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RESEARCH ARTICLE

Here comes the sun: social acceptability of solar photovoltaics in New Zealand

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ABSTRACT
Aotearoa is in a globally unique position regarding its high level of renewable electricity generation. However, increased demand has led to greater pressure to diversify green energies and increase infrastructure capacity. To date, photovoltaics has received relatively low uptake, particularly in the residential market. Consumer behaviour has been changing with individuals becoming increasingly climate conscious, making purchase decisions that consider the triple bottom line. This study seeks to understand consumer attitudes and social acceptability of photovoltaics. It also investigates what incentives might encourage greater uptake of photovoltaics in Aotearoa. To explore this, we surveyed 517 individuals from across New Zealand. The results show that information practices have a direct impact on social acceptability, while also being mediated by perceived risks and perceived benefits. However, there was no significant support for the role of emotions in influencing social acceptability. An explorative analysis of possible purchase incentives revealed free installation to be the most attractive consumer purchase incentive, whilst annual rebates are considered the least attractive. This highlights the opportunity for policymakers and corporate actors to engage in information campaigns and incentive programmes to inform consumers and remove barriers to photovoltaic technology adoption.

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Introduction

In the past decade, New Zealand consumers' interest and knowledge of planet-wide societal issues such as climate change and sustainability have been steadily increasing (Realini et al. 2023; Fehrer et al. 2024). Climate change and negative environmental externalities such as carbon emissions have led to the establishment of a climate-conscious consumer movement (Giezenaar et al. 2023; Kennett et al. 2023; Parsons

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et al. 2023). Climate conscious consumers are aware of the impact of their product choices and favour options that consider the triple bottom line of planet, people and profit (Rombach et al. 2023). In New Zealand, climate-conscious consumer behaviour has been widely researched for marketing (Wardana et al. 2024), food consumption (Kerslake et al. 2022; White et al. 2022; Kemper et al. 2023; Sharp et al. 2024), sustainability beliefs (Kemper et al. 2018), climate politics (Parsons et al. 2023) and other agricultural products, such as animal feed and fertilisers (Liu et al. 2018; Shelomi 2020). However, there exists a gap in exploring the attitudes and behaviours of individuals regarding energy transitions as the country attempts to increase energy infrastructure while lowering overall emissions from the sector (MFE 2022).

Renewable energy accounts for around 87% of electricity produced, and nearly 44% of New Zealand's total primary energy production balance (MBIE 2023a). As the country moves towards electrification, it is expected that current infrastructure needs to more than double in capacity by 2050 to meet energy demands (New Zealand Infrastructure Commission 2021). Further, New Zealand's target to reach net zero emissions by 2050 has led to pressure to further decarbonise the economy and move away from fossil fuels. To date, renewable energy uptake of newer technologies (such as wind and photovoltaics) has been relatively low globally, facing issues such as lack of infrastructure investment, consenting delays and policy uncertainties, and access to finance (IEA 2024). If New Zealand is to establish policy that encourages the installation and use of these renewable energy technologies, it is important to understand how individuals view alternative renewable energy sources. Understanding how people view an issue offers insights into what they will politically support – helping to ensure a just transition towards a greater renewable energy system.

The extant literature on attitudes towards renewable energy in New Zealand has been growing in recent years. It largely covers areas such as drivers and barriers to green energy consumption, grid modelling, types of green energy and their impacts, the potential of green energy for specific regions, willingness to pay for renewables, and microgeneration technology opportunities (Baskaran et al. 2013; Berka et al. 2020; Ndebele 2020; Zhang et al. 2023; Brent et al. 2024; Mohseni and Brent 2024; Pincelli et al. 2024; Roberts et al. 2024). Behavioural factors and consumer behaviour has received some attention in terms of exploring energy sources in New Zealand from an interdisciplinary lens (Graham et al. 2009; Stephenson et al. 2010; Stephenson et al. 2015; Ford et al. 2017). However, this is largely qualitative in nature, and there is a lack of empirical research that explores these concepts quantitatively. This is an important gap to address, as in recent years the cost of photovoltaics has reduced, and in many cases it has one of the lowest levelized costs of electricity (Mandys et al. 2023). Given the absence of prior empirical studies in the New Zealand context, this study attempts to quantitatively explore New Zealand's level of social acceptance of photovoltaics.

Amidst this background, the present study aims to explore factors driving and hindering public acceptance of domestic photovoltaics (on buildings) as a source of green energy by utilising a representative quantitative survey. This research will provide greater understanding of individuals' perceptions and provide valuable information for policymakers in moving towards a just transition towards renewable energy in Aotearoa New Zealand. To begin, the following section provides a theoretical foundation for the study.

Hypotheses development

Social acceptability

The success of renewable energy policies and local resistance towards new energy projects can largely be explained by social acceptance (Wüstenhagen et al. 2007). That is, a positive or favourable response to a technology in the form of opinion, consent, support or authorisation (Marrero et al. 2021). Wüstenhagen et al.'s (2007) research distinguished three dimensions of social acceptance: socio-political acceptance, community acceptance and market acceptance. In this conceptualisation, socio-political acceptance is broad, referring to issues such as policies and societal acceptance. Community acceptance rests around acceptance of siting decisions by local stakeholders, and market acceptance is the process of market adoption by individual consumers. More recently, Huijts et al. (2012) also distinguish three types of acceptance and acceptability: citizen, consumer and socio-political acceptance. Citizen acceptance refers to siting issues, and consumer acceptance to the public response to the availability of the technology and purchase behaviour. Finally, socio-political acceptance refers to individuals' responses to regional, national or international events or policymaking.

From the above, it is possible to identify three levels of social acceptance as highlighted by figure 1 below. At the highest or most general level is socio-political acceptance, moving down to the individual level. In the current paper, we refer largely to citizen or community acceptance, investigating the cognitive and affective processes that influence acceptance of photovoltaics to individuals of a population. However, we also touch upon socio-political acceptability through an explorative investigation of consumer purchase incentives and overall acceptability of photovoltaics.

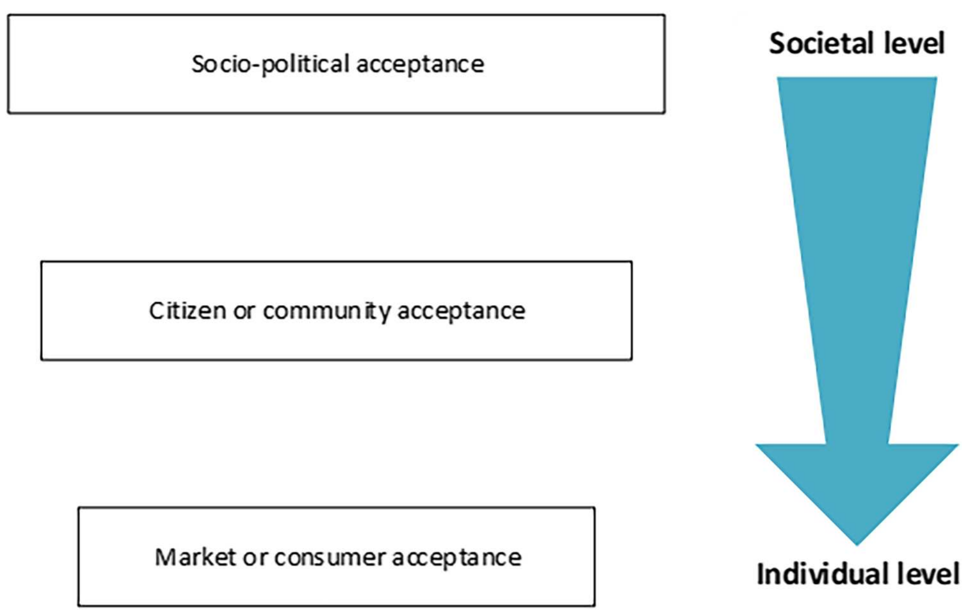

Figure 1. The three levels of social acceptance. Source: Adapted from Huijts et al. (2012); Wüstenhagen et al. (2007).

It is here that the authors highlight the distinction in the use of *acceptance* and *acceptability*. Huijts et al. (2012, p. 526) define acceptance as a 'behaviour towards energy technologies and acceptability as an attitude (an evaluative judgement) towards new technologies and attitude towards possible behaviours in response to the technology'. In this study, the focus is largely towards consumer attitudes around photovoltaics rather than actual behaviour, such as the purchase and installation of photovoltaics at a residential property. Therefore, 'acceptability' will be used from this point onwards. In dissecting the acceptability of a new energy technology, positive and negative affect, and perceived risks and benefits are affects and cognitions that influence a person's intention to accept a new technology, and act as mediators of acceptability (Huijts et al. 2012). These are explored further in the proceeding discussion.

Information practices

Access to information and the development of knowledge is a pathway that provides a platform for individuals to engage with new technology, while implementing mental shortcuts to filter information and develop opinions (Ho et al. 2019). These practices are a key element in the acceptability of renewable energy sources, and may have either a positive or negative effect on acceptability (Kardooni et al. 2016). In some streams of literature, researchers argue that providing more information about emerging technologies will lead to greater acceptability (Stoutenborough and Vedlitz 2016), while others suggest that gaining more in-depth information leads to increased hesitance to accept a new technology as additional perceived risks are uncovered (Gordon et al. 2022).

In the realm of social psychology, Huijts et al. (2012) suggest that knowledge may act as both a direct and indirect antecedent of acceptability. In this sense, knowledge acts as the foundation for decision-making, influencing not only acceptability, but also the affect and cognitions of individuals. As a result, we propose the following:

H1: Information practices are related to acceptability.

H2: Information practices are related to (a) positive emotions, (b) negative emotions, (c) perceived benefits and (d) perceived risks.

Acceptability mediators

Positive and negative emotions

Positive and negative emotions (affect) are hedonic goals or motives associated with making decisions that feel best and minimise negative feelings (Marrero et al. 2021). Previous research has shown emotions to play a key role in peoples' decision-making, especially in uncertain conditions or complex contexts (Slovic et al. 2007). In the context of renewable energies, this may arise in terms of the potential for changing personal circumstances, feelings around siting decisions and the impact it may have on the local community, or fair distribution of costs (e.g. Endrejat et al. 2020 O'Neil 2020; Li et al. 2022).

Previous research has highlighted that negative emotions tend to be more heavily weighted than positive emotions (Tversky and Kahneman 1991) and that individuals are often biased towards maintaining the status quo (Russell and Firestone 2021).

Therefore, it is useful to understand both the positive and negative emotions in the path to photovoltaics acceptability. As a result we suggest:

H3: (a) positive emotions are positively, and (b) negative emotions are negatively related to social acceptability.

H4: (a) positive emotions, and (b) negative emotions will act as mediators between information and social acceptability.

Perceived risks and benefits

Gain motives are related to the evaluation of costs and benefits of an action, or, the perceived risks and perceived benefits (cognition; Marrero et al. 2021). In other words, individuals will choose options that minimise their costs or risk, and maximise gains or benefits (Huijts et al. 2012). The level of perceived risk is related to the probability that risk occurs and its potential loss. On the other hand, perceived benefits are the level to which an individual believes themselves, or society, will benefit (Wang et al. 2019).

This area has been well researched, and there are several studies that highlight perceived risks and benefits do indeed influence social acceptability (see, for example, Midden and Huijts 2009; Visschers and Siegrist 2014; Wang et al. 2019). In terms of renewable energy, Marrero et al. (2021) suggest that risks may be categorised as factors such as financial, health, security or the environment, and perceived benefits may include factors such as job creation, energy efficiency, cost savings and environmental impacts. These perceptions are often derived from various sources whilst consuming information both actively and passively through, for example, social media exposure or informational events (e.g. Bidwell 2016; Li et al. 2019). As such, perceived risks are negatively associated with social acceptability and perceived benefits are positively associated. Based on this, we propose:

H5: (a) perceived benefits are positively, and (b) perceived risks are negatively related to social acceptability.

H6: (a) perceived benefits, and (b) perceived risks will act as mediators between information and social acceptability.

Material and methods

Data collection and sample description

This research utilises a questionnaire to conduct an empirical and quantitative study of social acceptability. In December 2023, an online survey was administered and distributed through the online survey software Qualtrics. Qualtrics also functioned as an opt-in panel provider, with quotas based on age, gender and region resided in. These quotas were provided in an attempt to reflect New Zealand's demographics and were calculated using the 2018 results of the New Zealand census. In addition to the quotas, the survey also included exclusion criteria that immediately terminated the survey if participants were less than 18 years of age, or did not reside within New Zealand. Based on this, Qualtrics initially recruited 524 participants. Seven survey responses were subsequently removed from the data set due to abnormal response times, while also exhibiting no variation in responses, including reverse questions. The result was a total of 517 suitable survey responses for analysis.

Within the sample, 51.6% of respondents identified as female, 48% as male and 0.4% identified as gender diverse, or were not willing to disclose their gender identity. The sample can be described as well educated, since 54.4% of participants had a university education, achieving qualifications such as diplomas, bachelor's and master's degrees, as well as doctoral degrees. Only 7.9% had obtained no type of formal qualification. Approximately 66.4% of the sample can be classified within the medium- to high-household income bracket (See Table 1).

Survey participants were informed of the purpose of the research, and the survey received human ethics committee approval. Participants were not provided background information on solar photovoltaics, other than being informed that this may also be called solar panel technology. The purpose of this was to understand how participants think and feel about photovoltaics with the information they already possess. Participants were asked about their socio-demographic backgrounds, attitudes and interest in green energy, as well as their willingness to accept photovoltaics as a prominent energy source.

The constructs information practices, perceived risk, perceived benefits, positive emotions and negative emotion stem from the technology acceptance framework.

Table 1. Demographics of survey participants.

Gender	Freq	%
Female	267	51.6
Male	248	48.0
Diverse	1	0.2
Prefer not to say/No information provided	1	0.2
Age	**Freq**	**%**
18–24	72	13.9
25–34	102	19.7
35–44	87	16.8
45–54	83	16.1
55–64	70	13.5
65+	103	19.9
Education	**Freq**	**%**
No qualification	41	7.9
Level 1 certificate	25	4.8
Level 2 certificate	22	4.3
Level 3 certificate	62	12.0
Level 4 certificate	69	13.3
Level 5 diploma	29	5.6
Level 6 diploma	46	8.9
Bachelor's degree and level 7 qualification	124	24.0
Post-graduate and honours degrees	34	6.6
Master's degree	38	7.4
Doctorate degree	10	1.9
Overseas secondary school qualification	17	3.3
Income	**Freq**	**%**
$0–$24,999	52	10.1
$25,000–$49,999	95	18.4
$50,000–$74,000	113	21.9
$75000–$99,999	103	19.9
$100,000 and higher	127	24.6
Prefer not to say/No information provided	27	5.2

Using this framework, it is possible to investigate social acceptability by incorporating individuals' risk perceptions, psychosocial processes and the wider environment (Huijts et al. 2012). Participants were asked a range of questions around personal beliefs, through to purchase incentives and country reputation on the world stage. By adopting a technology acceptance framework for this research, the survey was able to capture the three levels of social acceptability. Further, extant literature around technology acceptability, planned behaviour, goal framing and renewable energy was used to inform the survey development (see, for example, Ali et al. 2020; Ransan-Cooper et al. 2020; Khalid et al. 2021; Marrero et al. 2021). Items were adapted and adjusted to the New Zealand context and measured using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree).

The data analysis was carried out using the computer software SPSS 29 and Smart-PLS 4. SPSS 29 allowed the researchers to create the socio-demographic profile and their preferences for purchase incentives via descriptive statistics. The latter was executed as an additional explorative analysis aimed at assisting practitioners and government to set incentives appealing to the New Zealand public. The explorative analysis for the construct purchase incentive required survey participants to rank options on a scale from one 'being your most preferred option' to six 'being your least preferred option'. Mean values and frequencies for each incentive were calculated in an effort to provide some meaningful insight and understand preferred options.

SmartPLS 4 assisted the PLS-SEM, a methodological analysis appropriate for investigating complex explorative models (Hair et al. 2022). Further, this approach follows relaxed distributional assumptions of data where multi-items, single measures and smaller samples may be accommodated. Path analysis, principal component analysis and regression analysis are combined within PLS-SEM (Hair et al. 2011; Hair et al. 2019). Following Hair et al. (2022), the first step of the analysis is the measurement model that includes the consideration of factor loadings, which should be above the threshold value of 0.4 (Hair et al. 2011). To understand whether item/scale convergence is achieved, the average variance extracted (AVE) is an indicator taken into account, and values are suggested to be above 0.5 (Hair et al. 2019). To evaluate scale reliability, Cronbach's alpha and composite reliability are considered. The values for both criteria should exceed the threshold value of 0.6 (Hair et al. 2022). Lastly, discriminant validity is verified via the Fornell–Larcker criterion and heterotrait–monotrait ratio of correlations criterion (HTMT). While the Fornell–Larcker criterion is greater than the cross-loading, the HTMT values should be below the threshold value of 0.9 (Fornell and Larcker 1981; Hair et al. 2019). To assure the data set is free of multicollinearity problems, variance inflation factor (VIF) scores should be below 5 (Henseler et al. 2015; Hair et al. 2022).

In the final step of the analysis, a structural model is developed. This includes evaluating structural fit, explanatory power and predictive relevance of the model (Hair et al. 2019). Research convention in the PLS-SEM community requires the consideration of model fit indices. These include goodness of fit and normed fit index (NFI), where scores approaching one are desired. Hair et al. (2022) suggest using fit indices with caution, as specific thresholds and their interpretation are unclear. The Standardized Root Mean Square Residual (SRMSR) indicates a better fit when smaller; it is acceptable if it is under 0.08 and problematic if it is over 0.10.

To examine predictive relevance, the Stone–Geisser criterion (Q^2) is suggested. The Stone–Geisser criterion specifies Q^2-values as acceptable (>0), medium (~0.25) and strong (~0.50). Further R^2 values indicate explanatory power as weak (~0.25), moderate (~0.50) or substantial (~0.75) (Hair et al. 2022). The analysis is completed with hypotheses testing which includes direction and statistical significance of the coefficients (Baron and Kenny 1986). Given the aforementioned hypotheses suggesting that various variables act as mediators, a mediation test following Baron and Kenny (1986) is conducted. This test compares path coefficient scores of two models, (a) with the mediation variable included and (b) a model without the mediation variable.

Results

Table 2 presents the measurement model results. Given that all factor loadings were well above the threshold value of 0.4, the constructs contribute sufficiently to their respective scale. Moreover, both reliability criteria (Cronbach's alpha and composite reliability) showed values of at least 0.6, thus verifying the reliability of the model. Lastly, the AVE values were greater than the minimum threshold value of 0.5, confirming convergent validity, satisfying the requirements for construct reliability and convergent validity.

Table 3 displays the discriminant validity criteria. Both the Fornell–Larcker criterion and the HTMT were satisfied. Since the square roots of the scale's AVE were greater than the cross-loadings, the Fornell–Larcker criterion was confirmed. Given that all HTMT ratios were below 0.90, the HTMT was satisfied. Multicollinearity was not found to affect the model, as shown by the VIF values (max: 1.774 and average: 1.567).

Model structure analyses indicate a goodness of fit of 0.385, an NFI of 0.762 and an SRMSR of 0.073, indicating adequate model fit. The model has somewhat weaker explanatory power and acceptable predictive relevance with an average R^2 of 0.160 and an average Q^2 of 0.048. For the dependent variable 'acceptability of solar energy' strong explained variance of 54% was found (R^2: 0.540), however, the variables 'emotion negative' (R^2: 0.067), 'emotion positive' (R^2: 0.117), 'perceived benefit' (R^2: 0.059) and 'perceived risk' (R^2: 0.016) were weaker.

Table 4 displays the results of the hypotheses testing. The study found a significant, negative relationship between information practices and the New Zealand public's negative emotion, their perceived risk and acceptability for photovoltaics, thus supporting hypotheses H1, H2b and H2d. A significant positive relationship was found between information practices and individuals' positive emotion, as well as their perceived risk, indicating support for the hypotheses H2a and H2c. Surprisingly, no support was found for hypotheses H3a and H3b, which focused on the relationship between positive and negative emotion and acceptability. Lastly, a significant positive relationship was found between perceived benefit and acceptability, indicating support for hypothesis H5a, and a significant negative relationship between perceived risk and acceptability, supporting hypothesis H5b.

Given the lack of support for the direct influence of emotions on acceptability, we reject the hypotheses of H4a and H4b as mediators between information and social acceptability. When testing the first model assessing the relationship between information practice and acceptability, with perceived benefits not included as the mediating variable, the results display a β of -0.126 (significant at $p = 0.009$). When testing the second model with

Table 2. Scale loadings, reliabilities and convergent validity for multi-item scales.

Scales and Items	Factor Loadings	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
Information Practices		**0.828**	**0.885**	**0.659**
I consider myself informed about solar energy	0.853			
I find information about solar photovoltaics easy to find	0.776			
When I hear, see, or read something about solar photovoltaics I seek as much information as I can	0.795			
I understand the basics of how solar photovoltaics work	0.821			
Emotion (Negative)		**0.778**	**0.838**	**0.515**
I think that the solar photovoltaic batteries are large and ugly	0.730			
I think the batteries are unsafe	0.787			
I think buying new technologies like solar photovoltaics is scary	0.779			
Solar technology requires a lot of knowledge to use	0.503			
Learning how to use solar photovoltaic technology is difficult	0.749			
Emotion (Positive)		**0.708**	**0.869**	**0.768**
My friends will like that I get solar photovoltaics installed	0.828			
I think buying new technology like solar photovoltaics is exciting	0.922			
Perceived Benefit		**0.870**	**0.903**	**0.607**
I think the purchase of solar photovoltaics is a good investment for the future	0.743			
Promoting solar photovoltaics publicly will increase New Zealand's international reputation	0.793			
Greater installation of solar photovoltaics will help create new jobs	0.776			
Greater installation and use of solar photovoltaics will save money in the long run	0.726			
Using renewable energy sources is a good idea for our society	0.826			
Perceived Risk		**0.813**	**0.888**	**0.727**
I find that initial cost of purchase and installation of photovoltaics to be expensive	0.768			
Solar photovoltaics involves a risk to people's health	0.877			
Solar photovoltaics presents a risk to the environment	0.907			
Acceptability		**0.819**	**0.881**	**0.649**
In general, I accept solar photovoltaic energy	0.795			
I do not believe that solar photovoltaic energy should be installed	0.757			
In general, I am in favour of promoting solar photovoltaic energy	0.833			
I would accept the installation of solar photovoltaics in urban areas	0.834			

perceived benefits as mediator included, results displayed a β of 0.242 (significant at $p < 0.001$). Given the change in direction of the coefficient, a full mediation took place, therefore supporting H6a. Similarly, when testing the relationship between information practice and acceptability in the first model, without perceived risk as the mediating variable, the results show a β of -0.078 (significant at $p = 0.013$). In the second model, testing with perceived risk as a mediator included, resulted in a significant β coefficient

Table 3. Scale discriminant validity.

Fornell–Larcker Criterion	A	B	C	D	E	F
(A) Information Practice	0.812					
(B) Emotion Negative	-0.26	0.717				
(C) Emotion Positive	0.342	-0.165	0.877			
(D) Perceived Benefit	0.242	-0.329	0.593	0.779		
(E) Perceived Risk	-0.125	0.489	-0.124	-0.335	0.853	
(F) Acceptability	0.108	-0.216	0.441	0.714	-0.362	0.805
HTMT	**A**	**B**	**C**	**D**	**E**	**F**
(A) Information Practice						
(B) Emotion Negative	0.315					
(C) Emotion Positive	0.425	0.21				
(D) Perceived Benefit	0.279	0.351	0.741			
(E) Perceived Risk	0.153	0.602	0.147	0.393		
(F) Acceptability	0.128	0.259	0.56	0.842	0.426	

Table 4. Path coefficients.

Hypothesised Relationship	Coefficient	T Stat	*P* Value
H1 Information Practices → Acceptability	-0.076	2.404	**0.016**
H2a Information Practices → Emotion positive	0.342	7.387	**0.000**
H2b Information Practices → Emotion negative	-0.260	5.419	**0.000**
H2c Information Practices → Perceived Benefit	0.242	5.195	**0.000**
H2d Information Practices → Perceived Risk	-0.125	2.581	**0.010**
H3a Emotion positive → Acceptability	0.067	1.563	0.118
H3b Emotion negative → Acceptability	0.082	1.854	0.064
H5a Perceived Benefit → Acceptability	0.658	17.08	**0.000**
H5b Perceived Risk → Acceptability	-0.183	4.111	**0.000**

Bold = $P < 0.05$.

of -0.183 (significant at $p < 0.001$). Given the increase in the negative coefficient which constitutes an overall decrease on the effects of information practice on acceptability, a partial mediation effect was found. Therefore, H6b can be partially confirmed.

Explorative analysis

To achieve not only the acceptability and later acceptance of photovoltaics, but also its adoption, various instruments are necessary from a policy perspective (Bersalli et al. 2020; Hille et al. 2020). To address this, a question regarding people's preferred purchase incentives was included in the survey, allowing respondents to rank six options based on their preference. Analysing the average rank of each item, the most preferred option was 'access to free installation' ($M_{\text{rank}} = 2.86$), whereas the least preferred option was 'receiving an annual rebate relative to electricity generation and storage capacity' ($M_{\text{rank}} = 4.43$).

When analysing the frequency of each rank for the purchase incentives, a descending trend emerges in favour of 'access to free installation' from rank one to six, and the opposite ascending frequency in 'receiving an annual rebate relative to electricity generation and storage capacity'. However, other incentives show a more diverse distribution of rankings. For example, in the case of 'access to low-interest loans', nearly a quarter of the respondents ranked the incentive as their most favoured option (24.9%), and 22.8% ranked it last. A summary of these may be seen in Table 5 below. These descriptive findings offer initial insights into potential policy instruments and underscore the need for a suitable mix of policies to enhance the purchase intention of photovoltaic energy.

Table 5. Frequency of each rank for each purchase incentive.

Type of Purchase Incentive	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6
			Frequency (%)			
Receiving an annual rebate relative to electricity generation and storage capacity	25 (4.7)	52 (9.9)	66 (12.5)	83 (15.7)	117 (22.2)	174 (33.0)
Having an up-front purchase rebate	65 (12.3)	73 (13.9)	82 (15.6)	138 (26.2)	87 (16.5)	72 (13.7)
Being able to purchase the photovoltaic panels free of GST	58 (11)	115 (21.8)	100 (19.0)	95 (18.0)	80 (15.2)	69 (13.1)
Access to low-interest loans	131 (24.9)	87 (16.5)	72 (13.7)	55 (10.4)	52 (9.9)	120 (22.8)
Having the ability to sell unused electricity back to the grid once installed	88 (16.7)	81 (15.4)	122 (23.1)	87 (15.6)	86 (16.3)	53 (10.1)
Access to free installation	150 (28.5)	109 (20.7)	75 (14.2)	59 (11.2)	95 (18.0)	29 (5.5)

Discussion and conclusion

This timely study provides representative research results to shed light on factors that shape acceptability towards photovoltaics in New Zealand. The results reveal that cognitive components (namely perceived benefits and risk) serve as a strong predictor for acceptability, whereas the affective components do not impact the acceptability of photovoltaics in the sample. Moreover, the findings confirm a significant relationship between information practices (including perceived level of information and information gathering) and its acceptability. Surprisingly, this relationship, even if weak, was negative, indicating that people who feel more informed and gather more information tend to perceive photovoltaic energy as less acceptable. This may be due to factors such as the survey design, or selective processing of information based on prior attitudes (Jobin et al. 2019). However, benefits and risks act as both full and partial mediators, indicating that information has a positive indirect impact, but only when benefits are perceived and risk perception is lowered. Thus, the results validate the significance of providing information regarding, for example, potential benefits, and subsequently evoking interest in the topic to elicit individuals' perceptions and encourage further engagement through information practices.

The general acceptance of photovoltaics by research participants in this research is consistent with studies conducted in other countries (see, for example, Strazzera and Statzu 2017; Marrero et al. 2021; Abbas et al. 2024). With relatively low adoption rates by consumers, the issue then becomes how to remove barriers to purchase and incentivise adoption. Ford et al. (2014) highlighted that the greatest barrier to residential uptake of photovoltaics in New Zealand was the high upfront cost of purchase and installation. Other barriers in their study included uncertainty around return on investment and lack of certainty about buy back rates. In addition to this, there are currently no incentives provided by the New Zealand government to encourage uptake. To understand what would motivate consumers to install photovoltaics, the explorative analysis in this study explored possible incentives, with access to free installation and low interest loans appearing to be the two most attractive incentives for the public. In the New Zealand context, awareness campaigns, educational approaches and consulting opportunities ideally involve a variety of stakeholders, including local communities, and energy suppliers, to reach a large portion of society (see Berka et al. 2020).

Theoretical and practical implications

Technology acceptance is a culmination of several theories such as the theory of reasoned action, theory of planned behaviour, theory of interpersonal behaviour and technology acceptance model (Taherdoost 2018). Further, technology acceptance has largely been explored in the area of information technology and information systems (see, for example, Gillenson and Sherrell 2002; Lu et al. 2003; Tong 2010; Rafique et al. 2020). Specifically in the context of renewable energy, Huijts et al. (2012) have developed one of the most comprehensive technology acceptance frameworks. This research was conceptual in nature, and the current study provides an empirical application of the framework, adding to the extant literature.

In the wake of New Zealand's goal of achieving net zero emissions by 2050 (MFE 2022), public acceptability of, and personal investment in, renewable technologies is an important component. The results hold some valuable practical implications in the exploration of pathways to increase acceptability and subsequent acceptance of photovoltaics. Considering the rather young diffusion phase of solar energy in the New Zealand context compared to, for example, the European context (EEA 2023), it is important to create awareness around the benefits of solar photovoltaics, while also clarifying realistic risks and avoiding misconceptions. Policymakers and corporate actors should therefore focus on suitable communication approaches, where acceptance moves beyond just the cognitive to include emotions, ranging from one-way communication campaigns to two-way communication to create a dialogue and offer individuals a pathway to engagement (see Wolf and Moser 2011; Perlaviciute et al. 2018).

One-way communication approaches would ideally be built upon recent research findings, concentrating on information framing, such as loss and gain framing around climate change topics and associated changes to foster public acceptability (Gurtner and Moser 2024). For corporate actors, this could include research-founded marketing based on behavioural reasoning theory where market segmentation may be used to understand consumer reasoning and how this affects an individual's attitudes and decision to purchase (Claudy et al. 2013). In contrast, two-way communication could include public forums where policymakers at different levels provide a platform to address public needs, feedback and misconceptions. This could be combined with additional policy around the incentivisation of household photovoltaics purchase, focusing on free installation or working with financial institutions to provide access to low-interest loans. The challenge here are the differing goals of corporate actors and government. Any solution here to incentivise individuals would need a win-win scenario to be implemented and may ultimately require the government to provide subsidies.

Limitations and future research

When interpreting results, it is prudent to highlight some limitations in the present study. Firstly, we are limited to a proxy for actual acceptance and support, where the intention of social acceptance (acceptability) does not directly translate into latter action. However, the intention to accept serves as a directive for current public opinion and future reactions (Huijts et al. 2012; Boudet 2019).

Secondly, the findings are limited to photovoltaics as one type of renewable energy technology among many others. A successful transition towards low-carbon emissions in New Zealand will require a combination of various transition pathways, including different energy technologies, electrification of various industries, energy efficiency improvements and behavioural changes. These changes will inherently affect the public beyond sectoral actors (see Andersen and Geels 2023). This highlights the need for further studies on public reactions and support for different energy alternatives (e.g. wind, geothermal or photovoltaic), technologies (e.g. carbon capture storage) and political measures (e.g. regulatory streamlining or net metering) suitable for the New Zealand context to avoid public resistance and lack of support.

Third, while the study sample is representative overall of the New Zealand population, it is not possible to directly deduce cultural differences between participants. The findings validate western-oriented research models and findings within the realm of public acceptance of renewable energy technologies (Gupta et al. 2012; Bergquist et al. 2022). However, there is a lack of predictive power for the emotional components in this study. As this research focused on four distinct cognitive and affective components, further research should test additional components shaping public acceptability around energy technologies. This could include concepts that have been identified in the extant literature such as fairness perception, or trust, which tend to vary depending on regions and cultures (e.g. Huijts et al. 2012; Gölz and Wedderhoff 2018; Liu et al. 2019). This is particularly relevant in the New Zealand context where Indigenous values and world view are more focused on the interconnectedness of all living things, rather than the often mechanistic western-oriented view of the world (Reid and Rout 2016). Thus, there is a need for further research on the role of emotions in shaping acceptance for renewable energy technologies.

In general, the results present future avenues for research on attitudes and acceptance of photovoltaics and other forms of renewable energy in the New Zealand context. First and foremost, the researchers aim to inspire others to address the gap in recent research on attitudes towards, and support of, renewable energies, considering the country's potential and its low numbers in shares of wind and solar energy (New Zealand Infrastructure Commission 2021; Zhang et al. 2023). However, future studies should complement quantitative research with qualitative data to offer a more nuanced understanding of the public's trust, knowledge and information practices, as well as potential misconceptions regarding perceived risks and benefits, especially in the absence of empirical findings from New Zealand. Moreover, we recommend making use of person-centred approaches (e.g. latent class or latent profile analysis) beyond the applied 'variable-centred' approach. With the overarching goal to identify general patterns, the variable-centred approach is useful for generating knowledge across the sample, whereas the person-centred approach accounts for individual and group differences (see Woo et al. 2018). While former research in the Oceania context concentrated on climate change perception (see Hine et al. 2014; Hine et al. 2016; Milfont et al. 2024), a person-centred study examining attitudinal profiles towards renewable energy technologies can inform policymakers about which policy instruments might be effective for specific target groups and corporate actors around market segmentation and marketing efforts.

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