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Energy Procedia 151 (2018) 135–143

Energy Procedia

www.elsevier.com/locate/procedia

3rd Annual Conference in Energy Storage and Its Applications, 3rd CDT-ESA-AC, 11–12 September 2018, Sheffield, UK

Understanding lay-public perceptions of energy storage technologies: Results of a questionnaire conducted in the UK

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Abstract

Grid-scale electrical energy storage technologies (ESTs) are a means of tackling the challenges of introducing more intermittent power generators into national electricity networks. Public perceptions of emerging technologies are known to affect the likelihood of their commercial success; however, there is a paucity of research into the nature and antecedents of lay-public perceptions of grid-scale ESTs. We report on the findings of an online survey distributed to a diverse sample of the UK (N=1,044) designed to address this gap. The focus was on four grid-scale options (i.e. pumped hydro storage, compressed air energy storage, flywheels and lithium-ion batteries). Broadly, respondents were favourable to all technologies, although there was a preference for pumped hydro storage. Regression analysis revealed that intentions to support ESTs were positively predicted by attitudes, positive affect, perceived benefits, trust in developers, self-claimed awareness of ESTs and a belief that financial expenditure on the technology is warranted. Pro-ecological values were a negative predictor. Possible explanations for and implications of the findings are discussed.

Selection and peer-review under responsibility of the 3rd Annual Conference in Energy Storage and Its Applications, 3rd CDT-ESA-AC.

Keywords: Energy storage; Public perceptions; Attitudes; Acceptance

1. Introduction

Attempts to increase the proportion of renewable energy technologies in the UK electricity generation portfolio (consistent with ongoing efforts to decarbonize the sector) present significant challenges for energy security. Many

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Selection and peer-review under responsibility of the 3rd Annual Conference in Energy Storage and Its Applications, 3rd CDT-ESA-AC.
10.1016/j.egypro.2018.09.038

renewables generate electricity intermittently, which can threaten voltage stability within the grid and/or mean that the supply of electricity does not accurately meet with fluctuating demand (1). Grid-scale electrical energy storage technologies (ESTs) are seen as part of the solution to this problem being that they can provide a number of support/ancillary services; for example, allowing for real-time voltage regulation (helping to ensure grid-stability) and offering the capacity for longer term storage of energy that can be drawn upon at times when it is required (2,3).

While some grid-scale ESTs are commercially well-established in the UK (e.g., pumped hydro storage), others are at earlier technology readiness levels (e.g. compressed air energy storage) (3–5). A growing literature points to the strong, steering influence that publics can exert upon the fate of new, unfamiliar and innovative technologies (6–10). By engaging in supportive action or resistive protestation, for example, publics can shape the decisions of investors, policy-makers and societal leaders. Crucially, there is a growing list of examples where failures to engage, understand and respond to the opinions of publics (and other social stakeholders) has led to delays or curtailments in the introduction of new technologies at national (e.g. genetic modification technology) and local (e.g. wind farms) levels (6,11,12). Accordingly, understanding how publics perceive grid-scale ESTs will be integral to the design of public engagement strategies for their inclusion in low-carbon electricity systems. While research into public perceptions of ESTs, particularly at the household-level (e.g. electric vehicles) is growing, very little is still known about public perceptions of some larger, grid-scale energy-storage options (e.g. compressed air energy storage) (10).

The current study directly addressed this gap in knowledge by distributing an online questionnaire-based survey on grid-scale electrical storage to a demographically diverse sample of the UK population. The specific objectives of this questionnaire-based survey were twofold: (a) to understand more about the nature and antecedents of public perceptions of grid-scale energy storage in the UK; and (b) to investigate the comparative favourability of four different grid-scale electrical energy storage options (i.e. pumped hydro storage, compressed air energy storage, flywheels and lithium-ion batteries). This survey was a forerunner to a comparable one that is being conducted on a demographically diverse sample of the Canadian population. The longer-term aim is to investigate similarities and differences between perceptions within the UK and Canadian samples.

2. Methods

2.1. Participants

A broadly representative sample of the UK adult population (in terms of age and gender distribution) was recruited via an online survey-platform provider. A total of N=1,044 eligible respondents completed the survey. Eligibility was determined by: (a) being an UK resident; (b) stating a willingness to provide good answers; and (c) appropriately completing all survey questions. See Table 1 for key demographics of the sample.

2.2. Materials & Procedure

The questionnaire-based survey comprised six key sections, plus an introduction and debrief. The introduction section provided an outline of the purpose of the survey and relevant ethics and consent statements. The debrief identified that there were different framing conditions built into the survey (Section 2.2.2) and provided links to websites where respondents could learn more about ESTs. The following summarizes the six key question sections:

2.2.1. Demographics: Respondents provided their age; gender; current level of education; employment status; and political preference. All response options were categorical except political preference which was made on a 10-point sliding scale (1 = very left wing; 10 = very right wing).

2.2.2. Introductory EST information: Respondents received a passage of written text (282 words) which briefly introduced energy storage and outlined the survey's focus on grid-scale electrical storage. Pictures of the four target technologies (i.e. pumped hydro, lithium-ion batteries, compressed air energy storage and flywheels) were provided. Respondents were then distributed to one of four 'framing' conditions, where they received further information (296-338 words) about energy storage in the context of promoting either: (1) environmental sustainability; (2) energy security; (3) technological innovation; or (4) economic development. A fifth 'control' condition was also included where respondents received no further information about ESTs. The results of this framing manipulation do not constitute part of the current analysis and so all analyses are conducted on the full sample.

Respondents were then asked to rate the quality of the information received on five scales: understandability, balance, quality, sufficiency and trustworthiness (1 = strongly disagree; 5 = strongly agree + don't know [DK]).

Table 1. Key demographic details of the sample (*N*=1,044)

		%			%
Age (years)	18-24	10	Occupation status	Employed[2]	58.3
	25-34	17.8		Retired	16.3
	35-49	26.9		Homemaker	8.8
	50-64	26.0		Student	5.5
	65+	19.3		Other[3]	11.4
Gender	Male	45.6	Education status	≤ Secondary School	34.2
	Female	53.9		College degree	25.6
	Other[1]	0.5		Undergraduate degree	25.7
				Postgraduate degree	11.8
	Mean	SD		Other	2.8
Political preference	5.29	1.95			

[1]Other: *n*=4 'other'; *n*=1 'prefer not to say'
[2]Employed: Full/Part/Self-employed & military
[3]Other: Out of work/unable to work & other

2.2.3. Initial attitudes towards ESTs: Respondents stated whether they had heard of ESTs prior to the survey (Yes/No/Not Sure); where they first heard of the energy storage (eight categories: e.g. television, friend or relative, print newspapers, etc.) and listed their self-claimed knowledge of ESTs (1 = nothing at all; 5 = a great deal).

Respondents then registered the extent to which they (dis-)agreed with a number of purported issues with the UK electricity network (i.e. beliefs that it is: environmental unsustainable; insecure and unreliable; old and outdated; restricting to economic growth; and costly for consumers) before registering the extent to which they (dis-)agreed that ESTs could contribute to resolving each of these issues (1 = strongly disagree; 5 = strongly agree + DK). The section ended with a series of seven questions designed to assess various components of respondents' 'global attitude' to energy storage and attitude certainty (1 = strongly agree; 5 = strongly disagree + DK) (Cronbach's $\alpha = .75$, excluding attitude certainty, reverse coding of items 2 and 6):

- All things considered, I believe that the use of ESTs in the UK is a good thing
- Overall, I just feel uneasy about the use of ESTs in the UK electricity network
- I believe that the use of ESTs in the UK is necessary for the future of the electricity network
- I am happy that people are willing to invest financially in ESTs for the UK electricity network
- I would generally accept the installation of an energy storage facility within a mile of my home
- All things considered, I feel there are more risks than benefits to using ESTs in the UK electricity network
- I am certain of my opinions about the use of ESTs in the UK electricity network

A series of five questions also assessed respondents' newspaper readership (e.g. favoured newspapers) and beliefs about the representation of ESTs in the media, however, these are not considered further within the current article.

2.2.4. 'Flashcard' EST information & questions: Respondents received four pre-prepared 'flashcards' relating to each of the four target technologies presented in a randomized order (see Fig. A1, Appendix A, for an example of the flashcards used). These flashcards contained written information describing how the EST works, pictures of the technology, a statement regarding its commercial status and an assessment of the technology in fulfilling three functions: (1) maintaining power quality; (2) providing bridging power; and (3) contributing to energy management. Definitions of these services were provided and the ratings were based on U.S. Department of Energy data.

Following presentation of all flashcards, respondents assessed the quality of the information (as in Section 2) before registering their attitude towards each of technologies (1 = very unfavourable; 10 very favourable) and being asked to select (forced choice, incl. 'none') which technology they would favour for use in the UK. Respondents were also asked the extent to which they relied on each facet of the 'flashcards' (e.g. power quality rating, general description) when reaching their opinions about the ESTs (1 = strongly disagree; 5 = strongly agree + DK).

2.2.5. Intentions to support ESTs: A series of 32 items then assessed respondents': (1) intentions to support ESTs (e.g. "I am willing to support the use of ESTs in the UK"); (2) social norms (e.g. "I think that there is general support among the UK public for the use of ESTs"); (3) self-efficacy (e.g. "I believe that the general UK public have the ability to influence decisions regarding the use of ESTs"); (4) positive affect (e.g. "For me, using ESTs in the UK just feels right"); (5) negative affect (e.g. "I feel worried about the use of ESTs in the UK"); (6) personal and societal benefits (e.g. "For me, the use of ESTs in the UK holds benefits"); (7) personal and societal risks (e.g. "I believe that the use of ESTs in the UK holds risks for the natural environment"); (8) financial costs (e.g. "I believe that financial investment in ESTs for use in the UK is justified"); (9) trust in developers (e.g. "I trust that the people responsible for the use of ESTs in the UK know what they are doing"). All responses were made on a 5-point scale (1 = strongly disagree; 5 = strongly agree + DK) for a full list of the items and scale reliabilities, see Appendix B. The section ended with respondents re-completing the 'global attitude' questions (as in Section 2.2.3) (Cronbach's $\alpha = .79$).

2.2.6. Personality characteristics: A final section assessed respondents' environmental values (5 items: e.g. "The balance of nature is delicate and easily upset") (from (13)) and 'green' identity (4 items: e.g. "I think of myself as an environmentally friendly person") (14) (1 = strongly disagree; 5 = strongly agree); and their energy security concern (6 items: "To what extent are you concerned that in the future energy will become unaffordable") (15) and their concern with the societal and the personal impacts of climate change (1 = not at all; 4 = very concerned + DK).

3. Results

3.1. Problem perception

One-sample *t*-tests (vs. scale midpoint) revealed that respondents generally *agreed* that the UK electricity system was costly for consumers, environmentally unsustainable, old and outdated and restrictive to economic growth, $ts \geq 6.39$, $ps < .001$. They were *undecided* on whether the system was insecure and unreliable, $t\,(976) = 0.40$, $p = .687$. On average though, the respondents agreed that ESTs could play a role in resolving all of the issues. Bivariate (Pearson) correlational analysis confirmed that there were significant, weak, positive correlations between respondents' perceptions of the various problems and the perceived role that ESTs could play in resolving them. See Table 2 for the relevant means and significance values relating to these analyses.

Table 2. Mean evaluations of UK electricity network problems and the perceived role of ESTs in resolving these problems.

Problem	Mean evaluation of problem (SD)[a]	Sig. (*p*)	Mean evaluation of EST in resolving problem (SD)[a]	Sig. (*p*)	Correlation (*r*)[b]	Sig. (*p*)
Costly for consumers	3.87 (0.86)	< .001	3.43 (0.90)	< .001	.196	< .001
Environmentally unsustainable	3.54 (1.03)	< .001	3.49 (1.04)	< .001	.223	< .001
Old and outdated	3.45 (0.95)	< .001	3.28 (1.16)	< .001	.240	< .001
Restrictive to economic growth	3.20 (0.95)	< .001	3.35 (0.96)	< .001	.340	< .001
Insecure and unreliable	3.01 (1.03)	= .687	3.36 (0.99)	< .001	.222	< .001

[a] Means compared against the scale midpoint (3.0). [b] Correlations = pairwise deletion.

3.2. Attitudes towards individual ESTs

Respondents were favourable to all the EST options presented (see Fig. 1a). One-sample *t*-tests confirmed that the mean attitudes of all four options were significantly greater than the hypothetical mid-point of the scale, $ts \geq 6.91$, $ps < .001$. Repeated measures ANOVA revealed significant differences in the relative favourability for each option, F (3, 1041) = 47.38, $p < .001$. The mean favourability of pumped hydroelectricity was significantly greater than for all other options (Mean $_{\text{Diffs.}} \geq .52$, $ps < .001$). Of the other technologies, lithium-ion batteries were preferred to compressed air (Mean $_{\text{Diff.}} = .15$, $p = .039$) but comparable to flywheels (Mean $_{\text{Diff.}} = .04$, $p = .525$). Flywheels were marginally preferred to compressed air energy storage (Mean $_{\text{Diff.}} = .06$, $p = .052$).

These opinions were broadly echoed in responses to the forced preference question (see Fig. 1b). Pumped hydroelectricity was again the most favoured, followed by lithium-ion batteries. There was a reversal in the relative preferences for compressed air vs. flywheels (although both were not particularly favoured options). Only a minority of respondents were found to prefer no deployment of ESTs in the UK.

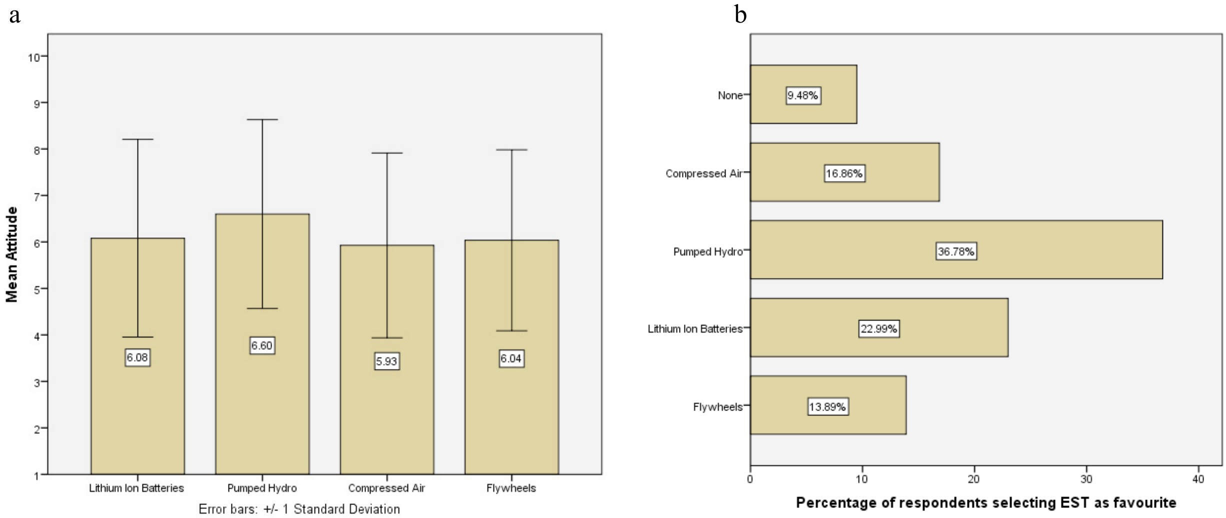

Fig. 1. (a) mean attitudes towards each of the four ESTs (1 = very unfavourable; 10 = very favourable); (b) percentage of people selecting each EST as their favoured option for use in the UK (forced choice, including 'none' option).
Notes: Scale mid-point for Fig. 1a = 5.50; Chance preference responding in Fig. 1b = 20%

3.3. Explaining the variance in intentions to support EST deployment in the UK

Multiple linear regression (MLR) analysis using pairwise deletion was used to explain the variance in respondents' intentions to support the deployment of ESTs in the UK. A total of 14 independent variables were entered as predictors in the model. These included key person characteristics (i.e. environmental values, environmental identity, self-claimed awareness of energy storage) and key constructs from the comprehensive model of technology acceptance (16) (i.e. social norms; self-efficacy; perceived benefits, risks and financial costs; trust in developers; positive and negative affect; global attitude [at time 2]) a composite measure of problem perception was also included.[2]

The regression model explained 74% of the variance in intentions, $R^2_{adj.} = .739$, F (14, 851) = 176.03, $p < .001$. Reference to the standardized coefficients showed that positive affect (beta = .33, $t = 10.93$, $p < .001$); attitude (beta

[2] Where relevant, internal reliability analysis (Cronbach's alpha) was used to ensure that it was feasible to form composite measures of each variable. These analyses revealed that the two financial cost items should be treated independently. One *behavioural intention* item and one *social norm* item were discounted from the analysis on this basis. Correlational analysis was also used to ensure that each predictor correlated significantly with behavioural intentions. Energy security concerns were not considered in the MLR due to the findings of this initial analysis. A total of n=17 outlying respondents were removed from the analysis.

= .25, $t = 6.13$, $p < .001$); self-claimed awareness (beta = -.07, $t = 4.13$, $p < .001$); benefit (beta = 5.63, $p < .001$); belief that investment in ESTs is justified (beta = .09, $t = 3.16$, $p = .002$); trust in developers (beta = .07, $t = 3.12$, $p = .002$) and environmental values (beta = -.05, $t = 2.25$, $p = .025$) were retained as significant predictors. The relationship between problem perception and intention was marginally statistically significant (beta = .04, $t = 4.13$, $p = .058$).

In summary, greater intentions to support the use of ESTs was shown among those who had stronger positive attitudes and positive affective responses to the technology; perceived there to be more general benefits and held more trust in developers of the technology; who saw investment in the technology to be warranted and who claimed to have awareness of ESTs upon commencing the survey. There was also a marginal tendency for those who saw the problems with the UK electricity network to intend to support ESTs. Crucially, respondents with stronger pro-environmental values were significantly less likely to intend to support the introduction of ESTs in the UK.

4. Discussion

In recognition of the influence that lay-publics can have on the fate of energy technologies, the aims of this study were to investigate: (a) the nature and antecedents of public perceptions of grid-scale electrical energy storage in the UK; and (b) the comparative favourability of four grid-scale electrical energy storage options (i.e. pumped hydro storage, compressed air energy storage, flywheels and lithium-ion batteries). This study constitutes one of the first (if not *the* first) to formally investigate lay-public comparative preferences for such energy storage in the UK.

Overall, respondents were positive towards energy storage in general and towards the four distinct ESTs examined within the survey. Moreover, there was a sense that energy storage *could* assist with a number of potential problems with the electricity network in the UK (although the relationships were relatively weak). Crucially, respondents were not equally favourable to all EST options. On two separate measures (one assessing individual preferences for each EST option and the other 'forced choice' measure) respondents showed a significant preference for pumped hydro storage. A number of potential explanations exist to explain this preference, which should be investigated in future research. For instance, it could be a product of perceived familiarity with the technology (or hydroelectricity more generally) or relate to a belief that pumped hydro storage is a somewhat more 'natural' solution to the issue of energy storage than the other options.

The results of the regression analysis shed light on the factors shaping respondents' general intentions to support the deployment of energy storage in the UK. To the extent that our respondents were positive about the technology, it is unsurprising that our measures of attitude and positive affect, as well as the perceived benefits of this technology (including a sense that investment in ESTs would be money well spent) shared direct relationships with intentions. Notably, there was a strong degree of multicollinearity among the attitude, benefit and positive affect variables (r = .72 to r = .82). While this finding is logical – as perceived benefits, costs and affect underpin attitudes – clarifying the nature of these relationships within the current context could be important. For example, the correlation between our measures of positive affect and attitude could be indicative of the respondents utilising an *affect heuristic* when forming opinions of energy storage (17). Reliance on affect (i.e. whether or not something *feels* good or bad) is found to be common when making judgements about unfamiliar things. This suggestion would also be congruent with the retention of *trust in developers* as a predictor of intentions within our study. Like the affect heuristic, trust is often used as a heuristic when making judgements under conditions of uncertainty or unfamiliarity (18).

Interestingly, one of the key findings from the regression analysis was that biospheric values shared a negative relationship with intentions to support energy storage. While on the surface this result might appear surprising – being that ESTs are a means of fostering the integration of renewables into the national electricity network – it could equally be seen as logical where investment in energy storage is viewed as an undesirable techno-fix to an important environmental issue (19). This hypothesis is, however, tentative and requires further investigation.

Overall, this article provides some initial insight into the results of a large national survey of lay-public opinion of energy storage in the UK. By elucidating more about the nature and antecedents of public opinion, the findings could have evident implications for policy makers and proponents of ESTs. For example, the findings could be used in the design and delivery of communication and engagement materials relating to the technologies. The next steps for the research are to: (a) engage in further modelling of the nature and strength of the identified relationships; (b) compare and contrast the findings from the UK sample with the sample currently being recruited in Canada; and (c) investigate further questions arising from this research (e.g. the influence of framing on respondents' preferences).

Acknowledgements

This research was funded by a University of Surrey, Faculty of Health and Medical Sciences, FRSF standard grant. The involvement of the second, third and fourth authors was supported by the Natural Sciences and Engineering Research Council of Canada (NSERC) as part of the NSERC Energy Storage Technology Network (NEST).

Appendix A. Example EST Flashcard

Pictured below (Fig. A1) is an example 'flashcard' used within the survey. These flashcards (presented in a randomized order) provided respondents with information about the four technologies (i.e. pumped hydro, compressed air energy storage, flywheels and lithium-ion batteries) of interest to the study. The intent was to allow respondents to better understand the technologies (and their relative strengths in providing three energy storage services) before being asked questions. This was done to help combat the likelihood of registering pseudo-opinions (20) within the survey.

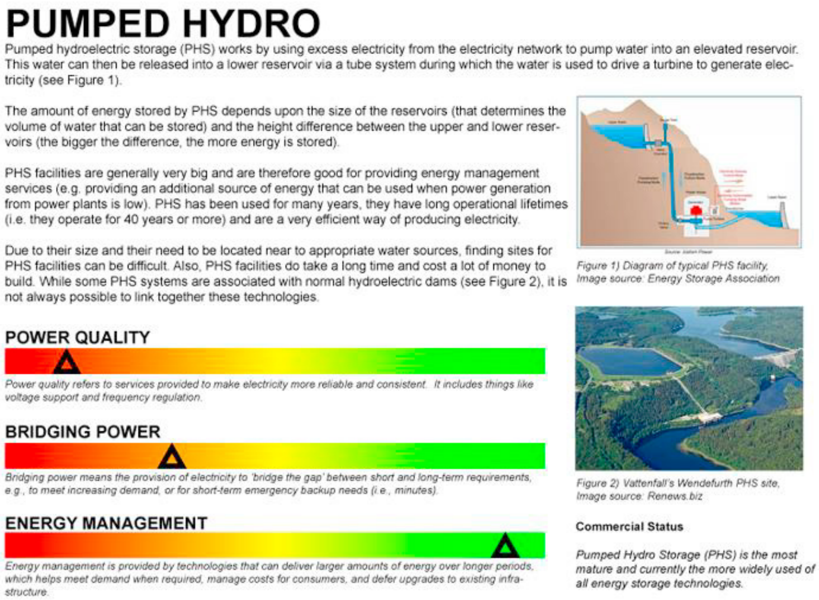

Fig. A1. (a) Information 'flashcard' for Pumped Hydro Storage

Appendix B. Technology Acceptance Items

Details of the 32 items (presented in a broadly random order) used to help profile the factors affecting respondents' general perceptions of energy storage are listed below. All responses were made on 5-point scale (1 = strongly disagree; 5 = strongly agree + DK). Cronbach's alpha was used to assess the internal reliability of the items relating to each construct. *Notes: ® = reverse coded item; * = item removed from scale following reliability analysis.*

B.1. Intention: (1) I am willing to support the use of ESTs in the UK; (2) I would not intend to support the use of ESTs in the UK if asked ®*; (3) If asked, I would actively endorse the use of ESTs in the UK (Scale: 3 items α = .66; 2 items α = .76).

B.2. Social Norm: (1) I believe that people who are important to me think that the use of ESTs in the UK is a good thing; (2) I think that there is general support among the UK public for the use of ESTs; (3) I think that people in the UK are generally not supportive of the use of ESTs ®* (Scale: 3 items α = .41; 2 items α = .63).

B.3. Self-efficacy/Perceived Behavioural Control: (1) I do not feel that I have the power to influence decisions being made about the use of ESTs in the UK ®; (2) I believe that if I wanted to, I could personally affect decisions being made about the use of ESTs in the UK; (3) I believe that the general UK public have the ability to influence decisions regarding the use of ESTs (Scale: 3 items α = .65).

B.4. Cost: (1) I believe that the financial investment in ESTs could be better spent on improving the UK electricity network in other ways ®; (2) I believe that financial investment in ESTs for use in the UK is justified (*Items treated separately within analysis*).

B.5. Risk: (1) I feel that there are risks to public health and safety from the use of ESTs in the UK; (2) I feel that there are health and safety risks for me and my family from the use of ESTs in the UK; (3) I believe that there could be personal financial risks associated with the use of ESTs in the UK; (4) I believe that the use of ESTs in the UK holds risks for the natural environment; (5) I believe that there are financial risks to the use of ESTs in the UK (Scale: 5 items α = .85).

B.6. Benefits: (1) For me, the use of ESTs has benefits for ensuring a secure electricity supply for 'end users' in the UK; (2) I believe that ESTs stand to have a positive effect on supporting the electricity network in the UK; (3) For me, the use of ESTs in the UK holds benefits for the national economy; (4) For me, the use of ESTs in the UK holds benefits for advancing technological innovation in the UK; (5) I do not believe that ESTs stand to have a positive impact on issues within the UK electricity network ®; (6) For me, the use of ESTs in the UK holds benefits for the national economy (*repeated item*); (7) For me, there are environmental benefits to the use of ESTs in the UK (Scale: 7 items α = .86).

B.7. Positive Affect: (1) For me, using ESTs in the UK just feels right; (2) I just feel good about the use of ESTs in the UK (Scale: 2 items α = .80).

B.8. Negative Affect: (1) I feel worried about the use of ESTs in the UK; (2) For me, using ESTs in the UK just feels wrong. (3) I feel worried about the use of ESTs in the UK (*repeated item*) (Scale: 3 items α = .88).

B.9. Trust in developers: (1) I trust that the people responsible for the use of ESTs in the UK know what they are doing; (2) I trust that the people responsible for the use of ESTs in the UK have the public's interests at heart; (3) I trust that I would be properly consulted should an EST be proposed to be sited near my home; (4) I trust that the people responsible for the use of ESTs in the UK will locate them fairly across the nation (Scale: 4 items α = .81).

References

1. Ould Amrouche S, Rekioua D, Rekioua T, Bacha S. Overview of energy storage in renewable energy systems. Int J Hydrogen Energy [Internet]. 2016 Dec;41(45):20914–27. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0360319916309478
2. Aneke M, Wang M. Energy storage technologies and real life applications – A state of the art review. Appl Energy [Internet]. 2016 Oct;179:350–77. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0306261916308728
3. Luo X, Wang J, Dooner M, Clarke J. Overview of current development in electrical energy storage technologies and the application potential in power system operation. Appl Energy [Internet]. 2015 Jan;137:511–36. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0306261914010290
4. Barbour E, Wilson IAG, Radcliffe J, Ding Y, Li Y. A review of pumped hydro energy storage development in significant international electricity markets. Renew Sustain Energy Rev [Internet]. 2016 Aug;61:421–32. Available from: http://linkinghub.elsevier.com/retrieve/pii/S1364032116300363
5. Rappaport RD, Miles J. Cloud energy storage for grid scale applications in the UK. Energy Policy [Internet]. 2017 Oct;109:609–22. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0301421517304743
6. Wüstenhagen R, Wolsink M, Bürer MJ. Social acceptance of renewable energy innovation: An introduction to the concept. Energy Policy. 2007;35(5):2683–91.
7. Sovacool BK, Lakshmi Ratan P. Conceptualizing the acceptance of wind and solar electricity. Renew Sustain Energy Rev [Internet].

2012 Sep;16(7):5268–79. Available from: http://linkinghub.elsevier.com/retrieve/pii/S1364032112003231

8. Jones CR, Olfe-Kräutlein B, Naims H, Armstrong K. The Social Acceptance of Carbon Dioxide Utilisation: A Review and Research Agenda. Front Energy Res [Internet]. 2017 Jun 9;5. Available from: http://journal.frontiersin.org/article/10.3389/fenrg.2017.00011/full
9. Batel S, Devine-Wright P, Tangeland T. Social acceptance of low carbon energy and associated infrastructures: A critical discussion. Energy Policy [Internet]. 2013 Jul;58:1–5. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0301421513001729
10. Devine-Wright P, Batel S, Aas O, Sovacool B, Labelle MC, Ruud A. A conceptual framework for understanding the social acceptance of energy infrastructure: Insights from energy storage. Energy Policy [Internet]. 2017 Aug;107:27–31. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0301421517302458
11. Lucht J. Public Acceptance of Plant Biotechnology and GM Crops. Viruses [Internet]. 2015 Jul 30;7(8):4254–81. Available from: http://www.mdpi.com/1999-4915/7/8/2819
12. Kontogianni A, Tourkolias C, Skourtos M, Damigos D. Planning globally, protesting locally: Patterns in community perceptions towards the installation of wind farms. Renew Energy [Internet]. 2014 Jun;66:170–7. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0960148113006629
13. Dunlap RE, Van Liere KD, Mertig AG, Jones RE. New Trends in Measuring Environmental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale. J Soc Issues [Internet]. 2000 Jan;56(3):425–42. Available from: http://doi.wiley.com/10.1111/0022-4537.00176
14. Whitmarsh L, O'Neill S. Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours. J Environ Psychol [Internet]. 2010 Sep;30(3):305–14. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0272494410000046
15. Corner A, Venables D, Spence A, Poortinga W, Demski C, Pidgeon N. Nuclear power, climate change and energy security: Exploring British public attitudes. Energy Policy [Internet]. 2011 Sep;39(9):4823–33. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0301421511004939
16. Huijts NMA, Molin EJE, Steg L. Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. Renew Sustain Energy Rev [Internet]. 2012 Jan;16(1):525–31. Available from: http://linkinghub.elsevier.com/retrieve/pii/S136403211100428X
17. Slovic P, Finucane ML, Peters E, MacGregor DG. The affect heuristic. Eur J Oper Res [Internet]. 2007 Mar;177(3):1333–52. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0377221705003577
18. Siegrist M, Cvetkovich G. Perception of Hazards: The Role of Social Trust and Knowledge. Risk Anal [Internet]. 2000 Oct;20(5):713–20. Available from: http://doi.wiley.com/10.1111/0272-4332.205064
19. Huesemann M, Huesemann J. Techno-Fix: Why Technology Won't Save Us Or the Environment. Gabriola, BC V0R 1X7, Canada: New Society Publishers; 2011.
20. Bishop GF, Oldendick RW, Tuchfarber AJ, Bennett SE. Pseudo-Opinions on Public Affairs. Public Opin Q [Internet]. 1980;44(2):198. Available from: https://academic.oup.com/poq/article-lookup/doi/10.1086/268584