Energy Policy 105 (2017) 10–16

Contents lists available at ScienceDirect

Energy Policy

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

Residential consumers' experiences in the adoption and use of solar PV

Jeff Sommerfeld*, Laurie Buys, Desley Vine

Queensland University of Technology, Brisbane, Australia

ARTICLE INFO

Keywords:
Solar photovoltaic (PV)
Energy policy
Renewable energy
Consumer behaviour
Demographic variables
Feed-in tariff (FiT)

ABSTRACT

Public policy in many nations is seeking to transition energy generation towards renewable sources such as solar photovoltaic (PV). Reviews of past policy aimed at increasing consumer acceptance of renewable energy sources have identified that policy implementation may not align with policy objectives of energy professionals. The research and analysis of consumers and their interaction with solar PV policy is important in assessing policy outcomes and how these can be better delivered or adapted. This paper reports on an in depth qualitative analysis of 22 persons under different feed-in tariff (FiT) policy settings to explore consumer experiences in acquiring solar PV and their energy use behaviour. The responses of participants indicate there were different motivations and energy use behaviour that were based on the policy in which solar PV was acquired and these may provide insight into policy development or follow up studies.

1. Introduction

Worldwide, public policy focusing on reducing pollution and greenhouse gas (GHG) emissions and expanding the uptake of electricity from sustainable resources has initiated a major transition in the generation and supply of electricity (Stigka, et al., 2014). Policies aimed at increasing consumer acceptance of renewable energy sources (RES) in the residential sector are being used as key contributors to GHG mitigation (Sardianou and Genoudi, 2013). Such policies have included different incentive regimes such as feed-in tariffs (FiTs), low interest loans, investment subsidies and other encouragements for the uptake of solar photovoltaic (PV), which have been used as mechanisms to support the diffusion of renewable energy technologies (Del Río and Mir-Artigues, 2012). Consequently, there has been a shift away from an electricity supply model based on centrally distributed power stations to smaller-scale renewable power generation at the community, industry, and household level. This worldwide shift is transformational, turning the electricity supply and transmission system upside down (Chapman et al., 2016; Sauter and Watson, 2007).

The success of policies that encourage the uptake of renewable energy at the domestic level requires consumer acceptance and engagement with new and emerging energy technologies such as solar PV (Devine-Wright, 2007; Sardianou and Genoudi, 2013; Sauter and Watson, 2007; Willis et al., 2011). To maximise the implementation of transformational energy policy, the role of the consumer is critical as their use of renewable technology may, or may not, align with policy objectives of the energy professionals or have consequences that are not yet considered (DeCicco et al., 2015).

The research and analysis of consumers and their interaction with renewable energy policy is important in assessing policy outcomes and how policies can be delivered or adapted (Greene, 2013). Such an understanding and responsiveness to consumer interaction with renewable energy technology would allow for policy options to be adapted to address technical or human related issues that impact on the effectiveness of public policy (Kanellakis et al., 2013). However, there has been a lack of primary research of consumers across different policy settings. Sommerfeld and Buys (2014) found much of the renewable energy research focus regarding consumers was often based on single dimensions of aspects of environmental, economic or social attitudes. Whilst the phenomena relating to consumer energy use was a key research focus, researchers did not explain the motivation or context of consumers who adopted or did not adopt renewables technology. As a result much of the research is inconclusive with regards to understanding consumer behaviour. The purpose of this study is to examine residential consumer experiences in acquiring and using solar PV and how the experiences of these consumers may provide insight that aids the development of solar PV policies.

1.1. Solar PV in Australia

Australia has one of the highest average solar irradiation levels of any continent in the world, with a 1 kW household solar PV system having an average generation potential of 1460 kWh per annum within participating National Electricity Market (NEM) states (Chapman

* Correspondence to: School of Design, Queensland University of Technology, 2 George Street, Brisbane, Australia.
E-mail address: j.sommerfeld@qut.edu.au (J. Sommerfeld).

http://dx.doi.org/10.1016/j.enpol.2017.02.021
Received 23 May 2016; Received in revised form 28 December 2016; Accepted 14 February 2017
0301-4215/

et al., 2016). However, Australia is also the largest per capita greenhouse gas (GHG) emitter in the Organisation for Economic Cooperation and Development (OECD) with electricity generation accounting for more than 30% of GHG emissions (Buckman and Diesendorf, 2010). The ability to generate electricity from renewable sources is seen as a mechanism towards reducing Australian GHG emissions (Buckman and Diesendorf, 2010). In 2001, the Australian Government introduced the Mandatory Renewable Energy Target (MRET) scheme to encourage investment in renewable energy technologies (Ferrari et al., 2012). The scheme was divided in 2010 into two parts: the Large-scale Renewable Energy Target (LRET) and the Small-scale Renewable Energy Scheme (SRES). During this period the Australian Government provided rebates to householders who acquired solar PV systems (Macintosh and Wilkinson, 2011). The SRES provided a fixed upfront incentive of approximately $5000 to reduce the capital cost of solar PV technology. In addition, most States and Territories offered the owners of small-scale solar PV installations a Feed-in-Tariff (FiT) that paid households for electricity generated that was funded by all electricity customers within the local network (Chapman et al., 2016; Nelson et al., 2012). As a result of consumer demand and government policies and incentives, Australia has one of the highest rates of solar PV adoption in the world, with as many as two million householders having 'solar rooftops' (Simpson and Clifton, 2015). In just four years, between 2007 and 2011, the cumulative installed capacity of solar PV units increased 100-fold from nearly 10 MW to more than 1000 MW (Nelson et al., 2012).

1.2. Solar PV in Queensland

By the end of 2012, Queensland, known as the "Sunshine State", had the highest up-take of solar, with almost one-third of all PV capacity in Australia, followed by New South Wales with 22% (Chapman et al., 2016; Flannery and Sahajwalla, 2013). From 2008–2012, public policy in Queensland provided additional incentives for consumers to acquire solar PV through a solar FiT of $0.44, equalling $440 MWh (Nelson et al., 2012). Consumers were also eligible for the national SRES rebate (Macintosh and Wilkinson, 2011). In July 2008 there were 533 solar PV installations in south east Queensland which grew to 157,849 by July 2012 (Table 1). In July 2012 a policy change occurred, with the Queensland government substantially winding back the guaranteed solar FiT of $0.44 to $0.08 which it guaranteed until July 2014. The current solar FiT is determined by the market which paid on average $0.06 for each kilowatt of power exported to the grid.

1.3. Reviews of solar photovoltaic policy

The objectives of policies that encourage consumers to acquire solar PV are designed to increase the amount of renewable electricity used and reduce the reliance on electricity from the grid associated with GHG emitting power stations (Macintosh and Wilkinson, 2011; Nelson et al., 2011). Many of the reviews of Australian solar programs acknowledge the success of solar PV policies in the development of the solar PV industry (Macintosh and Wilkinson, 2011; Nelson et al., 2011). However, some of these reviews have also identified adverse impacts such as solar PV policy being costly, socially regressive and environmentally ineffective. Solar PV has been identified as having a high generation cost of energy, requiring generous support mechanisms to be competitive with fossil fuel generation (Chapman et al., 2016). Conversely, it has also been argued that economic cost is only one among several aspects that need to be considered when devising policy (Mauleón, 2016) and issues such as intergenerational equity and long-term impact of climate change also need to be considered (Caney, 2014).

Table 1
Domestic solar PV south east Queensland 2008–2014 and relationship to Diffusion of Innovation categories.
Source: Energex, (2015); ABS, (2014); Rogers (2003); Robinson (2009).

Installation year	Solar PV systems	Population %	Diffusion category
As at July 2008	533	0.04%	Innovators
As at July 2009	5947	0.49%	Innovators
As at July 2010	27,100	2.2%	Innovators
As at July 2011	83,188	6.9%	Early Adopters
As at July 2012	157,849	13.1%	Early Adopters
As at July 2013	229,439	19.1%	Early majority
As at July 2014	264,807	22.1%	Early majority

The solar PV FiTs used to incentivize consumers to acquire solar PV are criticized by some researchers because they are funded through increased electricity prices impacting on lower income groups who are less capable of investing in solar technology (Chapman et al., 2016; Nelson et al., 2011). Previous research has also identified that households with higher levels of education and in higher skilled occupations were more likely to find it easier to access information on residential solar PV systems highlighting other equity issues in the design of solar policy (Grösche and Schröder, 2011; Macintosh and Wilkinson, 2011; Nelson et al., 2011). Questions have also been raised about the environmental benefits from past government incentives to solar PV due to a limited reduction of GHG emissions from traditional electricity sources (Macintosh and Wilkinson, 2011; Nelson et al., 2011). Researchers have identified some consumers have not decreased their use of power but rather changed it to other times to maximise benefits from solar FiTs. Based on the electricity supply profile of south east Queensland (Nelson et al., 2012), this type of behaviour is most likely to increase peak demand and increase supply of electricity during off-peak periods. However, it should be noted that the solar PV industry has matured and transformed in recent years and some of the past reviews may not reflect the current status of the market or the profile of customers (Mauleón, 2016).

1.4. Solar photovoltaic and consumers

Many of the past examinations of solar PV policy have been based on statistical data which identified consumer issues such as financial capacity, home ownership status and education (Byrnes et al., 2013; Grösche and Schröder, 2011; Macintosh and Wilkinson, 2011). As discussed above, there has been a lack of research into consumer motivation to adopt solar PV and subsequent behaviour that may provide insight into how consumers may impact on the successful outcomes of public policy. Much of the research on solar PV has been focused on technical, regulatory and information issues based on data at the national or international level and only identify consumer issues according to broad demographic definitions (Caird et al., 2007). Despite the awareness of the general importance of socio-economic variables that have arisen from these reviews of solar PV policy, there remains a knowledge gap about consumers and their impact on the effectiveness of solar policies. The literature on residential solar adoption, while growing, is still in the early stages (Rai et al., 2016).

The examination of solar PV uptake through the lens of diffusion of innovation theory (Rogers, 2003) to explore how individuals make decisions can provide a guide for researchers and policy makers concerned with the impact of human energy-use behaviour (Brewer and Stern Paul, 2005). The application of diffusion of innovation theory is valuable for policy development in understanding solar PV adopters and their decision-making process, as there are possible positive and negative policy outcomes in the adoption and energy use of solar PV.

The correlation of solar PV uptake for south east Queensland and the categories and characteristics of Diffusion of Innovation theory are summarised in Table 1. Prior to July 2008, 533 households, or approximately 0.04% of the 1.198 million dwellings in south east Queensland, had acquired solar PV (Australian Bureau of Statistics,