PAPER • OPEN ACCESS

Drivers and Anticipated Outcomes of Solar Photovoltaic Projects –The Construction Practitioners' Perspectives

View the article online for updates and enhancements.

Drivers and Anticipated Outcomes of Solar Photovoltaic Projects –The Construction Practitioners' Perspectives

Peter S.P. Wong [1], Lucas Cronin [2]

[1] School of Property, Construction and Project Management, RMIT University, GPO Box 2476, Melbourne 3001, Victoria, Australia
[2] School of Property, Construction and Project Management, RMIT University, GPO Box 2476, Melbourne 3001, Victoria, Australia

peterspwong@rmit.edu.au

Abstract. Despite Australia receives high levels of solar radiation annually, contributions to energy production from solar sources are significantly low across the country. Whist there is no lack of studies reviewing the initiatives of solar photovoltaic (PV) projects in Australia; few have been conducted in an approach that target construction industry's view and their professionals' perspectives on the solar PV projects. With the growing consensus that climate change is a threat facing today's society, this study aims to identify the relevant drivers and outcomes of solar PV projects for today's construction industry professionals and subsequently prioritise these phenomenon in terms of their importance and anticipation. Therefore, this study approached construction industry professionals to solicit their views regarding drivers and outcomes of solar PV implementation through an online questionnaire survey. The data received from the survey was subsequently analysed through an entropy ranking approach, facilitating prioritisation and ranking of both the drivers and outcomes. The findings reveal that construction professionals prioritise lowering the cost of solar PV technology as the most effective driver to result in their increased PV uptake, and resultantly anticipate greater solar PV efficiency and energy storage as the most important outcome. The findings of this study are insightful as they deconstruct barriers that may prevent construction professionals from implementing solar PV projects. Future study in this field is suggested to focus on ways in which lowered costs of solar PV technology can be achieved and technology efficiency levels increased.

1. Introduction

Australia has arguably the best access to solar resources of any nation in the world due to its unique location in the southern hemisphere and vast expanses of desert land in Central Australia. It has one of the 'highest average solar radiation per square meter' of any nations in the world [1]. Given the establishment of an ultimate goal of net zero greenhouse gas emissions by 2050 by nations around the world [2-4] , Australia is fortunate to be capable of effecting significant change by more extensive use of solar energy. Notwithstanding, Australia is only able to consume 0.53% of its total energy consumption from the overly abundant solar energy source [5]. Ironically, the utilisation of a mere 1% of total annual incoming solar radiation that falls on Australia would have the ability to provide Australians with enough energy annually [6]. Given that Germany, one of the world leaders in solar energy use, is able to provide as much as 7.6% of their nation's electricity needs from solar sources whilst receiving almost half the annual levels of sunshine that Australia receives [7] other factors must be at play to result in such skewed outcomes. According to [7], Germany is estimated to have over 38

gigawatts (GW) of installed solar photovoltaic (PV) capacity, more than 9 times the current capacity of Australia. Therefore, a question must be asked what enables this kind of solar PV projects success? The contribution of the construction industry is the key in this instance, as the inclusion of solar PV systems in all residential projects moving forward could heavily increase the solar capacity of our nation. Whilst there is no lack of studies surrounding the solar PV projects in general, few have been conducted in an approach that examines the drivers behind the uptake of solar PV projects, particularly in the construction industry context.

Solar PV system converts solar radiation from the sun into electricity. The system is usually installed on the roofs of homes and commercial buildings [1,8] Solar PV system is made up of one or more solar panels which are an interconnected assembly of photovoltaic cells [9]. Despite the high initial cost, solar PV system usually has a long life cycle with low maintenance and no fuel cost [4].The Housing Industry Australia [10] highlighted that new residential dwelling commencements reached an all-time high in 2015, with almost 212,000 dwellings commencing construction across the year. This emphasizes the unique opportunity presented to the construction professionals, highlighting the industry's capacity to integrate renewable energy systems in all new projects and become the leaders in up taking solar energy. Construction professionals are in a unique position to contribute beyond those possible from other industry sectors, and must therefore be considered a key player of the success of PV projects. The lack of associated studies surrounding the Australian construction context however makes it increasingly difficult to prioritize any strategy for fostering solar PV project success.

The aim of this study is to identify and prioritize the effectiveness of various drivers that could increase construction professional's uptake of solar PV projects. Subsequently, the anticipated outcomes of these drivers are identified and studied. This paper commences with a review of previous publications and external sources in order to identify the drivers and the outcomes of the solar PV projects in Australia. This is followed by a description of the research methodologies, with the research findings then discussed. Finally, concluding remarks and recommendations are made.

2. Drivers of solar PV projects in Australia

This study builds a literature review and classifies drivers of solar PV projects in five aspects: Financial, Social, Technological, Government and Environmental (refer to Table 1).

2.1. Financial Aspect

Cost can be a major driver for solar PV project uptake [9], Byrnes [11] argued that renewable technologies result in 'high up-front capital costs per unit of electricity compared to traditional sources'. As a result, customers may prefer to utilise conventional sources (national electricity grid) if they have options. Cucchiella, D'Adamo and Gastaldi [12] pinpointed that without government rebates, the cost of purchasing and installation of PV systems would outweigh the financial benefit from energy bill savings as a result of renewable energy utilisation. In Australia, Feed in Tariffs (FiTs) provides financial incentives for solar PV projects. FiT is a re-numeration system that rewards homeowners with solar panels at a set rate for electricity that's fed back into the grid for circulation. Heralded as the dominating factor in 'initial stimulus for rapid deployment', FiT programs in Australia were taken up by various States with differing degrees of commitment [13] (refer to Table 1).

2.2. Social Aspect

In regards to social aspect, a questionnaire survey conducted by Rai, Reeves and Margolis [3] indicated that the decision to implement solar PV systems is to certain extent affected by the same action taken by the neighbours. In the same study, researchers identified that 'over 50%' of respondents identify reliable information as extremely important for decision making in solar PV projects. However, a similar study conducted in Australia indicate that there is a lack of access to genuine information about installation of solar PV. Lack of relevant information becomes a major barrier for solar PV project implementation (refer to Table 1).

2.3. Technological Aspect

Uncertainties about technological performance are another driver that has impact on the deployment of solar PV projects. For example, the lack of grid connectivity leads to an overall inability to utilise the best solar resources in Australia and failure to provide remote communities with subsequent investment opportunities [1]. The lack of grid connection was also discussed by Engelken et al. [14] in their study 'Comparing drivers, barriers, and opportunities of business models for renewable energies: A review' and how grid parity is of more importance to industrialised nations like Australia. Supported in the work completed by Manasseh and Bass [15], there are many other 'technical challenges that need to be reconciled in order for PV resources to be at parity' with traditional electricity generation, including the innovation of inverters and energy storage systems. Through the successful innovation in these systems, homeowners could look forward to increased energy savings and reduction of carbon emissions as they could now access renewable energy even when the sun has stopped shining (refer to Table 1).

2.4. Government Aspect

The support that the government provides has been highlighted as an important driver of solar PV projects implementation. As mentioned previously, the Australian government have already initiated a renewable energy target supported by the once generous feed in tariffs and solar rebate certificates. There has also been an array of national acts which enforces similar initiatives in other countries [11]. Kuwahata and Monroy [16] studied government involvement in renewable energy policy in their paper, stating that in order to increase installations and the subsequent installed capacity, the federal government must make greater effort to 'streamline policies' between state and federal governments. In support of this study, Martin and Rice [17] agreed that policies should be co-ordinated at both levels of government, adding to the discussion that FiT scheme's whilst highly effective, often cause conflict between investors and energy retailors. Already we have seen the impact that government regulation can have on solar PV projects initiatives, as all new homes and renovations need to comply with the 6-star standard under the National Construction Code. As a result of this regulation, all new homes and renovations must now include the installation of either a rainwater tank for flushing toilets or a solar hot water system for heating their water. This information alone shows the massive potential that government support has for promoting the uptake of solar PV projects (refer to Table 1).

2.5. Environmental Aspect

Whilst several studies highlighted the need of solar PV projects for the sake of the environment; the rationales behind are not construction specific. One study that focused on this area was the paper from Breyer, Koskinen and Blechinger [18], who highlighted the reduction of 'greenhouse gas emissions' to be of 'utmost relevance'. As such, in the face of a variety of papers, drivers of solar PV projects in environmental aspect are proposed for general purpose to reduce the climate change effects or increase the mankind longevity (refer to Table 1).

3. Anticipated outcomes of solar PV projects in Australia

The achievements of the anticipated outcomes can be seen as the measurable criteria for assessing the effectiveness of the drivers of the uptake of solar PV projects. Through literature review, the outcomes of solar PV projects in Australia are identified and resultantly presented in Table 2.

Table 1. Drivers of solar PV projects in Australia

Drivers of solar PV projects in Australia	Citation							
	A	B	C	D	E	F	G	H
D1 Feed in Tariffs backed by the State or Federal government (Financial)	X	X	X	X		X	X	
D2 Rebate schemes introduced by the State or Federal government (Financial)	X	X	X	X		X	X	
D3 Investment in solar energy technology becomes more affordable (Financial)	X	X	X	X		X	X	
D4 Positive discussions with peers (Social)		X			X	X	X	
D5 Availability of reliable information (Social)		X			X	X	X	
D6 Sense of social responsibility (Social)		X			X	X	X	
D7 Solar panel efficiency levels (Technological)			X		X	X	X	X
D8 Understanding of solar panel technology (Technological)			X		X	X	X	X
D9 Grid connectivity status (Technological)			X		X	X	X	X
D10 Mandatory renewable energy targets (Government)	X	X	X	X				
D11 Government policies and regulations (Government)	X	X	X	X				
D12 National marketing campaigns (Government)	X	X	X	X				
D13 Reduction of climate change effects (Environmental)	X		X					X
D14 Increasing mankind's longevity (Environmental)	X		X					X
D15 Knowledge that current resource usage is not maintainable (Environmental)	X		X					X

References: A: [11]; B.[9]; C. [12]; D. [19]; E, [3]; F. [20]; G. [8]; H. [14]

Table 2. Anticipated outcomes of solar PV projects in Australia

Anticipated outcomes	Citation					
	J	K	L	M	N	O
AO1: Save energy cost in the long run	X			X	X	X
AO2: Cheaper solar energy technology	X			X	X	X
AO3: Greater community understanding behind solar energy technology		X			X	X
AO4: Increased community commitment to solar energy uptake		X			X	X
AO5: Further solar investment generation through peer correspondence		X			X	X
AO6: Improved solar panel efficiency/energy storage			X	X		X
AO7: Improved technological understanding and information availability			X	X		X
AO8: Increased grid connectivity			X	X		X
AO9: Stronger renewable energy policies	X	X		X	X	X
AO10: Cohesive policies at state/federal government	X	X		X	X	X
AO11: Increased employment in renewable energy sector	X	X		X	X	X
AO12: Fostering net carbon emissions	X	X	X	X	X	X
AO13: Reversal of climate change effects	X	X	X	X	X	X
AO14: Reduced dependence on fossil fuels for energy production in Australia	X	X	X	X	X	X

References: J. [17]; K. [2]; L. [21]; M.[13]; N.[14]; O. [11]

4. Research Methodologies
A questionnaire survey was designed with an intention to be completed by relevant construction industry professionals.

4.1. The questionnaire design
To accomplish the research objectives, a questionnaire survey was conducted for data collection. The survey questionnaire contains three parts. Part 1 deals with demographic information about the respondents. Respondents were asked to specify the solar PV projects they had been involved in for at least one year, and the questionnaires of those not having taken part in a specified project for more than one year were discarded. Part 2 seeks to solicit the degree of respondents' agreement (from 1 to 5

representing 'strongly disagree' to 'strongly agree' respectively) on whether the 15 attributes identified in Table 1 (i.e. D1 to D15) are the effective drivers of their respective solar PV projects. In Part 3, respondents were asked to express their degree of agreement (from 1 to 5 representing 'strongly disagree' to 'strongly agree' respectively) on the 14 attributes reported in Table 2 (i.e. AO1 to AO14) as the anticipated outcomes of the solar PV projects. This study received approval from the local university research ethics committee whose clearance standards are outlined in the Australia National Ethics Application Form (NEAF).

4.2. Data collection method

Relevant construction industry practitioners within the greater Melbourne region are the targeted participants of this study. In particular, construction practitioners who identify as developers, consultants, contractors and sub-contractors are the targeted respondents. We have been able to connect with a variety of these professionals through a wide range of sources. These sources include authorised access to professional databases searched from official websites of the professional bodies that include; the Master Builders (MA), Australian Institute of Building (AIB), Australian Institute of Architects (AIA), Australian Institute of Building Surveyors (AIBS), Australian Institute of Quantity Surveyors (AIQS) and Royal Chartered Institutes of Surveyors (RICS). With an understanding that some professional webpages don't disclose the exact numbers of members in the search engine, and these webpages cannot provide information on whether their members have relevant solar PV project experience, this study also adopted a snowball technique to source targeted respondents from an internet social network called LinkedIn. A list of potential respondents was compiled and 200 people from this list were randomly selected as the targeted respondents of this study. Invitations were sent to these 200 targeted respondents to complete the questionnaire via the online Qualtrics questionnaire platform.

4.3. Data analysis

Concerning data analysis, firstly the mean scores of the respondents' degree of agreement on the drivers and outcomes of solar PV projects were compared. Given the calculation of mean scores only facilitates a comparison of strength of agreements between the drivers and outcomes separately, further data analysis is required to measure the obtained results simultaneously. To do this, an Entropy Ranking Analysis was conducted. The entropy ranking analysis provides a means of measuring data through removing uncertainty between respondents and obtaining the relevant weighting of each phenomenon [22]. In this study, the entropy ranking analysis facilitates the prioritisation of both the identified drivers and outcomes through calculating the weight of each phenomenon. The equation used in the entropy analysis is as follows:

(1)

$$P = \frac{E}{e^H} = \frac{\sum_{i=1}^{n}(s * t)}{\sum_{i=1}^{n} t \log 5 (t)}$$

, where,
P = Priority rating of the driver/outcome, E = Expected Value of the driver/outcome,
e^H = Entropy Value of the driver/outcome, n = Number of categories,
i = A constant from 1 to n, s = Scales of degree of significance,
t = probability of a response

Through the formula presented above, the final entropy ranking of each individual driver and outcome was computed. The final step of the analysis required the priority rating of each phenomenon to be normalised.

The normalised value was obtained through dividing the individual priority rating by the total sum of all driver ratings. For example, the normalised weighting for 'D1: Feed in tariffs based by the state and federal government' was calculated as follows:

$$\text{Normalised Weighting of D1} = \frac{\text{Mean score of } D1}{\text{Mean scores of } D1 \text{ to } D15} \tag{2}$$

$$= 3.68 \, / \, (3.68 + 3.92 + 4.08\ldots + 3.79) = 0.064$$

Once the normalised weighting for each driver and outcome was calculated, the final prioritisation of phenomenon is possible.

5. Response Rate and Sample Profile

A total of 200 questionnaires were dispatched through Qualtrics. 87 responses were received but 29 of them were subsequently discarded because the respondents declared that they do not have relevant solar PV projects experience. The exclusion of the irrelevant responses help gain the credibility of the survey results. The total sample size of this study was 58 responses, surmising a response rate of 29%. The study has attracted a reasonable response rate in comparison to other questionnaire surveys in the construction field normally ranging from 25% to 30% [23]. The creditability of the respondents is indicative of their service to the industry thus their responses are considered to be reflective to the industry's views in the greater Melbourne region. Around one-third (19 out of 58) of the respondents are the project managers or project coordinators of the contractors firm; 10 respondents are developers; and the rest are design consultants who are working in solar PV projects either for the developers or the contractors. Among the respondents' backgrounds, 39 out of 58 (i.e over 65% of the) respondents have had more than 10 years' construction project management experience.

6. Findings and Discussions

6.1. Effective drivers of solar PV projects in Australia

Participants were asked whether D1 to D15 are the effective drivers of their respective solar PV projects on a 5 point likert scale from 1 "Strongly Disagree" to 5 "Strongly Agree". The mean scores and standard deviations (S.D.) are presented in Table 3. The respondents showed neutral to slight agreement towards the 15 drivers. The mean scores ranged from 3 to 4 of the five-point scale. Mean scores of D3: Investment in solar energy technology becomes more affordable (Financial) is the highest among the 15 attributes (Mean score = 4.21, Standard deviation = 0.71). The above results echoed with the findings reported by Mundada, Nilsiam and Pearce [24], surmising that reductions in overheads and investment costs can 'catalyse' the growth of solar PV industry. The close range of mean scores suggest that there is little evidence to support one driver being hugely more effective than the others. However, when comparing the effectiveness of drivers on aspects, mean scores of drivers in Financial and Environmental look more effective for promoting the uptake of solar PV projects. Surprisingly, drivers under government aspects are found less effective in driving the uptake of solar PV projects. The results indicate that the construction industry may not quite understand how to meet the renewable energy expectations and targets set forth by the government.

6.2. Anticipated outcomes of solar PV projects in Australia

Once again, the result does not show a large disparity of mean scores among the identified anticipated outcomes with values ranging between as little as 3.93-4.19 (Refer to Table 3). It indicates that respondents generally agree with the identified attributes as the anticipated outcomes of solar PV projects in Australia. Outcomes related to financial and technological aspects have an average mean score above 4 out of 5. This indicates the respondents' beliefs that solar PV projects have great potential to reduce energy cost of the building in the long run and enhance energy storage through technological advancement.

Table 3. Mean scores of drivers and anticipated outcomes

Drivers of solar PV projects	Mean	S.D.	Anticipated outcomes of solar PV projects	Mean	S.D.
Financial (Average)	**4.02**	**.69**	**Financial (Average)**	**4.19**	**0.64**
D1	3.80	.72	AO1	4.13	0.70
D2	4.05	.64	AO2	4.26	0.59
D3	4.21	.71			
Social (Average)	**3.98**	**.76**	**Social (Average)**	**3.93**	**0.71**
D4	3.96	.76	AO3	3.96	0.74
D5	4.07	.71	AO4	4.00	0.64
D6	3.91	.82	AO5	3.84	0.74
Technological aspect (average)	**3.97**	**.73**	**Technological aspect (average)**	**4.19**	**0.73**
	4.11	.71	AO6	4.40	0.66
D8	4.04	.81	AO7	4.20	0.80
D9	3.78	.69	AO8	3.98	0.73
Government aspect (Average)	**3.90**	**.75**	**Government aspect (Average)**	**4.05**	**0.66**
D10	3.93	.76	AO9	4.02	0.60
D11	3.89	.74	AO10	4.05	0.65
D12	3.89	.76	AO11	4.07	0.72
Environmental Aspect (Average)	**4.02**	**.84**	**Environmental Aspect (Average)**	**4.02**	**0.85**
D13	4.17	.69	AO12	3.87	0.88
D14	3.98	.92	AO13	4.00	0.93
D15	3.91	.90	AO14	4.18	0.72

6.3. Relative importance of drivers and outcomes of PV projects

The entropy analysis allows us to take a more scientific approach to the analysis of the returned data, as a comparison of mean scores only facilitates comparisons on the strength of agreement for drivers and outcomes as two separate categories. The entropy analysis process takes the mean values obtained in the survey and normalises them, creating a situation where two distinctly separate factors can be measured against one another accurately. Table 4 captures the expected value, entropy value, rating, and resultant normalised weighting for both the drivers and outcomes identified in the course of this paper. The normalised weighting values reveal which is the most important driver for the promotion of solar PV projects, and consequently the most anticipated outcome.

The results indicate that of all the drivers identified across the five categories, "D3 Investment in solar energy technology becomes more affordable" is perceived as the most important driver for solar PV projects. The relevant anticipated outcome of this driver, "AO2 Cheaper solar energy costs" achieved a weighting score of 0.075, the second highest score of all outcomes in the study. Given that the entropy scores for this driver and outcome achieved such similar rankings, it can be proposed that this combination has the greatest bearing on the uptake of the solar PV projects. The ability to offset one's cost of energy through the use of domestic solar PV and the capacity to reduce the upfront cost of installation is not a new concept. The results echo with the study from Chapman, McLellan and Tezuka [13] who identified that as a result of gradual removal and reduction of FiT's, annual installation rates of solar PV were found to drop in accordance with changes to financial incentives. Similarly, the work from Byrnes et al. [11] further verifies this in an Australian context, suggesting that 'high up front costs' and accessing the high level of capital required greatly affects many Australian communities in their ability to install solar PV. Engelken et al. [14] is another such paper that identifies 'financial benefit' for a 'private household' as one of the major influences as a result of their study. The authors of this paper proposed that successful PV implementation can be achieved not solely through tariffs or subsidies, but instead through the contractual lease of privately owned land and rooftops. The financial incentive

concept is further supported by work evidenced internationally from Hagerman, Jaramillo and Morgan [25], with their proof that socket parity is not achievable in 48 states across America without financial subsidies. Therefore, it is fair to assume that our research also supports the concept of financial drivers and outcomes having the most impact on solar PV installations in Australia.

Table 4. Relative importance of drivers and anticipated outcomes

Drivers	Expected Value	Entropy Value	Rating.	Normalised Weighting.	Anticipated outcomes	Expected Value	Entropy Value	Rating.	Normalised Weighting.
D1	3.804	0.033	3.681	0.064	AO1	4.127	0.034	3.990	0.073
D2	4.054	0.034	3.918	0.068	AO2	4.259	0.036	4.109	0.075
D3	4.214	0.033	4.076	0.071					
D4	3.964	0.032	3.838	0.066	AO3	3.964	0.033	3.836	0.070
D5	4.071	0.033	3.939	0.068	AO4	4.000	0.035	3.864	0.070
D6	3.911	0.032	3.789	0.066	AO5	3.836	0.033	3.712	0.067
	4.107	0.034	3.971	0.069	AO6	4.400	0.035	4.248	0.077
D8	4.036	0.032	3.909	0.068	AO7	4.200	0.033	4.062	0.074
D9	3.782	0.035	3.652	0.063	AO8	3.982	0.033	3.852	0.070
D10	3.929	0.032	3.804	0.066	AO9	4.019	0.036	3.878	0.071
D11	3.891	0.033	3.765	0.065	AO10	4.055	0.034	3.918	0.071
D12	3.893	0.032	3.769	0.065	AO11	4.073	0.033	3.939	0.072
D13	4.167	0.034	4.026	0.070	AO12	3.873	0.032	3.752	0.068
D14	3.982	0.031	3.861	0.067	AO13	4.000	0.032	3.875	0.070
D15	3.911	0.031	3.789	0.066	AO14	4.091	0.033	3.960	0.072

Increased solar PV efficiency/energy storage levels identified as the most highly anticipated outcome (weighting value of 0.077). The partner driver for this outcome too achieved a significant weighting score of 0.069, the third highest driver in the identified set. As Cucchiella, D'Adamo and Gastaldi [12] contend in their paper, 'the greatest limitation' of PV systems is the 'intermittency' of sunlight in certain areas of any country. The lack of efficient energy storage systems (ESS) proposed in this paper is one of the largest facilitators of this deficiency, as because solar PV energy can only be utilised while the sun is shining, the technology greatly lacks efficiency. The results of this study echoes with such views. The reduction of the effects of climate change driver achieved the second highest weighting score of all the drivers, with a value of 0.070, indicates that environmental influences carry significant weight with the Australian construction professionals. Palm [26] was able to contend in his work, that 'care for the environment' is amongst the most common factors influencing PV adoption in his work. He also identified in this paper, that local information channels can further incite the adoption of solar technologies.

One potential theory as to why this is the case takes base from the concept that individuals often fail to see the larger benefits of every minor change made. In the course of his work, Bichard [27] found several instances where respondents to his environmental minded questions selected options such as 'my small contribution won't make any difference' and 'it's not fair I make sacrifices if my neighbour isn't doing the same', despite the same participants acknowledging climate change as a real threat. The study from Higham, Reis and Cohen [28] further supports the concept introduced by Bichard, with several of their participants further contending that despite the 'scary' and 'concerning' nature of climate change, they have resigned to the fact that there is 'no solution that any individual can do'. Therefore, the results of this study and others provides an interesting area for further study, as such a highly ranked driver in terms of expected effectiveness failing to result in an equally ranked outcome exposes a disconnect between influences and their ability to impact changes.

7. The concluding remarks

This study aims to investigate the effectiveness of solar PV drivers and their capacity to achieve anticipated outcomes through a quantitative analysis. Through the literature review, 15 drivers and 14 outcomes were identified under five distinct categories; financial, social, technological, government and environmental. The identified attributes were culminated in the development of a questionnaire survey. Lowering the costs of solar technology was found as the driver that all the various employment categories agreed with the most. It was also deemed to be the most effective driver after completing the entropy approach, making this the most effective of the drivers identified at promoting uptake of solar PV in Australian construction. This suggests that once solar PV panels can be produced and sold at competitive prices or financially offset across their lifetime, solar PV implementation rates will be seen to improve across those employed in the construction industry. Of all the outcomes, improved solar panel efficiency and energy storage ranked first. It reveals that construction practitioners might expect further technological advancement to enhance the uptake of solar PV project. The culmination of findings suggests that once costs can be lowered to an affordable level, uptake of solar PV is likely to increase across the construction industry. It can be inferred from the results of this study that this value for money is anticipated in the form of increased PV efficiencies and through development of energy storage systems which remove the intermittency of energy production which current systems face.

This study contributes to enable the great uptake of solar PV projects in Australia. However, this information should be taken into consideration with limitation. The comparison of mean scores reported in the discussion section should be read with due caveats on the limitations of the working sample and the constraint on the scope of research. It should be noted that the respondents of this survey were randomly selected in the State of Victoria, Australia. The results of this study can be viewed as a case study conducted in the greater Melbourne region. As a further study this survey can be extended to collecting data in other Australian states and territories as well as other countries.

References

[1]   A. Bahadori & C. Nwaoha, "A review on solar energy utilisation in Australia", *Renewable and Sustainable Energy Reviews*, vol. 18, pp. 1-5, 2013.

[2]   M. Le Page & C. Brahic, 'Will Paris deal save our future?', *New Scientist*, vol. 228, no. 3052-3053, pp. 8-9, 2015.

[3]   V. Rai, D.C. Reeves & R. Margolis, 'Overcoming barriers and uncertainties in the adoption of residential solar PV', *Renewable Energy*, vol. 89, pp. 498-505, 2016.

[4]   Q. Wang & R. Li, 'Cheaper oil: A turning point in Paris climate talk?', *Renewable and Sustainable Energy Reviews*, vol. 52, pp. 1186-92, 2015.

[5]   Office of the Chief Economist (OCE), *Energy in Australia*, Department of Industry, Innovation and Science, Australia <http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/energy-in-aust/Energy-in-Australia-2015.pdf>, 2016.

[6]   B. Kumar Sahu, 'A study on global solar PV energy developments and policies with special focus on the top ten solar PV power producing countries', *Renewable and Sustainable Energy Reviews*, vol. 43, pp. 621-34, 2015.

[7]   M. Andor, M. Frondel, & C. Vance, 'Installing Photovoltaics in Germany: A license to print money?', *Economic Analysis and Policy*, vol. 48, pp. 106-16, 2015.

[8]   L. Strupeit, & A. Palm, 'Overcoming barriers to renewable energy diffusion: Business models for customer-sited solar photovoltaics in Japan, Germany and the United States', *Journal of Cleaner Production*, 2015.

[9]   A. Macintosh & D. Wilkinson, 'Searching for public benefits in solar subsidies: A case study on the Australian government's residential photovoltaic rebate program', *Energy Policy*, vol. 39, no. 6, pp. 3199-2209, 2011.

[10] Housing Industry Australia, *The Residential Outlook for 2016*, Housing Industry Australia, <https://hia.com.au/~/media/HIA%20Website/Files/IndustryBusiness/Economic/forecasts/Outlook%20for%202016%20-%20December%202015.ashx>, 2016.

[11]   L. Byrnes, C. Brown, J. Foster & L.D. Wagner, 'Australian renewable energy policy: Barriers and challenges', *Renewable Energy*, vol. 60, pp. 711-21, 2013.

[12]   F. Cucchiella, I. D'Adamo & M. Gastaldi, 'Photovoltaic energy systems with battery storage for residential areas: an economic analysis', *Journal of Cleaner Production*, vol. 131, pp. 460-74, 2016.

[13]   A.J. Chapman, B. McLellan & T. Tezuka, 'Residential solar PV policy: An analysis of impacts, successes and failures in the Australian case', *Renewable Energy*, vol. 86, pp. 1265-79, 2016.

[14]   M. Engelken, B. Römer, M. Drescher, I.M. Welpe, & A. Picot, 'Comparing drivers, barriers, and opportunities of business models for renewable energies: A review', *Renewable and Sustainable Energy Reviews*, vol. 60, pp. 795-809, 2016.

[15]   O., Manasseh, & R. Bass, 'Trends and challenges of grid-connected photovoltaic systems - A review', *Renewable and Sustainable Energy Reviews*, vol. 58, pp. 1082-94, 2015.

[16]   R. Kuwahata & C.R. Monroy, 'Market stimulation of renewable-based power generation in Australia', *Renewable and Sustainable Energy Reviews*, vol. 15, no. 1, pp. 534-43, 2011

[17]   N. Martin, & J. Rice, 'The solar photovoltaic feed-in tariff scheme in New South Wales, Australia', *Energy Policy*, vol. 61, pp. 697-706, 2013.

[18]   C. Breyer, O. Koskinen & P, Bleching, 'Profitable climate change mitigation: The case of greenhouse gas emission reduction benefits enabled by solar photovoltaic systems', *Renewable and Sustainable Energy Reviews*, vol. 49, pp. 610-28, 2015.

[19]   A. Pegels, 'Renewable energy in South Africa: Potentials, barriers and options for support', *Energy Policy*, vol. 38, no. 9, pp. 4945-54, 2010.

[20]   V. Rai, & S.A. Robinson, 'Agent-based modeling of energy technology adoption: Empirical integration of social, behavioral, economic, and environmental factors', *Environmental Modelling & Software*, vol. 70, pp. 163-77, 2015.

[21]   A. Darmani, N. Arvidsson, A. Hidalgo & J. Albors, 'What drives the development of renewable energy technologies? Toward a typology for the systemic drivers', *Renewable and Sustainable Energy Reviews*, vol. 38, pp. 834-47, 2014.

[22]   L.C.M. Tang, B. Atkinson, B & R.R. Zou, 'An entropy-based SWOT evaluation process of critical success factors for international market entry: a case study of a medium-sized consulting company', *Construction Management and Economics*, vol.30, no.10, pp.821-34, 2012.

[23]   P.S.P. Wong & J. Zapantis 'Driving adoption of carbon reduction strategies in the construction projects – the moderating role of organizational cultur. *Building and Environment*, vol. 66, pp. 120-130, 2013.

[24]   A.S. Mundada, Y. Nilsiam & J.M. Pearce, 'A review of technical requirements for plug-and-play solar photovoltaic microinverter systems in the United States', *Solar Energy*, vol. 135, pp. 455-70, 2016.

[25]   S. Hagerman, P. Jaramillo & M.G. Morgan, 'Is rooftop solar PV at socket parity without subsidies?', *Energy Policy*, vol. 89, pp. 84-94, 2016.

[26]   A. Palm, 'Local factors driving the diffusion of solar photovoltaics in Sweden: A case study of 5 municipalities in an early market.', *Energy Research & Social Science*, vol.14, pp.1-12, 2016.

[27]   E. Bichard, 'The application of sustainable behaviour change strategies in three built environment companies', *Journal of Engineering, Design and Technology*, vol. 7, no. 1, pp. 7-20, 2009

[28]   J. Higham, A. Reis & S.A. Cohen, 'Australian climate concern and the 'attitude–behaviour gap'', *Current Issues in Tourism*, vol. 19, no. 4, pp. 338-54, 2015.