Book Reviews

Bradford, Travis. 2006. *Solar Revolution: The Economic Transformation of the Global Energy Industry.* Cambridge, MA: The MIT Press.

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Travis Bradford's new book, *Solar Revolution,* begins and ends with the theme of the inevitable economic dominance of solar energy technologies in the global energy industry. Like a repeated melody in a piece of music, the proclamation of inevitability is woven throughout the book, supported by two basic assumptions. The first assumption relates to what Bradford terms "the bankrupt energy system" (p. 5), which weighs the decreasing energy savings of non-renewable energy resources against the increasing energy expenditures of the world system. The features of this deleterious system include various forms of pollution, global climate change, energy scarcity and price volatility.

Although the book contains some explanation of the environmental consequences of energy production, Bradford is primarily focused on how energy scarcity and supply disruption (especially referring to oil) relates to price volatility. Repeatedly, he emphasizes the idea that individual energy consumers, "who usually make decisions based on immediate concerns such as cash in versus cash out" (p. 17), will be the driving force of the solar revolution. Although he acknowledges that solar energy alone will not fulfill the entire world's future energy needs (instead, insisting upon a portfolio of technologies), for Bradford, solar energy technology eclipses other technologies for several reasons.

He considers the distributed generation quality of solar energy technology (off-grid and grid-connected solar energy applications) to be central to its future cost-effectiveness. In rural areas of the developing world like South Asia and Sub-Saharan Africa, off-grid applications of solar energy allow local people to forego the added expenses and technical difficulties associated with connectivity to a central grid. Bradford spends most of his time dealing with grid connectivity, in which features like net metering provides economic benefit to utilities by "taking in expensive daytime energy from the customer and reducing it at cheap nighttime costs" (p. 176). Sunlight is, of course, most abundant during the daytime hours of peak energy use. These features work together to create economic advantages for solar energy use.

The second underpinning of Bradford's argument for the coming solar revolution rests upon electricity-generation economics and the increasing cost-competitiveness of solar photovoltaic (PV) technology. He analyzes various

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metrics for determining the cost of solar-based electricity generation, including cost of installation and operation, and identifies the limitations of current approaches. Bradford also proposes more useful metrics like measuring "cost per kWh as delivered to the end user" by "adding transport cost to the standard calculation of cost per kWh of centralized generation" (p. 125) and including external costs described as "quantifiable societal or environmental costs of each electricity source" (p. 126).

Bradford's evaluation of electricity costs as applied to various energy sources may not be new, but he offers a well-structured and cogent argument for solar power's superiority. It becomes clear that measures commonly used in energy economics can be deceptive. PV's major economic disadvantage is that "over 90% of the lifetime cost of a system is paid up-front" (p. 137) at the time of installation. PV shows even greater cost-effectiveness when features of other metrics are considered. These features include the fuel and maintenance components of operating costs and the transportation costs associated with centralized production. To his credit, Bradford attempts to build his argument upon the true market viability of solar power without relying on assumptions about future government incentives and disincentives, the "assumed significant increase in the price of fossil fuels," or far-fetched advances in photovoltaic technology (p. 16).

According to Bradford, solar energy technology is currently marketable in certain locations such as the southwest United States, and will continue to become the preferred alternative based on the most likely projections in PV cost. He uses the "experience curve" to illustrate the relationship between cost and cumulative quantity produced. For every increase in installed volume there is an associated drop in per unit cost. Based on the experience curve, Bradford predicts that "an 18% learning rate and a 30% annual market growth rate would translate into a cost decline of 5% to 6% a year" (p. 110). The economic figures and forecasts presented in the book paint a favorable picture of the future of solar energy technology.

Much of the evidence for solar energy's predicted dominance, like complex concepts related to the pricing of electricity or the technical features of solar energy, receives only cursory explanation. It seems impossible to fully predict the future of such a complex and variable system. The likelihood of solar energy dominance seems less inevitable than Bradford suggests. He is most effective at presenting a well-crafted and quick-paced overview of the technological and economic dimensions of solar energy technology today and what it may look like in the future. This book is a valuable resource for policy-makers and scholars interested in how solar energy could transform the global energy economy.