Energy Policy 39 (2011) 887–893

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

A solar economy in the American Southwest: Critical next steps

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ARTICLE INFO

Article history:
Received 16 July 2010
Accepted 3 November 2010

Keywords:
Solar
Workforce
Arizona

ABSTRACT

Like many other sub-tropical deserts in the world, the southwestern U.S. has high rates of solar insolation. However, meaningful development there, especially in solar-rich Arizona, has been slow. This article addresses why this is so by concentrating on one critical contributor to success—workforce development. To identify shortcomings and needed changes, we used a survey of the significant solar firms operating in Arizona to ask three questions: Does a gap exist between existing and desired levels of solar engineering education and training? What skills should new graduates possess when entering the solar energy workforce? What course of study is considered important in the education of solar energy employees? We found that a stronger solar economy in Arizona will not depend, at least initially, on advanced graduate training in engineering, but on a broad-based Bachelor's level degree program that complements engineering studies with a strong emphasis on verbal and written communication, as well as business and teaming abilities. Non-technical skills and project management are at least as valuable as solar training. Given the high public awareness of Arizona's solar resource, a stronger solar future there should help stimulate similar progress elsewhere, both in the U.S. and abroad.

1. Introduction

Solar energy is destined to be an important element in any chance we have of achieving a sustainable energy future. Whatever future primary power requirements might develop – whether the 50 terawatt (TW) estimate of Hoffert et al. (1998) or the 10 TW estimate of Harvey (2010) – solar energy is predicted to make an important contribution (Blanco et al., 2009; Fthenakis et al., 2009). The question is, how should we best prepare for and accelerate the transition from conventional fuels? What do we need to do? According to the U.S. National Science Board (2009), the answer first and foremost is to develop more human capital in the form of solar education and workforce development. Presumably, such changes would most fruitfully be applied in the southwestern state of Arizona, a place that regularly receives recognition as the logical place for solar energy development (Zweibel et al., 2008), and "the established solar energy king" (Business Facilities, 2010). One might reasonably argue that if we cannot stimulate large-scale commercialization in Arizona, where would we be more successful? This is an especially salient question given that such success is predicted to produce both more jobs (Wei et al., 2010) and greater economic enhancements (Frondel et al., 2010).

Given the great resource in the American Southwest, it may be surprising – if not perplexing – to admit that other countries such as Germany, Spain, and Japan have been moving much faster to develop the solar energy available there. There are many reasons for this difference, such as the greater commitment Germany has made to reduce carbon emissions. Also, Germany has implemented favorable policies such as a generous feed-in tariff (Scheer, 2007). As feed-in tariffs continue to be downsized, however, we can expect that the pace of expansion in Germany will slow and other places, such as Arizona, will begin catching up. Such expansion should have a healthy effect on solar development throughout the U.S. as well as internationally.

In anticipation of such a progression, companies from many countries already have established a solar presence in Arizona. Yet, for now, further progress is needed. Some of that progress will probably have Arizona itself pass a feed-in tariff, but it will also require other steps such as a friendlier and more enthusiastic business climate overall, higher rates for conventional electricity that reflect their various environmental externalities, and more effective leadership. This article reports on the results of a survey of solar firms in Arizona that assessed the need for workforce development in the state, a recognized key element in any solar energy future. The survey posed three research questions: Does a gap exist between existing and desired levels of solar engineering education and training? What skills should new graduates possess when entering the solar energy workforce? What course of study is considered important in the education of solar energy employees?

1.1. The Arizona solar context

Arizona is the most attractive solar state in the southwestern U.S. "With an average of 325 sunny days each year, wide open

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0301-4215/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2010.11.013

spaces, and an increasing need to locate and take advantage of 'green' energy opportunities, the Arizona desert is prime territory for renewable energy in the form of natural sunlight" (U.S. BLM [Bureau of Land Management], 2010, p. 1). Specifically, insolation in the west-central and southwestern regions of the state can produce more than 6 kWh/m^2/day, about twice that of what is possible in southern Germany.

In recognition of this resource, the U.S. Bureau of Land Management (BLM) (2009) has experienced a 'gold rush' of right-of-way applications for solar facilities across Arizona. These prospectors are looking at 12.2 million acres of land administered by the BLM. Over 90% of these applications are for the development of projects using concentrating solar power (CSP) in the form of parabolic trough concentrators. Most of these projects would likely send their generated electricity to California, where retail rates substantially exceed those of Arizona.

As proposed projects have multiplied rapidly in recent years, people are seeking to avail themselves of the still great opportunities for solar energy to become big business in Arizona, despite the head start of other countries (Busch, 2010; AzSC [Arizona Solar Center], 2010; Arizona Goes Solar, 2010). Over 160 solar companies now operate in the state, and although many of them are "start-ups", some large international companies are also involved, including BP, First Solar, and Kyocera. One local utility company, Tucson Electric Power, has a 4.6 megawatt (MW) array already in place, and Arizona State University has more solar PV capacity than any other university in the country, currently about 2.5 MW with planned additions of 7 MW by the end of 2010. Increased development in the future will help Arizona "become a world leader in the solar power industry" (AERO [Arizona Economic Resource Organization], 2008, p. 1), and to cash in on the "Saudi Arabia of solar", as Gov. Janet Napolitano once characterized Arizona's solar potential (Copenhaver, 2009). Arizona Congresswoman Gabriel Giffords (2007), for one, believes that southern Arizona can become the "solar-con valley" of the U.S. (Copenhaver, 2009). Progress in Arizona is sure to be noticed throughout the world.

Thus far, however, installed capacity is low. By the end of 2009, the total photovoltaic (PV) capacity of systems in the state reached only 14.4 MW, out of a total of 826 MW nationwide (NREL [National Renewable Energy Laboratory], n.d.). This places Arizona eighth in the U.S. behind California, New Jersey, Florida, Nevada, Colorado, Connecticut, and Massachusetts and much farther down the list when compared with many places in other countries. By contrast, Germany installed a record 3800 MW of solar PV in 2009, a significant portion of the 21,000 MW installed globally (Russell, 2010). To the residents of the state, as well as its millions of visitors, the minor presence of solar energy development in Arizona is difficult to understand.

To others, the explanation is clearer. Arizona still lacks a plan for the promotion of solar energy that is coordinated, agreed, and well-funded. Nevertheless, it has made some headway in recent years. The present Renewable Energy Standard (RES) requires regulated utilities to generate 15% of their electricity from renewable energy by 2025, with about one-third of that from distributed sources (UCS [Union of Concerned Scientists], 2008). There is also a "solar–electric roadmap", developed in 2007, which affirmed that Arizona "has the potential to become a world leader in many aspects of solar development, and is a model location for the evolution of new solar technologies and applications" (Arizona Department of Commerce, 2007, p. 1).

One of the specific objectives of the Roadmap was to describe the necessary conditions to entice the solar–electric industry to make the required investment. Among the identified conditions were workforce development, research, and a call for public education programs on alternative energy. There has been some unhurried progress in all these arenas, with some recent progress at Arizona State University and the University of Arizona (AIRE [Arizona Initiative for Renewable Energy], n.d.; AzRISE [the Arizona Research Institute for Solar Energy], 2010; NSF [National Science Foundation), 2010).

Solar programs in Arizona have grown organically rather than systematically, and this is true of solar education in the state. Usually, solar energy courses have been inserted into curricula one at a time, commonly as part of a group of courses with another primary emphasis. This suggests that solar education programs, whether sponsored by the state or made available through institutions of higher learning, tend to develop with little attention to the ultimate application of acquired expertise to a future solar economy. It also reflects little coordination between industry needs and training response.

The solar companies in Arizona vary in size, function, and plans for expansion. First Solar, with headquarters in Tempe, Arizona had 2009 revenues of $2.1 billion for its thin-film products (which are lighter and cheaper than the more familiar silicon solar cells, albeit with a reduced energy conversion efficiency of 7–10%). It has more than 4700 employees worldwide (First Solar, 2010). Other Arizona companies include the American subsidiary of the Japanese company Kyocera with revenues of more than $200 million (Newman, 2010). Stirling Energy Systems (SES), a private company that uses a solar dish technology to focus sunlight on a Stirling engine for water-free generation, has estimated revenues of between $10 and $20 million (SES, 2010). Abengoa, a Spanish company with a local presence, plans to construct a 280 MW concentrated solar power (CSP) facility near Gila Bend with a capital cost of over $1 billion (Solana, 2010). Suntech Power, China's largest solar panel manufacturer plans to open its first American plant near Phoenix (Galbraith, 2009). In total, over three dozen solar projects of various sizes have been proposed for Arizona. Their combined capital contribution to economic development has people starting to pay closer attention to the ultimate commercial solar energy potential in the state. Our survey examined what should be done to best prepare the Arizona workforce to welcome and enhance this attention.

2. Methods

Achieving the potential for solar energy development in Arizona (or anywhere) requires understanding a complex interlocking of a diverse set of topics. These include economics, policy, legislation, technology, education and training. To obtain a greater understanding of these last two components, we used both quantitative and qualitative research to generate rich descriptions and provide an internally consistent account of constituent perceptions. We conducted formal interviews, administered an online survey, and examined the public literature.

To ascertain an initial willingness to participate in our study, a pre-survey letter of request was distributed to over 160 industries that we identified as possible solar energy firms. Of these 160 industries, we deleted several that were no longer in business. Of the others – such as those small operations involved in construction, roofing, sales, consulting, or marketing of some aspect of solar energy – some said they were not offering any jobs in the near future and consequently had not established any employment and training criteria. Some of the remaining industries felt "unqualified" to discuss the educational needs for employees in a solar energy workforce and opted out of this study. This process of elimination resulted in a list of 134 solar energy companies still doing solar business in the state. Ninety-two companies agreed they were appropriate candidates for the study and agreed to participate. Three reminders were sent out after the first online mailing in spring of 2010. Of the 92 local relevant companies, 76