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Estimating technical potential for rooftop photovoltaics in California, Arizona and New Jersey

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ABSTRACT

Due to the explosive growth of cumulative installed capacity of solar photovoltaic technology across the US in the last five years, industry attention has started to shift to understanding market saturation levels, at which year-over-year growth would be expected to decline significantly. On the residential and commercial scales, the saturation point in the market for distributed PV installations is directly dependent on physical roof space availability. This paper details the multi-level estimation methodology used to estimate rooftop PV potential in the commercial and residential sectors in three leading states: California, Arizona, and New Jersey, which combined account for two-thirds of the cumulative installed PV capacity in the U.S. The estimation methodology shows significant growth potential for rooftop PV in the residential and commercial sectors in these leading states, conservatively estimating that rooftop PV could provide 35%, 43%, and 61% of state electricity demand in New Jersey, Arizona, and California, respectively. According to the results of this analysis, these states could increase current installed distributed PV capacity by 20 times, 30 times, and 40 times, respectively.

1. Introduction

1.1. Current state of PV market in U.S

In the last ten years, state and federal-level policies have facilitated rapid adoption of photovoltaic (PV) technologies. According to a recent Interstate Renewable Energy Council (IREC) report [1], the 30% federal Investment Tax Credit (ITC) is the "foundational" incentive for solar installations. The ITC was originally introduced in 1978 under the Energy Tax Act, initially offering a 15% tax credit. In 1986, the ITC was reduced to 10%. The Energy Policy Act of 2005 (EPAct 2005) increased the ITC to 30%. The EPAct of 2005 was shortly followed by the Energy Improvement and Extension Act (EIEA) of 2008, which extended the ITC at 30% through 2016 [2].

Historically, states and electric utilities supported PV deployment through capital rebate programs. In recent years, however, support has begun to shift towards production based incentives [1,2]. Currently, 29 states and Washington D.C. have Renewable Portfolio Standards (RPS), mandating Load Serving Entities (LSEs)[1] to provide a fixed portion of the electricity sold from renewable energy sources. Eight more states have renewable energy goals. 21 states and Washington D.C. have solar or Distributed Generation (DG) provisions, or "carveouts," in their RPS scheme [3]. RPS requirements are typically met through Renewable Energy Certificates/Credits (RECs).[2] Consequently, RPS schemes promote the production-based incentive structure.

Federal and state renewable energy policies led to more than 50% annual cumulative capacity growth in a five year period, guiding cumulative installed PV capacity in the U.S. from less than 1 GW in 2008 to more than 12 GW by the end of 2013. The states leading this growth were California, Arizona and New Jersey [1,4], which when combined, represent nearly two-thirds of total cumulative installed PV capacity in the U.S. (see Fig. 1). In 2013, California with 5183 MW installed capacity was a national leader, followed by Arizona with 1563 MW and New Jersey with 1184 MW of installed capacity [1].

Until recently, residential and commercial installations were dominating PV markets. However, utility scale PV (here, installations greater than 1 MW) experienced steady growth and

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[1] Load Serving Entity (LSE) refers to entities, such as an energy provider or a load aggregator that has been granted the authority by the state or local law to sell electricity to end-users in its service region [41].

[2] For solar energy RECs are referred as Solar Renewable Energy Credits (SRECs).

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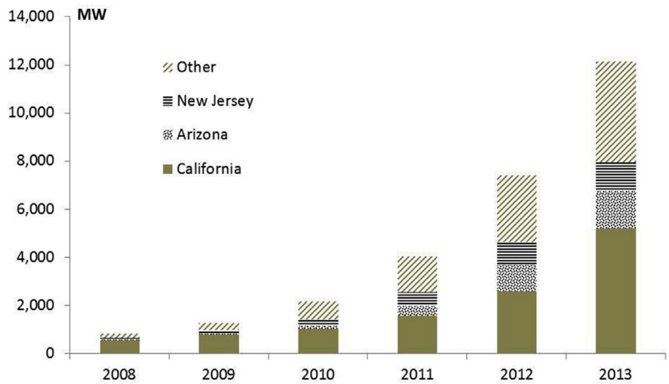

Fig. 1. Cumulative PV Installation by Three Leading States in U.S. Data source [1].

reached 46% of total installed capacity in 2013 (see Fig. 2). The significant increase in utility scale PV can be explained by LSEs desiring to meet their RPS obligations by developing their own PV projects. In many cases, utilities prefer this approach since they stand to benefit directly from the RPS and SREC market transactions in addition to the ITC [1]. Utility scale PV projects have lower initial unit costs and this can transpire in lower production costs for LSEs to meet their RPS obligations (through direct ownership or through SREC purchase). This might lead to conditions where utility scale PV meets the entire solar carveout under the RPS. This can be avoided by providing special policy provisions for small-scale PV installations.

Other stimuli that have helped to facilitate the growth of utility-scale solar plants in the U.S. in recent years were the Department of Energy's Federal Loan Guarantee program and the new forms of financial structures that attract the private financing entities in funding the PV projects. The USDOE's Loan Programs Office (LPO) supports large-scale solar PV utilities by issuing federal loan guarantees to back the new PV projects, bearing some of the risks inherent in a project without any commercial operation history [5]. According to recent LPO data, the program provided more than $4.6 billion in loan guarantees to support construction of the first five utility-scale PV solar facilities larger than 100 MW in the United States in 2011 [5]. Using new financial vehicles and mechanisms applied to PV projects that rely on long-term Power Purchasing Agreements (PPAs), such as single owner, all-equity partnership flip, leveraged partnership flip, and sale-leaseback, has been essential in lowering uncertainties and distributing profits among investors, which only incentivizes further investment and development [6]. These long-term PPA contracts are easier to set up for a utility-scale PV project and thus benefit utility-scale projects more than the residential and commercial sectors [1].

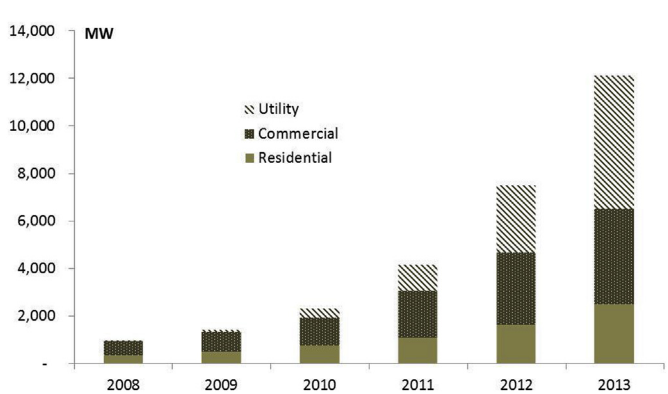

Fig. 2. Cumulative PV Installation by Type in U.S. Data source [1].

Due in part to the current policy environment, utility scale PV system have held the lion's share of new capacity additions. However, distributed residential and commercial-scale PV systems have distinct advantages over utility scale systems. Because distributed generation resources operate at the back of the meter, they can sell power independently at retail prices where electricity rates are higher than at bulk power supply. If the ITC reverts to 10% after 2016 and SREC prices fall, revenue from electricity sales will compose a greater share of the positive cash flow, giving distributed PV systems which are selling power at retail rates a noticeable advantage over utility scale systems, which sell at lower, wholesale rates. Distributed generation also decreases peak load, improves system reliability, minimizes transmission and distribution losses, stabilizes and applies downward price pressure to retail rates, and reduces uncertainty accompanying future bulk power generation [7]. More importantly, distributed PV systems make full use of existing local resources, i.e. roofs and other vacant spaces, and they can avoid the tedious siting procedures as applied to utility scale projects.

Some of the advantages of utility scale PV are also disappearing. Third Party Ownership (TPO) of customer-sited systems through PPAs and leases facilitated over 67% of all PV systems installed in 2013, responsible for supporting 68% of residential PV systems, and 61% of PV systems hosted by for-profit commercial customers [8]. The current trends under the TPO model suggest that distributed solar will continue its steady growth in the coming years. However, as federal incentives such as ITC and loan guarantees are reaching their sunset terms, the incentive burden on solar PV project development towards RPS goals will shift to local and state-level governments [6].

Even with high PV installed solar capacity growth rates, there is still vast potential for PV market growth in the U.S. Yet, markets, technologies and nature experience growth patterns which are normally confined by some limits [2]. To understand the potential scale of the future growth, it is important to understand the technical and geographical limitations of PV growth, particularly for distributed generation. Assessing the technical potential for PV installation is essential for utility planning and grid capacity accommodation [9]. Moreover, such studies can aid in the development of adaptive energy policies, regulations, and financing programs and further contribute to future researches on the market potential for rooftop PV [9–11]. This study proposes a methodology to understand the amount of electricity that can be provided from distributed PV hosted on residential and commercial roofs at the state level in the U.S.

Technical potential represents the theoretical maximum amount of PV that can be deployed on the rooftops of residential and commercial buildings, which depends on the available rooftop space as well as PV module efficiency. This analysis disregards all non-engineering constraints such as costs, regulatory hurdles, and end-user participation rates. There are two main methods to conduct technical potential analysis. The following section provides short description of the major differences among these methods.

1.2. Methods for estimating technical potential for rooftop PV

Studies estimating rooftop PV potential can be grouped into two major methodological categories: the constant-value methodology and the Geographic Information Systems (GIS) based methodology [10,12,13]. These methodologies vary based on the data availability and the scale of focus area [12,13].

The constant-value methodology collects the existing building-