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Influence of demographic variables on uptake of domestic solar photovoltaic technology

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ABSTRACT

In Australia during the past decade there has been a significant transformation of the electricity demand and supply sector. In five years from 2008 to 2013 the number of Australians installing solar photovoltaic (PV) technology grew from 8000 to more than one million. Governments in Australia used a range of policy incentives such as feed-in tariffs (FiTs) to encourage the uptake of solar PV and this had a range of consequences. Solar PV technology has transformed the residential consumer electricity market providing some consumers with greater choice in demand and supply of their power. This study contributes to the growing understanding of the role that demographic factors play in household uptake of solar PV technology. Based on a review of relevant literature and a multi-phased statistical analysis of more than 2 million people in south-east Queensland over five years, the paper highlights the complex interplay between socio-economics and household uptake. The paper identifies key demographic variables and quantifies their relative influence, and provides new insights into the role of age in solar PV uptake. This more nuanced explanation of the socio-economic variables influencing solar PV uptake offers an opportunity to more effectively and efficiently shape future policies and incentives.

Contents

Abbreviations: ABS, Australian Bureau of Statistics; CART, classification and regression tree; BRT, boosted regression tree; FiT, feed-in tariff; GHG, greenhouse gas; MRET, Mandatory Renewable Energy Target; PV, photovoltaic; PVRP, Photovoltaic Rebate Programme; REMODECE, Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe

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1. Introduction

For most of the past century the dominant paradigm of the electricity demand and supply sector has been a provider technology-push versus consumer demand-pull which has defined traditional electricity market participants [1]. However, in recent years a demand-pull for greater environmental, economic and social sustainability from government and the electricity sector has altered its traditional linear demand and supply dichotomy. Since the 1990s in Australia, state and federal governments have progressively been devolving from centralized monopoly electricity markets, encouraging deregulation and removing often hidden subsidies [2,3]. Coinciding with government deregulation of the electricity market has been the emergence of government policies and consumer preferences for energy from renewable sources that produce lower greenhouse gas (GHG) emissions delivering better environmental outcomes. Renewable energy, however, has been more costly than traditional sources of electricity. An unfortunate result of government policies encouraging electricity industry transformation towards renewables, such as solar photovoltaic (PV), is increased costs of electricity for consumers [2,3]. In Australia, policies such as solar PV feed-in tariffs (FiTs) are added to the cost of electricity for all consumers and is a factor contributing to cost increases of more than 100% in less than a decade [4].

The convergence of electricity sector deregulation and policies that promote solar has resulted in major market upheavals with significant economic and social impacts [3,5,6]. As renewable energy is continuing to be promoted as the future for global energy supply, it is important for regressive consequences of policy to be mitigated. Understanding consumer motivation and decision making regarding solar PV uptake is important to ensure negative consequences including equity issues are able to be mitigated in future solar policy initiatives.

The consumer decision to acquire a solar PV system is complex requiring information that the average consumer is unlikely to have in early stages of new technology [7]. Yet, research into the uptake of energy technology by consumers is considered to be narrowly focused and does not address the full range of external factors that influence decision making [8]. In particular, although the role of socio-economic factors has been suggested [2–6] the complement of relevant variables and their interplay have not yet been fully explored. The aim of this study is to provide a more comprehensive assessment of key demographic variables and their comparative influence on solar PV uptake. This is achieved by first evaluating policy drivers of consumer change, then conducting a population-based statistical analysis of demographic drivers of residential customer solar PV uptake. The target population is taken to be the greater Brisbane metropolitan region in Queensland, Australia, during the period from 2010 to 2014. A multi-phased analytic approach is adopted, comprising exploratory analyses to identify a suite of potential variables, followed by decision tree models to capture the relative importance of these variables and their potentially complex interactions. The need and importance of such research to track the influence of consumer behaviour and new trends in technology was a key finding of a review of the Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe (REMODECE) project [9].

1.1. Policy drivers of consumer change

Much of the electricity market transformation has been driven by government policy. Some of this transformation relates to policies on improved labelling and energy efficiency of appliances to increase the efficient use of energy, whilst generous government subsidies for domestic solar hot water systems and solar PV systems were a major factor encouraging consumer uptake of this technology [10]. In Australia, there have been three key periods in the evolution of solar PV technology, government policy and consumer behaviour since 2001. During the period from 2001 to 2008 policy focussed on solar hot water systems and early incentives for solar PV. From 2008 to 2012 government policies encouraged a rapid uptake of solar PV while from 2012 onwards these policies have been wound back or discontinued. As a result, the dynamics of the traditional push-pull paradigm of transmission and distribution of the electricity market has transformed with consumers becoming producers and contributing to a demand-pull for technology.

In 2001, the Commonwealth of Australia introduced the Mandatory Renewable Energy Target (MRET) scheme to encourage investment in renewable energy technologies [11]. During this period the Australian Government provided rebates to householders who acquired solar PV systems under the Photovoltaic Rebate Programme (PVRP) which provided a fixed upfront incentive of about $5000 to reduce the capital cost of solar PV technology [6]. From 2007 most States and Territories commenced programmes that offered the owners of small-scale solar PV installations generous FiTs for electricity generated [5] until these began to be reduced or concluded from 2012.

Table 1 summarises the growth of domestic solar hot water and solar photovoltaic (PV) systems in Australia since 2001. Commonwealth and State government policies and subsidies have been implemented at several stages of the solar energy production chain in Australia. During the period 2000–2008 the bulk of solar growth was in the form of solar thermal systems used for domestic water heating [10]. Since 2008 there has been a rapid uptake of small-scale solar PV systems on household rooftops. In five years from 2008 to 2013 the number of Australians installing solar photovoltaic (PV) technology grew from 8000 to more than one million [12]. In 2007, solar PV systems represented 9.6 MW of a 50,000 MW power grid and in just four years this had increased by 100-fold to 1031 MW [4]. During the period from 2008 to 2012 FiTs were provided in most jurisdictions in Australia. Table 1 shows the uptake of solar PV during this period and the subsequent decrease in demand for solar PV once FiTs were reduced or concluded.

The transformation of the residential consumer electricity market in the past decade has resulted in some consumers having greater choice in demand and supply of their power by being both consumers and producers of electricity, sometimes coined prosumers [see for example [13,14]]. This revolutionary change is a major paradigm shift in electricity demand and supply which will have ongoing policy and regulatory implications for some

Table 1
Small scale solar installations in Australia 2001–2014.Source: Clean energy regulator 2014.

Installation year	Solar PV systems	Solar water heaters
2001	118	10,075
2002	251	21,839
2003	664	28,653
2004	1,089	30,991
2005	1,406	33,964
2006	1,115	35,924
2007	3,480	50,977
2008	14,064	85,385
2009	62,916	194,695
2010	198,208	127,093
2011	360,745	105,050
2012	343,320	69,466
2013	196,429	55,189
2014	28,788	6,801
Grand total	1,212,593	856,102