connected to Europe via cables under the Mediterranean, that could meet all of that continent's electricity needs.

Because solar installations of all types are modular, the experience gained from working with smaller arrays translates directly into what can be expected for much larger applications. "I'm a big fan of large-scale

solar thermal," says Robert Jaffe, the Otto (1939) and Jane Morningstar Professor of Physics. "It may be the only renewable technology that can be deployed at very large scale."

And we do know how to harness solar energy, even at a colossal scale. "There's no showstopper, it's just a matter of price," says Daniel Nocera, the Henry Dreyfus Professor of Energy at MIT.

Nocera foresees a time when every home could have its own self-contained system: For instance, photovoltaic panels on the roof could run an electrolyzer in the basement, producing hydrogen to feed a fuel cell that generates power. All the necessary ingredients already exist, he says: "I can go on Google right now, and I can put that system together." Nocera's own invention, a low-cost system for producing hydrogen from water, could help over the next few years to make such systems cost-competitive.

In principle, we know multiple ways of generating electricity from the sun (direct photovoltaic, or solar thermal energy used to drive a turbine); of storing that energy (in batteries, by pumping water uphill, or by separating water into hydrogen and oxygen using an electrolyzer); and of converting that stored energy into electricity when it's needed (using fuel cells powered by hydrogen, for example). Some kinds of solar power are already cost-competitive, at least in some settings, and prices have been moving steadily downward.

"Costs have come down very dramatically" for solar power, says Ernest J. Moniz, the Cecil and Ida Green Distinguished Professor of Physics and Engineering Systems and director of the MIT Energy Initiative, "but it's still not that cheap." And even as the price of solar panels themselves has dropped, there has been little reduction in the costs associated with installing them.

Like nuclear power, Moniz says, solar is characterized by high initial costs, but very low operating costs. But one significant advantage solar has over nuclear is "you can do it in smaller bites," rather than needing to build multibillion-dollar plants.

Solar energy is a vibrant research topic, attracting scientists interested in many different approaches. For example, MIT researchers Angela Belcher and Paula Hammond are exploring approaches to solar power that would harness the power of biological organisms to create solar devices; Penny Chisholm and Shuguang Zhen are looking into the possibility of directly harnessing the photosynthesis done by plants or single-celled organisms; and various researchers including Vladimir Bulovic, Michael Strano, Tonio Buonassisi, Jeffrey Grossman and Yang Shao-Horn, among others, are working on ways of improving the efficiency or lowering the costs of solar photovoltaic cells.

Still others are pursuing a variety of approaches to solar thermal energy: using the sun's heat to power turbines or to heat homes or water. A significant breakthrough in any of these areas could make solar power an economically viable option for the world's energy needs. This year, for example, Alexander Slocum and others published a proposal for a solar thermal system that could provide steady, 24/7 baseload power for utility companies, helping to make it cost-competitive with other sources.

Other researchers are studying ways to make effective solar-power systems using common, inexpensive materials. For example, cadmium telluride is a very promising material for solar cells. But it turns out that tellurium, one of its ingredients, is "rarer than gold," Jaffe says. "We need to be able to make solar cells out of common materials, or at least things that are not exquisitely rare," he adds.

(web.mit.edu/newsoffice/), a popular site that covers news about MIT research, innovation and teaching.

More information: *Tomorrow: There are many sources that can make a contribution to our energy supply, but likely not at a major scale in the near future.*

Part 1. www.physorg.com/news/2011-10-dent.html
Part 2. www.physorg.com/news/2011-10-p … ons-electricity.html
Part 3. www.physorg.com/news/2011-10-v … ar-energy-earth.html

Provided by Massachusetts Institute of Technology