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Australian Consumer Attitudes and Decision Making on Renewable Energy Technology and Its Impact on the Transformation of the Energy Sector

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Abstract

This paper critically examines research on consumer attitudes and behavior towards solar photovoltaic (PV) and renewable energy technology in Australia. The uptake of renewable energy technology by residential consumers in Australia in the past decade has transformed the electricity supply and demand paradigm. Thus, this paper reviews Australian research on consumer behavior, understanding and choices in order to identify gaps in knowledge. As the role of the consumer transforms, there is a critical need to understand the ways that consumers may respond to future energy policies to mitigate unforeseen negative social and economic consequence of programs designed to achieve positive environmental outcomes.

Keywords

Solar Photovoltaic, Renewable Energy, Residential Consumers, Energy Policy, Australia, Transformation, Feed-in-Tariffs

1. Introduction

In Australia, electricity generation is seen as the key for high quality of life and economic development, yet it is responsible for 35 per cent of greenhouse gas (GHG) emissions [1]. For most of the past century, the dominant paradigm of the electricity demand and supply sector has been a technology-push versus consumer demand-pull which has defined traditional market participants [2]. The traditional linear dichotomy of the electricity sector has been rapidly transformed in the past decade, with a demand-pull by residential consumers seeking technolo-

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gical alternatives that supply more environmentally sustainable and cheaper electricity. Residential consumers who were once at the end of the energy supply chain are now using technology to transform themselves into producers and exporters of electricity.

As the role of the residential consumer transforms, there is a need to understand how the consumer will engage future energy policy in an era of technological change. Research into the uptake of energy technology has been identified as being narrowly focused and limited the ability of policy makers to make informed decisions to deal with the complexity of the modern electricity supply paradigm [3]. Recent transformation of the electricity sector has had negative social and economic consequence as a result of the implementation of policies designed to achieve positive environmental outcomes. An examination of accumulated Australian research, with supporting international knowledge on customer behavior to solar and renewable energy technology is timely. The purpose of this article is to explore available Australian research on the energy behavior, understanding and choices of residential consumers in order to identify gaps in knowledge that may guide future research specific to renewable energy and consumer engagement.

2. Background of Australia's Electricity Market

Historically, Australia's small population and vast expanses has been the driver for government initiation of key infrastructure. In late 19th century the electricity industry in Australia was based around numerous small utilities located in individual regional areas with the transfer to State ownership almost complete by the late 1940s. The National Electricity Market (NEM) that exists today did not evolve until the late 20th century [4]. Currently, Australia's electricity network has more than $100 billion in assets with an electricity generation capacity of 54 gigawatts, more than 785,000 km of overhead transmission and distribution lines and more than 124,000 km of underground cables covering vast distance to serve a relatively small population of 23 million people [5].

Global economic and environmental policy shifts in the late 20th century have been the catalyst for change in the Australian electricity sector, including a move towards less government involvement, greater deregulation of energy markets and improved environmental outcomes [4]. The resultant policies led to greater emphasis on renewable energy and the emergence of solar as transformation technology. Government, business and individuals have become increasingly aware of the need to reduce our environmental impact and many individuals have moved beyond mere compliance by engaging in environmental friendly behaviors [6]. Renewable sources of energy are viewed as the most economically viable and environmentally sound options to meet the growing energy needs of the world until technological and safety breakthroughs with other low emission technologies are achieved [7]. This has led to more than 100 countries implementing policies that provide support for renewable power generation and many of these include measures that support domestic solar PV [8]. These economic and environmental policy changes have resulted in major electricity market upheaval and subsequent economic impacts with electricity prices increasing by more than 100 per cent in the past decade and contributing to the demand-pull for technology by consumers seeking alternatives to control costs.

3. Changing Technology

The challenges for electricity markets internationally are significant with socio-economic changes and technological developments posing complex adaptation dilemmas for policy makers and utilities [4]. One of the most significant transformations, since 2001, has resulted from enhanced solar technologies and the domestic rooftop solar PV system. First patented in 1954 [9] the solar cell has in the past decade emerged as a major alternative source of electricity generation. Solar PV systems convert light energy directly into electricity by transferring sunlight photon energy into electrical energy, whereas solar hot water systems use solar radiation to heat water [10] [11]. Consumer demand for solar and renewable energy and resultant government policies and incentives has given rise to almost11 per cent of the Australia population (about 2.6 million people) now using solar for their electricity.

Ongoing technological change such as battery storage is likely to further transform the energy demand and supply paradigm [12]. Transformational technology and the changing role of the consumer has the potential to impact traditional energy market participants which are likely to be faced with lessened demand for electricity from grids. Currently cost of infrastructure and electricity production is shared amongst all consumers. As customers reduce demand or opt out of the electricity supply system due to transformational technology, a diminishing number of customers will directly pay for the electricity supply system. Many of these customers are

currently unable to access solar PV and renewable energy technology due to low income (affordability) or living arrangements (renting) [13] [14]. Upward pressure on electricity prices has the potential to migrate greater numbers of consumers to alternatives to the traditional electricity market.

Socially, the move towards alternative energy sources has major ramifications for government policy, given the impact on consumers least able to afford new technologies such as solar PV and batteries. Customers from lower socio-economic demographics often spend a higher proportion of their income on energy and struggle to pay current electricity costs [11] [15]. The structure of incentives for uptake of solar PV technology such as Feed-in-Tariffs (FiTs) is mostly funded from higher electricity charges passed on to all customers [13]. The policies that encourage consumer investment in solar PV and renewable energy technology also have an impact on the electricity network which was designed for a one-way flow of electricity but now must cater to domestic customers feeding solar electricity back into the grid.

The costs of these network upgrades supporting rooftop solar are paid for by all consumers further adding to the costs of people on lower incomes [11] [15]. In Australia and internationally socially regressive aspects of solar, policies have resulted in the transfer of income from lower socio-economic groups to higher socio-economic groups. In many cases only higher socio-economic groups have possessed the necessary access to knowledge and capital that has enabled them to take advantage of solar programs [10] [13] [14] [16].

4. Australian Solar and Renewable Energy Programs

For 20 years, government policies have focused on reducing the cost of solar technologies for consumers and encouraging their uptake. These policies focused on several stages of the energy production chain including rebates for solar water heating systems and residential PV installations [11]. The proportion of households with solar water heaters doubled between 1999 and 2011 [17]. In 2001, the Australian Government introduced the Mandatory Renewable Energy Target (MRET) scheme to encourage investment in renewable energy technologies [17]. The scheme was split 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 called the Photovoltaic Rebate Program (PVRP) which was rebranded in 2007 as the Solar Homes and Communities Plan (SHCP) [10] The SRES provided a fixed upfront incentive of about $5000 to reduce the capital cost of solar PV technology while most States and Territories offered the owners of small-scale solar PV installations a Feed-in-Tariff (FiT) that paid households for electricity generated [16].

As a result of consumer demand and resultant government policies and incentives over one million rooftop solar PV systems have been installed in Australia. In just four years, between 2007 and 2011, the cumulative installed capacity of solar PV units increased 100-fold from about 10 MW to more than 1000 MW [16]. The state of Queensland, known as the “Sunshine State”, has the largest number of solar PV installations of any state, followed by New South Wales and Victoria [18].

5. Consumer Uptake of Solar and Renewable Energy Technology

For most of the past century the dominant paradigm of the electricity demand and supply sector has been a technology-push versus consumer demand-pull for this technology which has defined traditional market participants [2]. In recent years, better informed consumers are increasingly taking into consideration the environmental and social impact of products and services [19]. As a consequence of consumer demand and resulting government policy there has been a demand-pull for better environmental, economic and social sustainability that has transformed the traditional linear dichotomy of the electricity sector. Consumers who were once at the end of the energy supply chain are now using technology to transform themselves into producers and exporters of electricity. Yet, much of the research to date has focused on either the reasons for adoption or non-adoption of renewable energy or the social consequences from it.

Prior to the surge in uptake in solar PV from 2008, Caird and colleagues [20] undertook a study of consumers surveying reasons for adoption or non-adoption of renewable energy and energy efficiency measures. This research drew together previous quantitative surveys of consumers from the UK, USA and Australia on attitudes to renewable energy and installation barriers. The main drivers for installation were environmental concern and saving money whilst the main barriers were capital cost and lack of trustworthy information or reliable brands. It was concluded that research tended to focus on addressing financial, regulatory and information barriers and

drivers. The researchers identified that social context was crucial in understanding consumer energy behavior and sociological and anthropological research focusing on motivations and actions suggested consumer motivations were more complex.

Research focusing on the financial uptake of solar PV and renewable energy, examined the impact of policy mechanism used to encourage consumer uptake of solar PV such as the solar FiT [10] [13] [14] [16]. An evaluation of the Australian Government Photovoltaic Rebate Program (PVRP), later rebranded the Solar Homes and Communities Plan, concluded the program was environmentally ineffective, economically costly and had social equity issues [10]. This Australian finding is similar to an examination of German climate policy that encouraged the uptake of solar PV and use of FiTs [13]. In the decade between 2000 and 2011 the share of renewables in Germany increased from seven to 20 per cent. Whilst FiT policies in Germany encouraged the dissemination of renewables technology, subsidies that unpinned the expansion increased from 900 million Euros to 16.7 billion Euros was funded by adding three Euro cents per kilowatt hour to the cost of bills. The authors concluded these policies were regressive as they facilitated that expansion of expensive technology without fostering cost-reducing innovation and had a negligible impact on climate protect [13].

Social context to customer decisions to adopt or non-adopt solar PV and renewable energy technology appears to have so far attracted limited research interest to date. Hampton and Eckermann [21] explored the ways social learning can be used to improve understanding of solar PV's based on changing attitudes. Through qualitative workshops in 2005 and 2012, knowledge and understanding of solar PV and renewable energy products was found to have considerably improved during the two workshops but customers still had difficulties understanding financial aspects of solar PV policy.

The profile of consumers adopting renewable energy technologies appears to be inconclusive with investigations into educational status and environmental behavior providing conflicting evidence. Demographic variables associated with positive environmental attitudes such as age, gender and income have identified conflicting conclusions [3]. For example, the researchers identified studies that found having a higher education level encouraged environmentally positive behavior whilst another study found less educated consumers were more likely to be green consumers. To overcome demographic variations a study of Australian consumers cross referenced both socio-economic status based on income and value of the housing [22]. They concluded that lower income households were not engaging solar PV and renewable energy technology and owning a property was found to be the most important criteria in decisions to adopt or non-adopt solar PV and renewable energy technology.

6. Impacts of Consumer Uptake of Solar and Renewable Energy Technology

Whilst consumers may have been mentioned in most research, the majority of researchers focused on energy policy at the national and international level with specific attention on government energy policies and the implications of these policies. Solar PV has diverse economic, environmental and social values and policies encouraging it has generally been developed and implemented without any comprehensive social cost-benefit analysis being undertaken [8]. The research examining consumer uptake of energy technology focused on addressing financial, regulatory and information barriers and drivers. Underpinning much of the research is a primary assumption that environmental outcomes are the key indicator of success. This type of examination looked at societal values from solar PV including carbon abatement, consumer outcomes from deferring network augmentation and offsetting energy losses [8] [23]-[25]. Evaluations of the policies that encourage the uptake of renewable technology found that only some home owners had the capacity to afford and install solar PV systems based on socio-economic profiles [10] [13] [14] [16]. In examining the uptake of solar energy policies, the type of housing was identified as an obstacle (e.g. apartment, unit) or living arrangements (e.g. renting) [14]. Overall the policies that encouraged renewables also were found to impose additional networks costs that were funded by consumers not using renewables. These customers were further disadvantaged if they were on lower incomes as they spend a higher proportion of their income on energy [11] [15].

In an examination of government policies that encouraged the technological transformation, Taylor [2] concluded the effectiveness of innovation was not a primary consideration. Immediate pollution reduction and energy conservation has been the policy drivers rather than an empirical evaluation of the comparative effects of various options. Additionally, research into the uptake of solar and renewable energy technology by consumers is mostly silent on the impact of renewable energy uptake on other consumers. The unforeseen outcome of consumer decisions to adopt or not adopt solar and renewable energy technology has been an increase in the social

divide between consumers [10] [13]-[15].

7. Conclusions

Currently the research focus is on single aspects of environmental, economic or social attitudes of consumers and the impact on the electricity sector or electricity policy [11] [19] [26]. Other researchers tended to focus on policy, policy-induced technical change, financial issues and consumer environmental attitudes [6] [9] [27]. Policy and policy implications were explored, but the investigations did not extend to examining the consumer behavior resulting from these policies. Whilst the phenomena relating to consumer energy 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 regard to understanding consumer behaviour.

Consumers were examined from a macro perspective rather than the more complex approach recommended by Caird *et al.* [20] and Faiers *et al.* [3]. Conclusions on the effectiveness of solar and renewable energy technology policy need to address the complex social, economic and environmental interactions and outcomes that lead to a holistic understanding and insight into the complexity of energy use and impact. Research needs to address this complexity in order to identify and integrate the social, technical and environmental changes and their impact on the diverse groups of consumers.

Internationally, a review of the European *Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe* (REMODECE) project identified the importance of ongoing research to track the influence of new trends in technology and consumer behavior. The REMODECE project was established to better understand household energy consumption and identify demand trends. It concluded that research examining consumer uptake of energy technology must encompass personal values and attitudes and the impact of external factors [28]. Research needs to go beyond cognitive assessment and rational choice because of emotional, societal and cultural issues impact on consumer energy behavior [3].

In conclusion, the purpose of this paper was to examine contemporary research on consumer behavior, understanding and choices towards solar technology in Australia. With almost 11 per cent of the Australian population now using solar for their electricity, research in this area is essential to developing future policy. The rapid uptake of technology by consumers has not only transformed the demand and supply dichotomy but also social and economic aspects of the electricity market. The consumer decision to acquire a solar PV system is complex requiring information that most average consumers are unlikely to have in early stages of new technology [29]. Research into the consumer uptake of energy technology has been narrowly focused and limits the ability of policy makers to make informed decisions [20]. Understanding the demand-pull social phenomena has significant relevance given the equity issues for low-income consumers. Whilst the adoption of solar PV is positive in terms of environmental concerns, researchers have failed to adequately examine the resultant economic or social consequences across user groups. As the role of the consumer transforms, there is a need to understand how the consumer will engage future energy policy to mitigate unforeseen negative social and economic consequence of programs designed to achieve positive environmental outcomes.

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