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Estimating the net societal value of distributed household PV systems

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Abstract

This paper presents a methodology for estimating the net marginal societal value of distributed residential PV systems within the Australian National Electricity Market. It includes PV's potential direct marginal energy value including avoided losses, and marginal environmental value with respect to regional air pollutants and greenhouse gas emissions. This methodology is then applied for the example of 61 domestic rooftop PV systems located in Sydney. Results highlight that residential PV systems would seem to offer net societal benefits under reasonable assumptions of their energy and environmental values including the social cost of carbon, and given social discount rates. Much depends, however, on the assumed level of the social cost of carbon (SCC) and the system performance including issues of orientation, maintenance and shading. While such evaluations of societal value are challenging, they have an important policy role in better aligning private incentives for and against residential PV deployment with the societal benefits that such deployment can bring.

Keywords: Photovoltaics; Social valuation; Electricity industries

1. Introduction

Photovoltaics (PV) has experienced remarkable growth over the past decade. While system costs have fallen significantly over this time, PV deployment has largely been driven by supportive government policies. More than 100 countries have implemented policies to support renewable power generation, and many of these include measures intended to specifically support PV deployment. Feed-in tariffs (FiTs), which provide a premium 'tariff' for eligible renewable generation, are the most widely implemented such mechanism for PV, and were in place in more than 65 countries and 27 states/provinces worldwide in 2012 (REN21, 2012). Other policy measures include capital subsidies and renewable portfolio standards. Such policy efforts have been driven by a range of factors that have varied by jurisdiction and over time. However, in essence they reflect a view that PV provides a range of societal benefits that are not currently reflected in existing energy markets and wider commercial arrangements. These include the energy security value and environmental value of renewable generation that offsets the use of highly polluting and diminishing, often imported, fossil fuels. Longer term benefits might include the investment and job creation potential of the PV industry, and the promise of reduced future PV costs with growing industry scale that will improve its societal value (NREL, 2008). Against these benefits, are a range of potential costs including not only the PV systems themselves, but potentially wider adverse impacts such as the use of toxic materials in their manufacture.

One formal economically oriented policy development approach is to estimate these various costs and benefits and seek the scale and nature of PV deployment that maximises net societal benefits. Specific PV policy measures

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then provide the means to better align self-interested, largely private, decision making by key stakeholders in PV deployment, with maximisation of PV's societal benefits.

The starting point for such policy development is estimating PV's societal costs and benefits and this is much harder in practice than might be expected. PV has diverse energy, environmental and social values that are highly context specific, have significant uncertainties and will vary with the scale and particular characteristics of its deployment. As just one example, the energy value of electricity within a power system depends on a wide range of factors from the mix of generation types and their fuels, to the nature and extent of the electrical network and underlying characteristics of demand. As such, electricity's energy value varies by time and location within a network, subject to a wide range of uncertainties (MacGill, 2010). PV generation itself has significant temporal and locational variability and unpredictability. As such, the energy value of PV systems are very context specific, strongly influenced by factors such as the match of PV generation to existing electricity demand and network capacities at different points in the grid, and the underlying generation mix. Both shorter-term operational and long-term investment costs and benefits are relevant. Similarly, the environmental value of PV generation depends on which types of other electricity generators are offset, and their particular environmental impacts.

In theory, ideal electricity markets would reflect these complexities and hence have time and location varying prices that reflected the immediate to longer term economic value of energy including its environmental impacts. This is, however, far from the case for existing market arrangements around the world, particularly at the retail market level. Rather than prices, these markets generally have energy and network tariffs (schedules of fees) that do not reflect the time and location varying economic value of electricity and associated environmental costs (Elliston et al., 2010; Outhred and MacGill, 2006). Even where there is some environmental pricing such as seen in electricity industries with carbon pricing, the prices paid may be very different to the underlying economic costs.

Despite these challenges there is considerable policy value in attempting to estimate the societal benefits of PV both in terms of how much, if any, policy support is warranted, and how best it might be targeted to maximise its value. In Australian jurisdictions, policy processes such as regulatory impact statements may include such assessments. With regard to PV, however, policy support has generally been developed and implemented without any comprehensive social cost-benefit analysis being undertaken (Victorian Auditor-General, 2011; NSW Auditor-General, 2011). There have been Federal Government efforts to estimate the Levelised Costs of Energy (LCOE) of a range of electricity supply options including different PV technologies, incorporating the impact of carbon pricing (BREE, 2012). The Productivity Commission (2011) has also attempted to estimate the effective societal abatement cost of emission reductions associated with a range of measures including PV policy support. This trend can also be seen at the international level, for example, an early study by Haas et al. (1999) shows that in Austria PV support had not yet been optimally designed. However, and as discussed in the next section, these efforts have applied narrow and simplistic evaluation frameworks.

In this paper we present a methodology for estimating key aspects of the net societal value of distributed residential PV systems within the Australian National Electricity Market (NEM). Almost all of the near two GW of PV deployed to date in Australia has been small (less than 5 kW) domestic rooftop PV systems. Such systems represent particular challenges for societal valuation. They are located within the distribution network with all the challenges of network economics this presents. They are also commercially located within the NEM's highly abstracted and simplified retail electricity market. Furthermore, and very importantly, the performance of domestic rooftop systems has proven to vary very significantly according to the location and quality of installation including issues of system orientation and shading (Lewis, 2011).

The chosen methodology considers only a subset of potential societal costs and benefits and, as detailed later, makes a number of simplifying assumptions. The focus is on PV's potential direct energy value (including network value) and environmental value (including not only greenhouse gas emissions but also regional air pollutants). Furthermore, we only consider costs and benefits on the margin – that is, those costs and benefits associated with adding small amounts of PV that do not fundamentally change underlying energy market operation. We also make no estimates of job and investment value associated with PV industry development alongside greater PV deployment.

We then apply this methodology to estimate the societal value of domestic PV systems located in Sydney based on a year of actual performance data for 60 PV systems located in Western Sydney, and actual NEM outcomes over that period.

The structure of the rest of the paper is as follows. Section 2 presents a brief review of previous Australian and international work attempting to assess the societal costs and benefits of PV, and its various strengths and limitations. A possible methodological framework for making such assessments in the context of the Australian NEM is presented in Section 3. Section 4 provides details of the data and assumptions used to estimate the societal value of the 60 PV systems located in Western Sydney. The findings are presented in Section 5 and their potential relevance to policy makers is then explored in the concluding Section.

2. Previous work on societal valuation of PV

There is considerable and growing work exploring aspects of PV economics, however, only a limited subset of this is relevant to societal valuation. Much of the work