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Solar energy strategies in the U.S. utility market

Wesley Herche

Arizona State University – Global Security Initiative, United States

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ABSTRACT

Given the exponential cost decline trend of solar energy generation technologies, and the targeted tax incentives and loan guarantees for renewable energy in the American Recovery and Reinvestment Act of 2009, and other policy measures, solar energy generation has been enjoying rapid growth in the United States. This paper examines the incorporation of solar renewable energy into generation portfolios, and the effects of natural capital – specifically the geospatially calculated potential solar energy generation as measured by potential average annual kilowatt-hours per square meter per day – and respective state mandated "renewable portfolio standard" targets on utility-scale solar energy generation. Findings suggest that a state's natural solar energy potential is a predictor of solar energy generation development, and further this relationship is significantly moderated by state-specific renewable energy portfolio standard targets.

1. Introduction and background

1.1. Introduction

Consumer demand for a greater emphasis on renewable energy generation is very high in the U.S.; a 2013 Gallup poll of Americans showed support for "more emphasis" on solar and wind energy at 76% and 71% respectively [20]. The poll further indicated that support for solar power was high regardless of geographic region with "East", "Midwest", "South", and "West" indicating support at 79%, 75%, 74%, and 78% respectively. Meanwhile prices for solar generation technologies continue to rapidly decrease; unsubsidized costs for solar photovoltaic systems have become cost-competitive with fossil fuels, utility scape PV specifically is on average cheaper than all forms of fossil fuel based generation [23]. Further, this strictly economic comparison ignores the externalized costs of fossil fuels in terms of environmental degradation and public health, thus when factoring in these negative externalities renewable technologies become even more attractive [5]. Despite large consumer appetite and falling prices, the most current estimates show renewables making up just 13% of US electricity production with solar (utility scale and distributed) being just under 1% [13].

Policy initiatives at the national and state level have directly targeted renewable energy production. At the federal level Section 1603 of the American Recovery and Reinvestment Act of 2009 (ARRA) had investment tax credits (ITC) of 30% for qualifying commercial renewable installations. These took effect in 2009, were extended twice, and have run through 2016 [37].

At the individual state level many states have created some version of a "Renewable Portfolio Standard" (RPS). An RPS mandates a specific target percentage for production of energy that must be from renewable sources such as solar, wind, geothermal, and biomass; electric utility companies must source their energy generation according to these minimum targets or face penalties imposed by the state. The RPS concept was first proposed and developed in the 1990s and implementation varies widely across states [26]. Fig. 1 shows the 29 U.S. states have some form of statutory RPS, usually these are a targeted percent of renewable generation by a certain year with a graduated schedule of advancement to the target goal, and an additional 8 states have non-binding voluntary renewable goals [11].

States differ on their overall target goals as well as respective "carve outs" and "multipliers" for specific renewable technologies that legislatures may be trying to promote in their state.[1] It should also be noted that many states without an existing RPS still have sizeable renewable energy generation collections.

The RPS, ITC utilization rates, and the natural capital potential of solar irradiance within each state are all examined against solar energy generation for electricity. The results provide a contribution to the literature on identifying the relative strengths and interaction effects of key correlates of electrical generation from solar. Because this examination is across multiple sets of data with varying degrees of temporal currency various annual ranges were utilized to have valid comparisons across datasets. In all cases the most current points or ranges of available data were used where appropriate.

E-mail address: wherche@asu.edu.

[1] i.e.: Within an overall goal of "15% renewables by 2015" a particular portion may be mandated for residential rooftop solar, or a wind energy generation may be counted towards the goal as at "1.5 times" rate.

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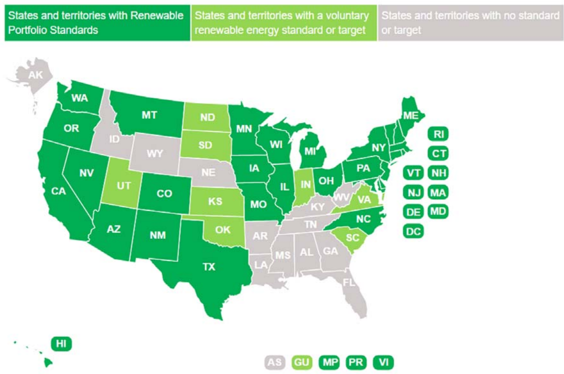

Fig. 1. Renewable portfolio standards [11].

1.2. Background

Benefits from both economies of scale [32] and technological innovation [15], have yielded exponential and consistent performance improvements in solar PV technology when examined on a global scale. The notion of "Swanson's law" has emerged; similar to "Moore's law" for computers [27], this phenomenon was named after SunPower Corporation founder Richard Swanson, who first noted, "module prices reduce 20% for every doubling of cumulative volume." [33,35]. Fig. 2 illustrates Swanson's Law with the non-linear (inflation adjusted) dollars per watt from 1977 to 2013. Thus considering a broader framing that also considers policy, geospatial explicitness, and market factors might yield more heterogeneous, and therefore more interesting, insights. Numerous bodies of literature have identified the need to incorporate these types of sociocultural and sociotechnical dynamics into the energy discussion [2,25,31,36,39,4,9].

For this analysis only the RPS goal for the state, if applicable, will be used as a general proxy indicator of the state's civic appetite for renewable energy within their electricity generation portfolio mix. Prior research on RPS policies have found that initial adoption of RPS by a state varies depending on the political makeup of the state legislature, the size of the existing renewable energy industry within the state, the state's reliance on natural gas, and the regulatory state of the electric utility market [24]. Further, not recognizing the heterogeneity of implemented RPS programs across various U.S. states has been insufficient for analysis in explaining variation among specific properties and provisions of the state's RPS and the resulting growth of renewables in that state [38].

This discussion extends the discourse on market effects of state and federal policies and incentives on a still emerging industry [10,29]. Further it extrapolates from well-established geographic theories of spatial autocorrelation [34]. Understanding these interaction effects has significant strategic implications for state and national policy makers, renewable energy advocates, entrepreneurs, and utility industry managers.

2. Hypotheses

The overall effect of RPS policies on the retail price of electricity is contested in both the political and academic arena. Generation is certainly the dominant factor in price; Fig. 3 illustrates estimates by the U.S. Environmental Information Administration revealing 58% of retail electricity prices are determined by generation, with transmission and distribution making up the other major components of the cost [6].

While critics often make unsubstantiated claims that renewable generation is more expensive than fossil fuels, if true this would logically indicate that the influence on markets of RPS laws would ultimately increase retail electricity prices. Yet previous research pursuits have been mixed arguing that RPS implementation could raise prices by increasing electricity generation costs or even lower prices because of reduced demand on non-renewables [12,16,17].

Those assumptions are tested here with empirical findings based on the state average change in retail energy price from 2005 to 2012 against the state's RPS percentage of renewables target for 2012. The years from 2005 to 2012 seem most critical as this is the general

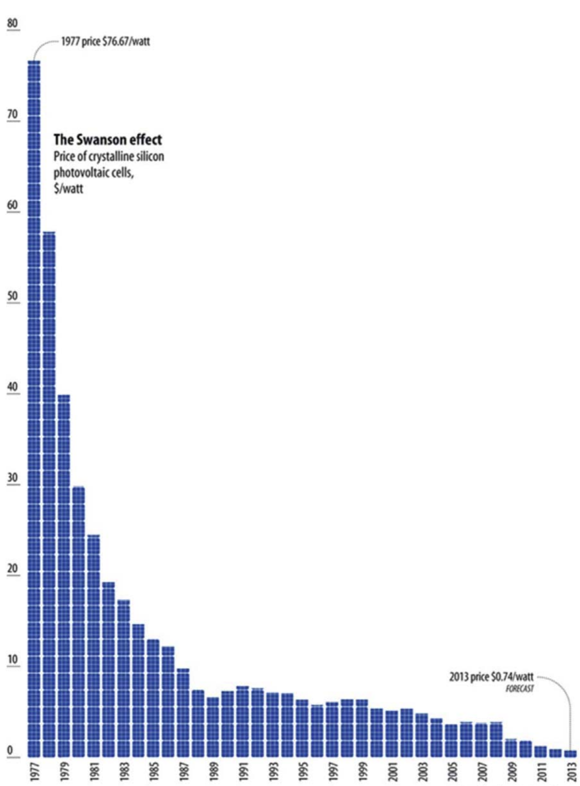

Fig. 2. The Swanson effect [35].

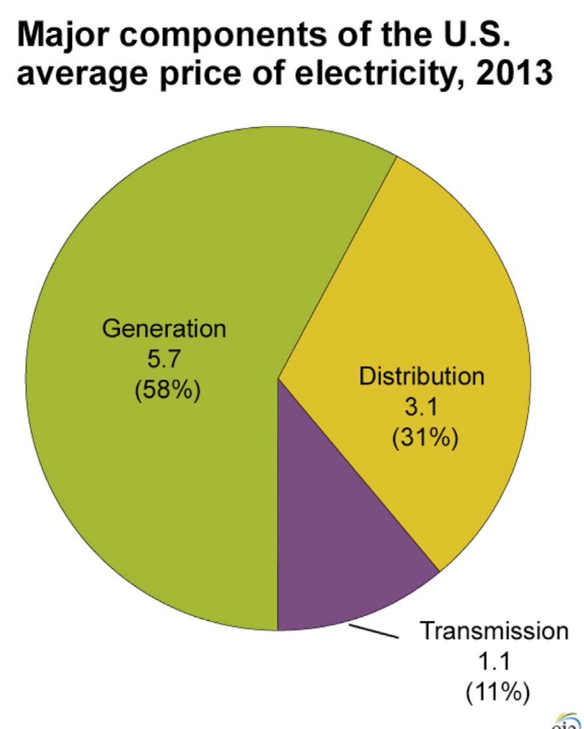

Fig. 3. Major components of the U.S. average price of electricity [6].