Innovation Brief

Value of Solar for the United States

Overview

The United States, along with a majority of countries around the world, is on a course to transition away from a fossil fuel-based economy to one driven by domestically produced renewable energy sources. This transition has been spurred by a desire for energy independence and security, a need to address public health concerns related to the burning of fossil fuels and an imperative to address and avoid the worst consequences associated with climate change. Incentives at the state and federal levels, such as Renewable Portfolio Standards (RPS) and investment tax credits, have helped spur growth in the renewable energy field including a rapid increase in solar power installation. While solar currently accounts for only 0.6 percent of electricity generated in the United States, installed capacity has been increasing at double-digit rates over the past six years. Jobs in the solar sector now outnumber those in coal mining and oil and gas extraction with over 200,000 Americans employed. The sector has grown from nearly $70 million in revenue in 2010 to almost $200 million in 2016. Solar has transitioned from a niche energy source to one that employs and provides electricity for thousands of Americans across nearly all 50 states.

Globally, U.S. solar firms currently rank among the top producers behind firms in China, Taiwan and South Korea. In order for the United States to maintain its leadership position and out-produce competitors in terms of quality and quantity, several barriers and challenges will need to be overcome.

Problem Statement

Solar power has the potential to contribute to U.S. energy security by generating safe, domestically produced electricity. For solar to achieve a greater market share in the energy mix, however, advancements in the technology will be necessary to bring the total cost of a solar power system down to reach grid parity with fossil fuel-based sources.

The Facts

Solar cells absorb sunlight and generate electricity without generating any pollution or noise, making it a highly desirable energy source. Historically, solar power generation as been cost prohibitive compared to more traditional fuels, but the cost of solar electricity generation has been falling rapidly. With continued research and development the cost could drop within five years to the point where it will be cheaper to get electricity from unsubsidized solar cells than conventional power plants that run on fossil fuels. The solar industry is expected to grow explosively at that point.

Ninety-two percent of the solar cells shipped in 2015 were made from silicon. The price of silicon solar cells has dropped remarkably over the last six years as economies of scale have been achieved and factories have been designed to produce silicon, especially for solar cells instead of computer chips. The current total price

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of a solar system is $2.60/W and the average cost of the electricity produced by that system over its lifetime is $0.12/kWh. Many factors make up the total system costs including the modules at approximately $0.42/W, the racks that support the solar cells and their installation at $2.10/W and the technology to convert DC to AC electricity at $0.3/W.

If the total price of installing a solar system was reduced to $1/W, then the average price of generating electricity over the lifetime of the system would be approximately $0.05/kWh and the system would be competitive with power plants that run on fossil fuels. A key part of reducing installation costs will be raising the efficiency of the solar cells from 16 percent so that the total area that needs to be covered with solar cells can be reduced. Technologies that have at least 20 percent efficiency and preferably 25 percent efficiency are therefore highly desirable. Academic researchers in this field are exerting significant effort towards achieving this breakthrough.

Government programs, such as the U.S. Department of Energy's Sunshot Initiative can help accelerate the necessary reductions in solar costs. Sunshot aims to cut the cost of electricity from utility-scale solar by an additional 50 percent between 2020 and 2030 to $0.03/kWh. At the same time, the program will address grid integration challenges and key market barriers in order to enable greater solar adoption. One goal is to significantly reduce the costs of installing solar cells by making them so easy and safe to install that unskilled workers could be employed for this task.

In addition to government programs, companies, universities and national labs have important roles to play. For example, it should be possible to make solar modules that are cheaper than those based on silicon by depositing thin film semiconductors on inexpensive substrates made of materials like glass, metal or plastic. The three most promising semiconductors are cadmium telluride (CdTe), copper indium gallium diselenide (CIGS) and perovskites. Companies are commercializing these technologies, but more basic research needs to be done in universities and national labs to better understand these materials so that more efficient and reliable solar cells can be made with them. All three semiconductors have the potential to yield modules with power conversion efficiency greater than 20 percent at a price less than $0.4/W. The efficiency could increase to over 30 percent if two thin film solar cells are stacked on top of each other inside the same package. If advances are made in making flexible transparent packaging material that can last for 25 years in sunlight, modules based on thin films of semiconductors could be flexible which would increase their range of application. The shipping costs for these modules would be lower because they would weigh much less and installation costs could potentially be lower as well. These lightweight, flexible modules would be highly desirable, especially for military applications when power is needed in places where it is difficult to obtain fuel.

The Challenges

Several key barriers exist that hold back the growth of the solar industry, including:

- The cost and difficulty of solar system installation;
- Higher per kilowatt hour costs relative to existing, incumbent electricity sources; and
- A complicated permitting process that is different for nearly every county in the country and which often substantially delays projects and adds to their costs.

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The Recommendations

The United States is a world leader in installed solar capacity and in the research and development of new solar technologies. To maintain our leadership position and remain competitive with countries such as China, Germany and Japan on future development and deployment of solar energy, policy attention should focus on:

- Continuing programs that support top-quality research, such as the U.S. Department of Energy's Sunshot initiative, in order to make solar electricity affordable by producing more efficient and cheaper solar modules, reducing installation costs and improving power electronics;
- Supporting research and development for more advanced solar cells;
- Creating instructional programs to train installers;
- Addressing the permitting challenge by developing requirements and processes that are the same across large geographic areas; and
- Promoting manufacturing in the United States, a move that could create millions of jobs.

This brief is based on research and findings by Michael McGehee, Professor in the Materials Science and Engineering Department and a Senior Fellow of the Precourt Institute for Energy at Stanford University.