
Article:
Hall, S orcid.org/0000-0002-1558-7081, Anable, J orcid.org/0000-0002-4259-1641, Hardy, J et al. (3 more authors) (2021) Matching consumer segments to innovative utility business models. Nature Energy, 6 (1). pp. 349-361. ISSN 2058-7546

https://doi.org/10.1038/s41560-021-00781-1

Matching consumer segments to innovative utility business models

Authors: Stephen Hall*, Jillian Anable (1), Jeffrey Hardy (2), Mark Workman (3), Christoph Mazur (4), Yvonne Matthews (5),

*Corresponding Author: Dr Stephen Hall, s.hall@leeds.ac.uk: Sustainability Research Institute, School of Earth and Environment, University of Leeds, UK, LS2 9JT

1 Institute for Transport Studies, University of Leeds, UK, LS2 9JT

2 Grantham Institute, Imperial College London,

3 Energy Futures Lab, Faculty of Engineering, Imperial College London

4 Chemical Engineering Department, Imperial College London,

5 Independent researcher, Waikato, New Zealand

Abstract

Energy as a service, smart home opportunities, and electrification of heat and transport, can lead to new ways of switching supplier or choosing new energy contracts. Here we used business model collaboration workshops to create 'archetypes' of new utility business models that were then tested with a representative sample of British energy consumers to explore their attractiveness to different segments of society. We show that some of these segments have a substantial appetite for new business models. However, the segments that choose these models are more likely affluent, educated homeowners. Without intervention, innovation in utility business models risks exacerbating existing social inequalities, as lower incomes, lower home ownership, and low education, result in lower preferences for, or no ability to engage with, new utility business models. We also find that institutional trust beyond the energy sector is a key driver of consumer segmentation.

The energy companies that domestic consumers choose in competitive markets affects energy transitions[1,2,]. Energy utilities have adopted a 'volume sale' business model to reduce costs and attract consumers[3,4,5,6,7]. This incumbent business model is threatened by low-carbon transitions[8,9], because large renewables reduce the profitability of legacy fossil plant[10], prosumers and microgeneration reduce predictability and volume sales[6,11], more suppliers are entering the market[7,12], and more flexible demand competes with traditional plant for flexibility services [13]. These pressures are forcing the volume sale model to change and adapt to survive the energy transition[14].

The changes utilities make to survive in low-carbon transitions can also change the consumer energy contract[15]. New consumer contracts are emerging that integrate decentralised renewables[9,16], move to 'energy as a service' as opposed to 'pay per kilowatt' tariffs[17,18], and reward consumer behaviour change[19,20,21]. The energy transition in liberalised markets is shaped by these trends[22]. However little has been done to understand consumer preferences for these new business models and how these consumer preferences could affect the transition.

Most research on consumer preferences in energy retail markets relates to switching suppliers[23]. This work shows that consumers do not respond well to price signals, and the number of households who enter the market to find a better deal is lower than regulators would hope or economists predict [24,25,26. 27]. Recent research has turned to behavioural economics[28] to explain these trends. Behavioural economics recognises consumers are not perfectly rational; they operate in dynamic markets, where options are too complex to fully process[29].

This complexity leads consumers to adopt 'satisficing' over 'optimising' behaviour. Satisficing behaviour aims at satisfactory levels of performance given existing resources and imperfect information[30]. There is strong evidence that consumers are satisficing in their choice of energy supplier [31,32,33]. Consumers are likely to make decisions based on simplification strategies that reduce the complexity of decision making and fall back on heuristics such as trust in institutions to distinguish between options[34,35]. Consumers also exhibit status quo bias and loss aversion behaviour in making energy choices[36]. This satisficing behaviour comes at a price however, as even consumers on the poorest energy contracts report high confidence they are on the best deal for them, and report high trust in their current supplier[23].

Consumer satisficing is problematic enough when consumers are choosing between contracts competing only on price. This problem may be compounded if consumers are being asked to choose between diverse contracts created by utility business model innovation. Yet there has been little work to explore the types of utility energy contracts consumers are likely to opt for when presented with a range of possible offers. This is the problem we address in this study. We explicitly assume both the utility companies and their consumers are operating under uncertainty, both are searching for satisfactory strategies in the market and these decisions will evolve with each other to affect the direction and outcomes of energy transitions. To explore this relationship, we define the business models utilities are exploring to respond to the pressures of a low carbon transition and what contractual attributes might they offer consumers, and test how consumers respond to those new business models, and which consumers prefer which new contracts. We then use the results to explore the implications of these data on energy transitions and market regulation.

We found that utilities are developing new ways of electrifying heat and transport, servitising the energy contract, bundling energy services with other infrastructure services, and facilitating peer to peer platforms. We also identified four consumer segments with varying appetites for new utility contracts. The segment with the highest appetite for new models is also the smallest (16% of respondents), suggesting new utility business models might only have a limited niche to expand into. The other three segments face barriers to participation based on tenancy type, or income levels; or barriers to acceptance based on social trust or market engagement. Based on our segmentation we define three challenges for the energy transition. First, the potential for market innovation to stall due to the most receptive segments being relatively small and/or most likely to rent; and the most disengaged segments being most likely to own homes and have the ability to include building fabric alteration in their energy contracting. Second, there is a social trust barrier to overcome that leads to low confidence in new utility business models but also applies across other societal institutions. Finally, the culmination of these issues could lock in existing social inequalities and lock out some sectors of society from participating in low carbon transitions.

Business Model Generation

We adopted a collaborative business model innovation process[37] to explore how utility business models can evolve to meet the challenges of a low carbon transition. We followed Rohrbeck *et al*, who uses this approach to support collaborative business model generation in the German utilities sector[38]. The workshop was undertaken on June 15th 2016 with 38 industry, academic and government stakeholders. We identified 11 future utility business model 'archetypes' that responded to a hierarchy of threats to the current utility business model. We use the term 'archetype' to describe a new utility business models. Rohrbeck et al suggest collaborative business model generation is done in three stages: 1) Idea generation, 2) prioritisation and 3) validation. As this research was time constrained to a one day workshop, we used a project steering group comprising three utility executives, two infrastructure consultants and two energy financiers drawn from the Energy Research Partnership for initial 'idea generation' and took these ideas on utility business models for further development in the workshop. See Supplementary Methods for details of the workshop process.

Stage 1 prioritised the 'systemic challenges' to the incumbent utility business model (see Supplementary Figure 6). The six highest priority threats to the incumbent volume sale utility model were: 1. Policy Uncertainty, 2. Large Penetration of Intermittent Renewables, 3. Demand side management, 4. Diversifying Supply Market, 5. Cost of Capital, and 6. Increasing Micro-decentralised Optimisation.

In Stage 2 groups were asked to explore the implications of six proposed innovative utility business models designed to address these systemic challenges. These business models were visualised in component diagrams[39] The six initial business model concepts and component diagrams were generated by the project steering group and were refined and expanded by workshop participants. Figure 1 shows the resultant utility business models, Supplementary Figures 7-17 show all business models considered in the workshop.

The five business model archetypes shown in Figure 1 were derived from the workshop in June 2016 and set the business models to be researched to the middle of 2019. During this time, some of these propositions have been tested by utilities in the UK and elsewhere, none have been rendered obsolete or unlikely since their conception. Indeed new electric vehicle tariffs are beginning to enter the market[40], peer to peer trials are ongoing[41], automated switching models that show the early stages of the 'third party control' archetype are emerging[42], and bundled retrofit and energy service models are being piloted[43].

The attributes of the business models which could be presented to a consumer in a switching situation were then developed by the research team and are shown in Table 1, along with a control business model 'same but smart'.

Conceptual model development

The attributes of each business model were presented to 2,024 British residential utility bill payers in a questionnaire survey. The theoretical basis of the questionnaire design was the Technology Acceptance Model (TAM)[44]. The value of TAM, or adapted variants of it, has been demonstrated in several technology contexts including the uptake of IT services, e-commerce, and smart grids[45]. Using an adapted version of the TAM in the technology driven context of innovative utility business models is justified given that each business model involves different engagement with technologically mediated, energy 'smart' behaviour[46].

The original TAM model explains willingness to adopt a technology by two factors: perceived ease of use and perceived usefulness. Expanded versions of the TAM have found additional constructs to add explanatory power and these capture individual experience as well as beliefs about how the innovation under study would perform in relation to multiple societal factors. We ensured that our measure of perceived 'usefulness' includes specific measures of expected value for adopters of energy contracts as they involve both technology and service components[47]. The model draws upon diffusion of innovations theory by capturing notions of perceived ease of use and complexity[48] and the theories of reasoned action or planned behaviour[49]. These social-psychological theories have informed behavioural economic approaches which recognise consumers are not perfectly economically rational; they operate in dynamic markets, where choice is expanding and options are too complex to fully process[29].

Through a combination of our domain specific knowledge of energy efficiency and tariff switching behaviours within current energy markets, together with the components of trust[50] and personal innovativeness[51] both proven to enhance the TAM, we developed a conceptual framework on which to base the questionnaire design and analysis (see methods). The key constructs consist of *Experience* (current knowledge, engagement and status quo bias), *Salient Beliefs* (concern about the future, green beliefs), *Personal innovativeness* (openness to new technology), *Trust* (trust in operators and perceived risk of system use), *Perceived ease of use*, *Perceived usefulness* (including the value perceived from adopting the contracts), and *Intention* (stated likelihood to adopt).

Archetype preference

Survey participants were presented with the information in Table 1 on each archetype and were asked to score it on several semantic differential attribute scales. This exercise provided for some reflection on and assimilation of each option. Intention to adopt was measured using a 'likelihood to adopt' scale. Participants were asked: *"If this option was available today, what is the likelihood that you would sign up for it?".* Responses were made using a sliding scale from 0 (not at all likely) to 1 (Very likely), which was then banded to create a 3-point scale (likely, neutral, unlikely). Figure 2 shows the control case 'Same but Smart' (see Table 1) performed best, followed by 'Peer-to-peer' with 'Energy Service Company' showing lowest overall attractiveness.

Consumer segments

We then identified energy consumer segments based on their likelihood of adopting the new energy contracts. Segmentation studies have been used to identify different types of consumer in relation to household electricity storage[52], acceptance of demand control[53], energy conservation behaviours[54], or acceptance of smart grids. Some studies have used measured or metered consumption data combined with only basic household and building characteristics to identify groups of energy consuming households[55]. Others use a richer suite of variables based on qualitative surveys and constructs from behavioural psychology to capture the psychosocial antecedents of likely market acceptance and targets for behaviour change[56]. The bases used to cluster the sample populations in these studies are multifarious, ranging among general values, lifestyles, general

patterns of energy consuming behaviours, attitudes to environmental issues, and specific energy related behaviours. Some focus the clustering on the antecedents of behaviour only[45], others mix both the antecedents and the intentions or behaviours themselves**Error! Bookmark not defined.** as we have done here.

The cluster analysis identified four groups individually representing between 16% and 35% of the sample. The groups were profiled using the variables used to create them as well as other factors such as demographic characteristics and current energy use. Profiling consists of characterising each segment individually using descriptive statistics as well as in comparison to the other segments using measures of variance and association. Each of these segments was given a short name and a representative narrative statement (Figure 3).

Segment archetype preferences

In a paired comparison task, respondents were forced to choose one or the other archetype in each of the ten paired cases (order randomized). Each archetype was presented using the short paragraph in Table 1, with two paragraphs displayed side by side. Whilst this method means that the key attributes are less directly comparable than can be the case with some forms of conjoint analysis, it was designed to promote engagement with the task by requiring identification and consideration of salient characteristics of each business model.

Figure 4 shows the number of times each business model was chosen as a proportion of the number of times it was available to be chosen (out of 4 eligible times for each archetype for each person). This is the unweighted probability which shows that there was a statistically significant difference between at least two of the segments for all but the New Electrifier archetype. Table 2 provides these probability variables weighted by the stated 'likelihood to adopt' score to account for the fact that the paired comparison exercise forces people to make a decision of some kind. Here there are differences between at least two of the segments on all of the archetypes. This shows that some segments are more discriminating across the archetypes than others.

The status quo option (SBS) is the standout preference of three of the segments although *Engaged but Cautious* are still significantly more likely than all other groups to choose this option. This segment demonstrates the joint-highest tendency to switch utility providers now and have achieved high levels of satisfaction and engagement by doing so. They therefore represent an engaged and informed group of consumers, but do not perceive the current system to be problematic enough to need to change.

P2P stands out as being the second most favourable option for three out of four of these groups. The *Aspiring Opt-Outs* are the most enthusiastic about this archetype (and the least in favour of the ESC), motivated by a chance to break free from large utility companies and to achieve greater cost savings.

Although the differences in preference for the NE archetype are less strong and more dependent on which measurement of likelihood to adopt that we use, this option is nevertheless consistently perceived more favourably than ESC for all but the *Pragmatic Innovators* for whom it is no more or less acceptable than any other. The long contract term involved in the ESC seems to be off-putting to both those who are less trusting of large energy suppliers (*Unconvinced & Unmotivated* or *Aspiring Opt-Outs*) or those who are more trusting but still want to take some control and look for the best deals when they can (*Engaged but Cautious* or *Pragmatic Innovators*).

The *Pragmatic Innovators* have the highest appetite for new types of contract overall, although they have a lower tendency than the other three groups for the P2P solution. This segment is already markedly more likely to have adopted new technology such as solar PV or electric vehicles and express great faith in scientific and technological solutions. However, they are shown to have greater levels of trust in larger companies than all the other segments, and feel less convinced that there are large financial savings to be made from choices about energy suppliers. This might explain why the greater level of 'hands on' decision making involved in P2P is not regarded as so necessary to overcome trust and financial issues as the *Aspiring Opt-Outs* or even the *Unconvinced and Unmotivateds*. Whilst the *Unconvinced & Unmotivateds* appear marginally more receptive to this option than both the *Engaged but Cautious* and the *Pragmatic Innovators*, when the scores are weighted by the stated likelihood to adopt (Table 2), their tendency to say they are unlikely to adopt any of the models means they are the least enthusiastic for all the options.

Demographic, experiential and attitudinal characteristics

Table 2 displays characteristic variables for each segment, organised by the constructs of the conceptual model in addition to some demographic variables which were not used in the segmentation. Figure 5 focusses on one construct that proved to be one of the strongest predictors of segment membership. Out of the 23 predictor variables of the segments identified using discriminant analysis, 'Trust in existing supplier' is ranked fifth, and in 'other suppliers' ranked sixth. Figure 5 shows further differences between the segments on trust of additional societal institutions using a question that has been used to understand comparative switching behaviour in a number of different markets and to set this in context of a person's general trust tendency[57]. In Table 3, we bring together the analysis of all of the characteristics to provide a brief summary profile of each segment and the implications for energy market transitions.

Discussion

These data show that there is some consumer demand for innovative retail energy contracts. Although it is clear that the business archetype which represents only an incremental change from the status quo (SBS) has proven the most popular, there are clear indications that different consumers would be attracted to some other types of contractual relationships. Even the least innovative segment in our sample (*Engaged but Cautious*) rejects the SBS model 15% of the time, rising to 45% for the most innovative segment (*Pragmatic Innovators*). These show some desire for tying in new services, appliances, and even building works into an energy bill. This goes well beyond what energy retail market regulation was initially designed to achieve[59].

As flexible tariffs, home retrofit/appliance bundles, and potential Peer-to-peer trading are all now technically possible[58], and these data show they each can find a compatible consumer segment, there is substantial potential for market disruption.

Given the UK retail market already experiences regulatory challenges from expanding conventional competition [59,] this latent demand for innovative business models complicates the regulatory task further and invites a policy and regulatory response. From this data we extract three challenges:

Pragmatic Innovators show a high preference for two utility business model archetypes that are radical departures from the current utility model 'Energy Service Company' and 'Third Party Control'. Importantly, the two segments with above average owner occupation status (Engaged but Cautious (66% owned outright or mortgaged) and Unconvinced & Unmotivated (72%)) are the least likely to choose the two archetypes that require alterations to building fabric, i.e. Energy Service Company and Third Party Control. This is a problem when these business models rely on changes to the building fabric which are paid for by long term energy bill savings. UK housing tenure trends show a reduction in owner occupation and in increase in private rented tenure[60]. This is especially true for younger demographics (op cit). Since both *Pragmatic Innovators* and *Aspiring Opt-Outs* are younger than the average in the sample, and of below average or decreasing likelihood of owning their own home, this means there is a disconnect between the segments that find such business models attractive and their ability to sign up to them when in rented tenure.

For '*Aspiring Opt-Outs'*, who are younger, lower income, and likely renting, the opportunity to benefit from their preferred archetype of 'Peer-to-peer' may be limited as they are least likely to have their own microgeneration to trade. With an average of 36% of the whole study sample in rented tenure there is a large proportion of consumers unable to access many of the benefits of new utility energy contracts.

Trust in one's own and other suppliers is a significant driver of segment membership. However it may not be trust in the utilities alone that drives segments to prefer different business models, but also trust across societal institutions. Other recent work has pointed to the role of trust and legitimacy between consumers and the evolving retail energy market[61]. However the data reported here show remarkably consistent trust scores across societal institutions by segment, in sectors as diverse as broadband provision, insurance, banks, and car manufacturers.

While societal legitimacy and institutional trust is important for energy transitions[62], this work shows that the sector may make more progress on business model innovation by targeting segments that already trust the system, than working to change the perceptions of *Aspiring Opt-Outs* or

Unconvinced and Unmotivated consumers. The low trust levels displayed by these segments may be relatively fixed across institutions, resistant to trust messages from the energy community, and not entirely unfounded, given the Competition and Markets Authority found UK utilities were serially overcharging less engaged consumers by hundreds of pounds per year[7].

We may expect utilities to focus new tariffs and services towards *Pragmatic Innovators* and *Aspiring Opt-Outs*, which make up 43% of the sample and are much more likely to choose a new type of utility business model in a future switching decision. Further investigation of the Pragmatic Innovators shows they are also amenable to direct load control of appliances and most likely to already have or to purchase a plug-in electric car in the next 10 years. This segment also reports the highest income; these segments find this innovation most attractive and are likely to have the highest ability and desire to purchase smart, flexible appliances and vehicles first. Therefore, to mitigate the risk that the monetary benefits of flexible electricity tariffs are most likely to be captured by higher income groups, groups such as the *Aspiring Opt-Outs* who also desire flexibility and autonomy but more specifically in order to manage their more limited income more freely, need to be targeted directly and given the means to act on their preferences. This segment expresses the greatest preference for the Peer-to-peer archetype yet has the least understanding of current bills, lowest trust scores, and lowest incomes. This highlights a particular risk as Peer-to-peer offers may only be beneficial to flexible, active consumers or those with microgeneration to trade. While the current energy market suffers from inequitable outcomes for unengaged consumers, the types of utility business model innovation explored here may only risk entrenching poor distributional outcomes.

Here we have shown that some consumers do want the types of business model being developed by utilities in response to the pressures of existing low carbon energy policy. While the entry of these new types of contractual relation into the energy market may be disruptive by itself, it also poses at least three specific challenges to the UK sector, which under similar demographics and market conditions may be present in other liberalised, decarbonising power sectors. First, there is the potential for market innovation to stall due to the most receptive segments being most likely to rent, and the most disengaged segments being most likely to own homes and have the power to opt for contracts that include building alteration. Second, there is a social trust barrier to overcome in the energy sector with low confidence across societal institutions for some segments. Finally, there is a real risk that the culmination of these issues could lock out some sectors of society, including low income, low information, and renting demographics, from participating in low carbon transitions. As the market diversifies and contracts become more complex, consumers may rely even more on heuristics to make decisions, introducing more complex consumer risks. The challenge for regulatory institutions, is to recognise these risks and evolve the regulatory model of the retail market.

Methods

Survey design

The research aim for the questionnaire was to elicit the preferences of domestic energy consumers across a set of business archetypes and to identify a rich set of possible explanatory factors for these choices. The explanatory factors included in the study were based on the Technology Assessment Model combined with a literature review detailed multiple situational, demographic and attitudinal antecedents of engagement with electricity and energy usage in the home, including energy efficiency and tariff switching behaviours[45,63,64,65]. These findings were used to inform the design of the survey including some batteries of questions already tried and tested in the UK context in the examination of domestic energy usage[66,64,67,68]. The novelty in the present study is the

profiling of potential future consumer groupings based on theoretically underpinned conceptual framework of individual motivations involved in opting for different ways of engaging with their energy supply arrangements.

The questionnaire contained nine sections consisting of: (1) Domestic arrangements including housing type and occupancy; (2) Supply of energy to the home including billing, tariff and expenditure, and comprehension of these elements; (3) Heating methods and fuel including perceived levels of insulation and satisfaction; (4) Perceived comfort and affordability, concern for and likely response to future energy prices, experience with smart metering and demand control; (5) Reasons for choice of supplier, switching behaviour, satisfaction and trust in energy suppliers and other types of service provider; (6) Business archetype attribute rating, paired choice experiment and overall likelihood to adopt each model; (7) Current car ownership and usage, willingness to adopt electric vehicles and shared mobility; (8) Attitudes towards different forms of energy generation, energy supplier regulation and environmental beliefs/concerns, and (9) Individual and household socio-demographic characteristics.

Addressing limitations of hypothetical choices

Eliciting beliefs about and preferences towards a set of 'products' that are not currently available and also represent an area of consumption (domestic energy use) in which consumers tend to be minimally engaged, is a serious research challenge. Three principal strategies were used to mitigate this:

1. Sampling of householders at least partially responsible for (and therefore most likely to be engaged with) energy supply in the household (see 'sampling')
2. Building up engagement with the issues successively through the questionnaire by starting with factual questions about current arrangements for energy supply against which people can mentally benchmark future archetypes
3. Inclusion of topic areas which have been found by other studies to result in a diversity of opinion relating to trust in organisations, environmental behaviour and cost of energy.

Altogether, the questionnaire took a minimum of 15 minutes to complete, with a median duration of 30 minutes. The data that support the plots within this paper and other findings of this study are available from the corresponding author upon reasonable request.

Data collection

The study employed a market research company (Accent) to programme the online survey and organise the data collection. Accent specialise in online stated preference surveys with randomisation and have access to the SSI's global market research panel of demographically diverse adults (>18 years of age) who have voluntarily subscribed to undertake such research. People register by providing varying amounts of personal and demographic information that is later used to select participants for specific surveys. Thus, as is typical with such panels, the SSI panel does not use probability-based recruitment. Nevertheless, the panel from which this study's participants were selected is large enough to enable the selection of a nationally representative sample or sample representative of sub-groups that reflect the actual breakdown of their key demographics (e.g. age, gender, region, social grade, ethnicity, disability etc.).

Participants were sent an electronic communication (email or through a phone app) to be asked to participate and were rewarded a small incentive (approximately 0.85 GBP) for completion of the survey. The survey underwent a pilot test in March 2017 during which 66 participants completed this version. This led to some removal of attitudinal questions eliciting a disproportionate number of neutral responses. The final questionnaire was in the field between 30th March and 13th April 2017.

Sampling

The aim was for a representative sample of electricity bill payers in England, Wales and Scotland. To screen for such people, we used the following question:

Sample screening question

"Which one of the following describes your level of involvement in decisions about which company your household uses to supply gas and/or electricity?

1. ***It is my responsibility entirely***
2. ***I have equal responsibility with someone else in the household***
3. ***I have some involvement in the decision***

I have no involvement at all THANK & CLOSE

As there are no reliable statistics against which to benchmark our achieved demographic profile of bill payers to achieve representativeness among them, we used a proportionate stratified sampling approach to mirror the general population[69] with quotas based on age (six groups), gender and residential location (eleven Government Office Regions). Thus the sample itself is made up only of bill payers but unlikely to be entirely representative of them. For example, the number of 18-24-year-old respondents had to be specifically boosted as a disproportionate number of this age group were otherwise consistently screened out due to being less likely to fall in to this group. However, given the focus of this research requires future facing preferences, over-representing this group was justified.

SSI sent a total of 41,579 invites, of whom 3,552 started and 2090 completed the survey (i.e. a 5% response rate and a 59% completion rate). Whilst this appears as a low response rate, it is not possible to calculate one with on-line samples due to the need to consider the incidence rate (the proportion of respondents contacted who qualify for the survey) and the fact the survey closes as soon as the required sample size has been achieved. Once full quotas are considered, the incidence rate was 57%. The final achieved sample was 2,024 respondents after some were removed (N=66) who were deemed to have provided incomplete or invalid data based on 'straight liner variables' detected to indicate whether participants had given the same response for all sub questions in a relevant block.

Participant characteristics

As discussed, this is a sample comprising only of domestic energy bill payers but with their proportions set through quota sampling to match the characteristics of the general population. Comparisons with national data for England, Wales and Scotland[70,71,72] suggested that participants were somewhat better-educated, more likely to be on 'home duties', included higher shares of people amongst the higher earners (>£40k per household per year), more 'owned outright' but also more 'rented' households and had slightly higher car accessibility than the general population. Otherwise the study population was largely representative in its demographic, socio-economic and geographical characteristics. Therefore, no post-stratification weighting was applied. See Supplementary Table 1 for details.

The sample was segmented using hierarchical followed by non-hierarchical cluster analysis. The clustering variables were those representing the constructs in the conceptual model which are a compilation of beliefs, experiential and preference factors. Note that we chose to include a measure of 'likelihood to adopt' among the clustering variables. The mixing of generic and specific attitudinal variables in this way has a solid conceptual justification. If based only on general antecedent constructs to intention (ie not including the likelihood variable), the segmentation model could fail to identify that there is more than one group exhibiting similar core beliefs or psychological processes but expressing different intentions or behaviours due to important contextual or experiential antecedents. The converse may also be present whereby groups with similar intentions may be present, but with markedly different beliefs or experience. If only one or the other type of variable is put into the segmentation, there is a risk that such multi-faceted 'attitude-behaviour' linkages are hidden among generic groupings. It is important to realise that we are not developing a segmentation model here that we claim will stand the test of time. The purpose is to understand now what the appetite for change is, for what and by whom. We believe, therefore, that our model can serve as a practical

tool that offers a robust building block for the development of strategy in the initial market evolution of new utility business models.

Identification of preference factors

The first stage in identifying variables to use as the bases for the cluster analysis was the development of measures of 'preference' for the five business archetypes. Five measures were derived from the various questions on the survey: (i) *Likelihood to adopt* each archetype ('Likely_1' – 'Likely_5') using a single question asked after each archetype was scored on a number of sematic differential attribute scales. (ii) *Adoption spread* ('Adoptspread') is the highest value of 'Likely' minus the lowest for each individual to generate a signal of preference certainty. If a person scores one or more options very high in terms of likelihood to adopt, and another option very low, they have a larger spread than someone who scores all options similarly. (ii) *Probability of adoption* (Prob_1 – Prob_5) the number of times chosen during the paired comparison experiments divided by the number of times available to be chosen (see SI1 figure SI1.4). (iv) *Weighted probability* of adoption ('WeightedP_1' – 'WeightedP_5') from the 'Prob' score and multiplied it by the 'Likely' score. (v) *Preference stability* ('Reversals') was a test of internal consistency calculated using an excel macro to detect reversals between each combination of 3 options and then adding up the number per person. The majority of people were perfectly internally consistent as 76% did not reverse their 'ranking' of options across the three possible combinations with each option.

Data reduction

The attitudinal variables on the survey were subjected to data reduction in order to reduce the variables to a smaller set of underlying dimensions to be used in the subsequent segmentation. In Factor Analysis, variables that show similar patterns of variation across respondents are assumed to be associated with the same underlying construct. Principal axis factoring was used in IBM SPSS Statistics v.22.0, chosen to account for some non-normal distribution in the data. Rotation of the final solution is necessary in order to clarify the underlying structure and produce a set of arbitrary factors which provide the clearest conceptual picture of the relationships among the items[73]. A direct oblim rotation was used as this maximises the variance of the loadings within factors across variables so that each of the original items loads on only one factor. Oblim rotation also allows the factors to correlate which avoids unnecessary loss of information in orthogonal methods and thus leading to more reproducible solutions[74].

The three batteries of questions each subject to the Factor Analysis (amounting to 30 statements in total, each measured on a 5-point scale (usually strongly agree to strongly disagree)) were: (i) Attitudes towards the environment and renewable energy (ii) General approaches to purchase decision making (iii) Process of choosing energy suppliers. Each of these were subject to a series of analyses which were ran iteratively, each time excluding items with low communalities ($h < 0.5$). Communalities identify the items' variance and thus the ones which form highly consistent scales that discriminate well in the clustering procedure[75]. Each component was subject to reliability test using Cronbach's Alpha (α) which measures internal consistency based on item correlation. Alpha coefficients range from 0 to 1 and may be used to describe the reliability of each factor. 0.5 is generally regarded as an acceptable reliability coefficient[76] and was used here.

The three batteries of questions were reduced to six latent constructs: (i) Green Urgency (ii) Green Scepticism (iii) Information seeking when purchasing (iv) Inspiration seeking (v) Perceived Savings (vii) Engagement with energy usage Discerning about trustworthiness and quality of service suppliers. Six questions had been discarded from the analysis as inspection of the correlation matrix revealed that they were not significantly related to any other items in this set or were found to be responsible for a lower alpha value. These factors are a very valuable set of internally consistent constructs to be used in further analyses to understand consumer

perceptions and motivations. Factor scores, as opposed to summated scale scores, were computed for each respondent in the data set to be used in the cluster analysis.

Supplementary Table 2 itemises the constructs with the interpretive label, factor loadings, Cronbach's Alpha score and percentage of variance explained in each of the three 'batches' of questions.

Cluster analysis

A two-stage cluster analysis common in market research[77] was performed to identify segments of potential consumers of the business archetypes. Segmentation market research begins with the assumption that there is little value in targeting the average customer and more value in treating different people in different ways because they are motivated by varying rationales[78]. Hierarchical cluster analysis (HCA) is used first in an exploratory 'structure-seeking' phase, followed by the iterative partitioning method (K-means) to 'fine tune' the analysis[76].

HCA was performed on a set of 31 standardised variables comprised of those detailed in Supplementary Table 3 and chosen to represent the constructs of the conceptual model. The variables were standardized and subjected to HCA, applying Ward's method. The squared Euclidean distance was used as the proximity measure in the clustering procedure. This gave an indication of how the sample population was partitioning and hints at the optimal number of clusters to be used in the second stage. Following visual inspection of the HCA Dendrogram (Supplementary Figure 4) a range of cluster solutions was chosen (from three to six segments) to be carried to the next step.

The k means clustering takes the cluster centres of the HCA cluster solution as input and re-clusters the sample according to the squared Euclidean distance from the centres. Since HCA does not correct cluster assignments, k means can generate more homogeneous groups and hence improved solutions whereby variability within clusters is minimised whilst maximising the variability between them[76]. The number of clusters was specified at three, four, five and six. Selection criterion suggested in the literature range from highly subjective to complex mathematical procedures. The Agglomeration Schedule (Supplementary Figure 5)[79] shows a jump in which the value of the error coefficient nearly doubles when 4 clusters are reduced to three, giving a strong indication that a four cluster solution made the most senses. This was confirmed by inspecting one-way ANOVA tables performed for the different solutions using the 31 variables used to create them to ensure high variability between groups compared to within them and the presence of discrete and concentrated clusters. This procedure indicated that the four-cluster solution may be marginally better than both the three and five cluster solutions, although significant and meaningful differences were found across all 30 segmentation variables for all solutions. Since the four-cluster solution separated clusters with particularly distinctive views on adoption likelihood, this solution was selected. Two participants were not clustered due to some missing data on key variables. Hence the sample size for the cluster profiling is 2022.

Characterising the segments

The cluster analysis concluded that four relatively stable groups could be identified ranging from 16% to 35% of the sample. The groups were profiled on the variables used to create them as well as other factors such as demographic characteristics. ANOVA with Tukey post hoc tests were used for means comparisons, and chi-square tests (two-tailed) where we compared relative frequencies of categorical variables across clusters.

We also undertook at discriminant analysis (DA) to test whether it was possible to define a set of variables which could predict group membership with adequate reliability without including the specific willingness to adopt ('likelihood') variables in the analysis. The DA confirmed that segment membership could be predicted by only using the antecedent model constructs used to form the clusters as well as some demographic variables we had found to strongly discriminate across segments. As explained in Supplementary Note 1, a satisfactory solution that would predict group membership with 80% accuracy was found using 23 out of the original 31 variables.

Ethics statement

The field-work proposal was reviewed and approved by the University of Leeds AREA Faculty Research Ethics Committee (Ref: AREA 16-155). The research was undertaken in line with the requirements of the international quality standard for market, opinion and social research, ISO 20252:2012, to which Accent is registered and audited annually. Accent is registered under the Data Protection Act 1998.

Acknowledgements

This research was part funded by Engineering and Physical Sciences Research Council Grant: EP/N029488/1 and the Economic, Social Research Council under grant Ref: ES/M500562/1 and the UK Research Councils (Grant No: EPSRC EP/L024756/1 and NERC NE/G007748/1) as part of the UK Energy Research Centre (UKERC).

Author Contributions

Hall led the development of the utility 2050 research process and led the literature review discussion and conclusions, Anable led survey design, with input from Hardy, Hall, Mazur and Workman, data collection and analysis. Workman, Mazur, Anable, and Hardy contributed substantive analysis, redrafting and editing. Matthews aided early analysis and drafting.

Competing Interests

The Authors confirm they have no financial or non-financial competing interests.

Data Availability

Relevant survey data, including all raw data, generated or analysed during this study are included in this published article in the Supplementary Data file. Data generated in the construction of business model archetypes is summarised in the Supplementary Information.

Figure 1: Utility business model archetypes. The business models synthesised from the business model collaboration workshop. The pure low carbon generator is not analysed in the consumer facing experiment as it sells only to wholesale markets. Reproduced from ref[80]

Table 1: The consumer facing attributes of each new business model archetype

New utility business model	Consumer facing attributes
Same but Smart (SBS)*	Free to switch companies as and when you want to. You will have a 'smart meter' with 'live' information at home and on your phone etc. Your supplier can see how and when you use electricity. You can change your behaviour (not use the washing machine etc) when you see that electricity is cheaper.

New Electrifier (NE)	You have a two-year contract. You get a discount for switching your home from gas to electric heat. It will cost about the same as now. You might have some new things installed like electric radiators or a heat pump. Your supplier can pause your heating occasionally for up to 15 minutes at a time, or take control of when to charge your electric car to help you avoid paying the highest prices, though you can opt out of this.
Energy Service Company (ESC)	You have a 10-year contract. Your energy bills are guaranteed to be lower than you are currently paying for the duration of the contract. You receive one bill for all your light, heat and any electric car needs. You might have some new things installed, like insulation and a home energy management system. Your supplier can pause your heating and appliances (such as your fridge) occasionally for up to 15 minutes at a time, or take control of when to charge your electric car to help you avoid paying the highest prices, though you can opt out.
Peer-to-peer (P2P)	You have no contract with an energy supplier. You use an app on your phone to choose who to buy energy from - you can choose based on price, type or location of energy. (For example, you might want local green energy, even though it might not be the cheapest). You can change who you get your energy from as often as you like. If you have a solar panel on your roof you can make money by selling the energy from it through the app.
Third Party Control (3PC)	You have a multi-year contract. You tell the company how you want to live your life and it takes decisions on your behalf to deliver this. You receive one bill for all your energy, broadband, TV, mobile phone, electric vehicle and water services. Your company may offer to install equipment like insulation and a home energy management system to make your home more efficient and smarter. Your company can pause your heating and appliances (such as your fridge) occasionally for up to 15 minutes at a time, or take control of when to charge your electric car to help you avoid paying the highest prices, though you can opt out of this.

*Control archetype used to reflect contracts available to consumers today

Figure 2: Likelihood of adopting each archetype. Percentage of participants (n = 2024) that were likely, unlikely or neutral in their intention of adopting each archetype. Responses were scored on a sliding scale from 0 to 1 ('Very unlikely' to 'Very likely') that were then coded as unlikely (0-0.4), neutral (0.5), and likely (0.6-1).

Figure 3: Consumer segments. Labels, size and defining statement for each consumer segment.

Figure 4: Probability of adoption of each archetype in each consumer segment. Using ANOVA the segments differ on all of the 5 archetypes at p>0.0001 with the exception of New Electrifier (NE) with p=0.21 (SBS: F=95.138 (3) p>0.0001; NE: F=1.509 (3) p=0.21; ESC: F=36.898 (3) p>0.0001; P2P: F=22.477 (3) p>0.0001; 3PC: F=37.408 (3) p>0.0001).

Figure 5: Trust across societal institutions by consumer segment. For each institution, the question was: *"To what extent do you trust or distrust the following types of organisation to treat you in a fair and honest way?"* This was measured on a 5-point scale from 1 (Distrust Strongly) – 5 (Trust Strongly). Using ANOVA, the segments differ significantly on all of the 10 institutions at p>0.0001 Supplementary Table 5 shows the mean value, standard deviation, ANOVA and Tukey post hoc tests for these 10 comparisons.

Table 2: Profile statistics on each segment on demographic characteristics and clustering variables

	(A) Engaged but Cautious % or	**(B) Aspiring Opt-Outs** % or	**(C) Unengaged and Unmotivated**	**(D) Pragmatic Innovators** % or	X^2/F **(df) p-value** [+]

	Mean (SD) ~	Mean (SD) ~	% or Mean (SD) ~	Mean (SD) ~	
Demographics					
Male (%)	45.9*	42.5 ˇ	**55.9**ˆ	52.7	24.424 (6) p=0.00
Owner-occupier (%)	66.1	53.1 ˇ	**71.7**ˆ	58.8	43.459 (6) p=0.00
With children (%)	23.8	28.7	12.9 ˇ	**49.4**ˆ	134.081 (3) p=0.00
Degree+ education (%)	38.7	35.4	28.3 ˇ	**43.6**ˆ	24.399 (9) p=0.00
In work (%)	51.1	60.0	44.8 ˇ	**75.5**ˆ	83.908 (4) p=0.00
> £60k p.a. income (%)	15.5	10.2 ˇ	11.1	**18.7**ˆ	43.039 (12) p=0.00
Mean age (yrs)	49.6(15.8) B,C,D	44.2(14.9) A,C,D	**55.1**ˆ (14.0) A,B,D	36.6 ˇ (13.0) A,B,C	113.413 (3) p=0.00
Experience/ Engagement					
Never switched supplier (%)	27.2 ˇ	**49.2**ˆ	35.9	31.5	24.034 (6) p=0.00
Satisfaction with supply#	**4.1**ˆ(0.5) B,C	3.1 ˇ (0.8) A,C,D	3.5(0.7) B	4.0(0.6) B	262.091 (3) p=0.00
No. of energy actions[3]	3.2(0.5).C,D	3.2(0.5) C,D	3.1 ˇ (0.5) A,B,D	**3.6**ˆ (0.7) A,B,D	58.788 (3) p=0.00
Think about electricity	2.7(0.8) B,C,D	3.4(0.9) A,C,D	2.3 ˇ (0.8) A,B,D	**3.8**ˆ (0.9) A,B,C	254.647 (3) p=0.00
Willingness to think	2.6(0.8) B,C,D	3.1(0.9) A,C,D	2.1 ˇ (0.8) A,B,D	**3.7**ˆ (0.9) A,B,C	286.575 (3) p=0.00
Energy engagement	3.6(0.9) B,C,D	3.3(0.9) A,C,D	3.1 ˇ (1.0) A,B,D	**3.8**ˆ (0.7) A,B,C	5.794 (3) p=0.00
Salient Beliefs					
Worried about price now	1.6 ˇ (0.8) B,D	**3.1**(1.2) A,C,D	1.7(1.1) B,D	2.6(1.3) A,B,C	275.571 (3) p=0.00
Worried for future	2.5 ˇ (0.9) B,D	**3.8**(0.9) A,C,D	2.6(1.1) B,D	3.4(1.1) A,B,C	223.035 (3) p=0.00
Environmentally responsible	3.8(0.6) C	3.8(0.6) C	3.2 ˇ (0.7) A,B,D	**3.9**ˆ **(**0.6) C	101.669 (3) p=000
Environmentally Sceptic	2.4 ˇ (0.6) B,C,D	2.8(0.6) A,D	2.7(0.6) A,D	**3.4**ˆ (0.8) A,B,C	191.267 (3)p=0.00
Descriptive norm	3.3(0.9) D	3.2 ˇ (0.9) D	3.3(0.9) D	**3.6**ˆ (0.9) A,B,C	16.928 (3)p=0.00
Personal Innovativeness					
Adopts latest technology	2.7(1.0) C,D	2.7(1.1) C,D	2.1 ˇ (0.9) A,B,D	**3.8**ˆ (1.0) A,B,C	176.039 (3) p=0.00
TRUST					
Trust own energy Co.	3.8(0.7) B,C,D	2.8 ˇ (0.9) A,C,D	3.1(1.0) A,B,D	**4.1**ˆ (0.8) A,B,C	233.642 (3) p=0.00
Trust other energy Co.'s	3.2(0.7) B,C,D	2.6 ˇ (0.8) A,D	2.6 ˇ (0.8) A,D	**3.7**ˆ (0.8) A,B,C	225.853 (3) p=0.00
Willing to share info	3.3(0.8) B,C,D	3.1(0.8) A,C,D	2.3 ˇ (0.9) A,B,D	**3.9**ˆ (0.7) A,B,C	249.425 (3) p=0.00
Perceived Ease of Use					
SBS	**0.7**ˆ (0.2) B,C,D	0.6(0.2) A,C	0.4 ˇ (0.2) A,B,D	0.6(0.2) A,C	8.906 (3) p=0.00
NE	0.5(0.2) B,C,D	0.5(0.2) A,C,D	0.3 ˇ (0.2) A,B,D	**0.6**ˆ (0.2) A,B,C	165.999 (3) p=0.00
ESC	0.4(0.2) B,C,D	0.4(0.2) A,C,D	0.3 ˇ (0.2) A,B,D	**0.6**ˆ (0.2) A,B,C	136.260 (3) p=0.00
P2P	0.4(0.2) C,D	0.4(0.2) C,D	0.2 ˇ (0.2) A,B,D	**0.6**ˆ (0.2) A,B,C	135.804 (3) p=0.00
3PC	0.5(0.2) B,C,D	0.4(0.2) A,C,D	0.3 ˇ (0.2) A,B,D	**0.6**ˆ (0.2) A,B,C	115.045 (3) p=0.00
Perceived Usefulness					
Perceived savings	2.4(0.9) B,C,D	3.5ˆ (0.8) A,C	3.1(1.0) A,B,D	**3.5**ˆ (0.9) A,C	158.602 (3) p=0.00
Less energy to save money	3.9(0.7) B,C	4.2(0.7) A,C	3.5 ˇ (0.8) A,B,D	4.1ˆ (0.8) C	93.795 (3) p=0.00
Less energy for Environment	3.6(0.9) C,D	3.7(0.9) C	2.7 ˇ (1.0) A,B,D	3.9ˆ (0.9) A,C	132.611 (3) p=0.00
Smart control benefits	3.2(1.0) C,D	3.0(1.0) C,D	2.0 ˇ (1.1) A,B,D	**4.1**ˆ (0.8) A,B,C	280.458 (3) p=0.00
Intention					
Weighted probability**: SBS	0.56ˆ (0.27) B,C,D	0.45(0.26) A,C,D	0.27 ˇ (0.24) A,B	0.32(0.23) A,B	158.955 (3) p=0.00
Weighted probability: NE	0.20(0.18) C,D	0.22(0.19) C,D	0.10 ˇ (0.14) A,B,D	**0.27**ˆ (0.20) A,B,C	160.901 (3) p=0.00
Weighted probability: ESC	0.15(0.20) C,D	0.12(0.17) C,D	0.07 ˇ (0.13)A,B,D	**0.31**ˆ (0.25) A,B,C	179.495 (3) p=0.00
Weighted probability: P2P	0.22(0.24) B,C	0.32ˆ (0.27) A,C,D	0.14 ˇ (0.19) A,B,D	0.25(0.23) B,C	129.876 (3) p=0.00
Weighted probability: 3PC	0.13(0.17) C,D	0.14(0.17) C,D	0.06 ˇ (0.11) A,B,D	**0.29**ˆ (0.24) A,B,D	170.559 (3) p=0.00
Spread of scores	**0.55**ˆ (0.26) B,C,D	0.49(0.26) A,C,D	0.30(0.24)A,B	0.29 ˇ (0.21) A,B	145.771 (3) p=0.00
Consistency of scoring	0.25 ˇ (0.64) D	0.34(0.80) D	0.31(0.72) D	**1.27**ˆ (1.45) A,B,C	114.550 (3) p=0.00
Cluster size (*N*)	706	537	449	330	2022
Cluster share	35%	27%	22%	16%	100%

~The homogeneity of variance test was met in each case to apply the Tukey post-hoc test alongside the ANOVA test. Different letters indicate significant differences between specific segments using this test ($p<0.05$)

+A one-way analysis of variance (ANOVA) producing the F statistic or Chi Square (X^2) was conducted to evaluate the relationship between cluster membership and each variable

*For each segmentation variable, the value of the segment with the highest score is denoted withˆ and the lowest with ˇ whereby in all cases a low score equates to lowest agreement or most negative score on each statement

For an explanation of each variable name and the measurement scale used, please see Supplementary Table 3. In each case, the higher the mean score, the greater the agreement or value on this construct or issue

**The probability score (proportion of times chosen (0-1)) multiplied by the stated likelihood of adoption score (0-1)

Table 3: Summary profiles of each segment and implications for energy market transitions. See Supplementary Table 4 for a longer version and Supplementary Data for background response scores.

	Summary Profile	Implications for energy market transitions

Engaged but Cautious (EbC) (35%)	• These consumers are engaged in their energy, the most likely to shop around and switch supplier, finding it relatively straight forward, understand tariff information and calculate potential savings. They have high trust in own and other suppliers and high willingness to share information with them. However, because they feel satisfied that they can get what they want out of the current market, are paying the least for their energy and have the highest satisfaction levels, they are not enthusiastic about alternative business archetypes. • They appear more motivated at getting the best price for their energy than saving money through demand reduction or by being early adopters of alternative energy sources. Their motivations for being price conscious do not appear to be driven strongly by affordability or fuel poverty. • They are the most environmentally conscious and most consistently minded towards green energy, although cautious about paying more. Although they are environmentally motivated, they do not want to work very hard for this. For instance, they are the most likely to admit that they *could* reduce their energy demand, despite being highly likely to say that reducing energy would make them feel good. But, they are clear about being not overly willing to spend time thinking about the energy they use and this is reflected in them being unconvinced by smart meters and not standing out for undertaking many other energy saving behaviours. • Tendency to be older, female, childless, educated, in employment, average income and owner occupiers.	• This group stands out as the highest scorer on SBS with only moderate rankings of all the other archetypes. So, although they are motivated to shop around and inform themselves about tariffs, their satisfaction with the status quo appears to lead to resistance towards new business models. • Importantly, the two segments with above average owner occupation status (*Engaged but Cautious* and *Unconvinced & Unmotivated*) are the least likely to choose the two archetypes that require alterations to building fabric, i.e. ESC and 3PC.
Aspiring Opt-Outs (SOO) (27%)	• These consumers are the least likely to have switched supplier despite lowest satisfaction and the highest tendency to say they have thought about switching. Those who have switched have the greatest tendency to say they found it difficult and believe tariffs to be deliberately confusing, with little financial gain from one company or tariff to another. They are the most likely to say they find their bills difficult to understand. This is also reflected in them showing the lowest levels of trust in their own and other suppliers and the greatest resistance to suppliers controlling appliances. • They do have some tendency to think about their energy use and do show the highest engagement in energy saving, as they are very motivated to save money. They are paying above average for their energy bills yet are by far least likely to say they are able to keep warm in winter with a high proportion citing cost as the reason. Despite being most worried about keeping warm in winter, they are by far the most likely of all segments to say they would cut down on the amount of energy used if prices were to rise by 20%. • They are only moderately environmentally concerned and have the lowest faith in science and technology, not considering themselves to be early adopters of technology. They are reluctant to pay more for environmental gain.	• Highest overall for P2P, though SBS still highest for them. Low for ESC and 3PC. • It is interesting that those who currently have the greatest difficulty navigating the energy market now would want to take responsibility for a more interactive market experience. However, it makes sense in that they do not trust the larger suppliers and this would enable them to 'opt out' of their control. • Their low trust is likely to have led to ESC being their least favoured archetype as this would involve being tied in for such a long period. NE is their third most preferred option, perhaps based on their expressed desire for improvements to their home heating systems.

	• Tendency to be younger, female, with children, less educated, average employment, low income and high renting.	
Unconvinced and Unmotivated (U&U) (22%)	• This group are indifferent about their energy use and seem to have paid very little attention to it in terms of their supply or their own behaviour. • Although this group have switched suppliers in the past at an average frequency for this sample and they are not particularly likely to say that it is too hard to switch, they have low satisfaction with their current supplier and are the least likely to know things such as the tariff they are on, the insulation level of their home or to believe that they understand their energy bills. • They are not motivated by money savings or climate change to change behaviour and they are the least likely to be paying attention to any deals or their own energy use. They are the least likely to say they are thinking about electricity use now and want to think more about it in the future or that they want to change anything about their home energy system. They are the least likely to have a smart meter or say they want one, with the highest likelihood to say that this kind of information is 'not at all' helpful and the lowest (8%) saying they want one. They have the lowest willingness to share their energy data with others or having suppliers control their appliances. • They consider themselves to be late adopters of technology. Oldest, out of work or retired, male, childless, low education, slightly below average income although high owner occupier	• Although P2P is the second most popular archetype after SNS for this group, their tendency to say unlikely to actually adopt any of them gives them lowest likelihood of choosing any of the business models. They consistently rate all the archetypes as complicated with the most extreme scores on this measurement of all the segments. SBS is rated as the least complicated and P2P the most. • This group of consumers appear difficult to 'hook' in to any alternative models as they are not engaged in their energy use or particularly motivated by cost or environmental benefits. Even though it would seem that they do not want to put the effort in to anything which involves them having to think much about their supply, they are also very negative towards the idea of their data being shared or appliances being controlled.
Pragmatic Innovators (PI) (16%)	• This group of consumers are engaged, potentially active but discerning. • They have the joint-highest experience of switching suppliers so far, have very high awareness and understanding of their energy tariff and are the most likely to be actively undertaking energy saving activities now and spending time thinking about their electricity use. They are the most likely to say their homes are already insulated, to have a smart meter and they are by far the most likely to have a source of heat or electricity individual to the dwelling such as solar panels. They are also the most likely to have alternatively fuelled cars. So, they are early adopters and perceives themselves as such. • Interestingly, they have high trust in energy suppliers and do believe that switching suppliers brings much benefit because they are too similar. This means they have the greatest preparedness to share information with these suppliers and fore suppliers to control appliances. • They have a complex view about the environment. They say they are motivated to do something about it and believe that issues are urgent, but do not believe people's freedoms should be curtailed and that the problems may be slightly exaggerated. • They do believe that reducing energy use can save money and be environmentally beneficial and they	• Fairly equal choices among the options. Highest of all the groups on 3PC which may have appeal across the variety of lifestyle services involved in a working family home with some innovation tendencies. • Largest number of reversals showing some ambivalence in choice. So this groups appears the least wedded to the status quo and can see merit in a number of different solutions

	are the most likely to say that reducing energy consumption would make them feel good. However, they are also the most likely to say they could not reduce *their* energy use any further. • Youngest with few above 55 years, balanced gender, with children, highest education, highest income, highest employment, owner occupiers	

References

[1] Schot, J., Kanger, L. and Verbong, G., 2016. The roles of users in shaping transitions to new energy systems. *Nature energy*, *1*(5), p.16054.

[2] National Grid, 2018, Future Energy Scenarios, National Grid System Operator, Available online at http://fes.nationalgrid.com/media/1363/fes-interactive-version-final.pdf

[3] Council of European Energy Regulators (2017) Retail Markets Monitoring Report. CEER Report C17-MMR-83-02 Accessed online April 2017 at: https://www.ceer.eu/documents/104400/-/-/56216063-66c8-0469-7aa0-9f321b196f9f

[4] Hortaçsu, A., Madanizadeh, S.A. and Puller, S.L., 2017. Power to choose? An analysis of consumer inertia in the residential electricity market. *American Economic Journal: Economic Policy*, *9*(4), pp.192-226.

[5] Sen, A., Nepal, R., and Jamasb, T. (2016) Reforming Electricity Reforms? Empirical Evidence from Asian Economies. Oxford Institute for Energy Studies, Accessed April 2018 at: https://www.oxfordenergy.org/wpcms/wp-content/uploads/2016/02/Reforming-Electricity-Reforms-Empirical-Evidence-from-Asian-Economies-EL-18.pdf

[6] van Beek M, Holst A, Keeble J. Low carbon, high stakes - do you have the power to transform? Accenture Strategy; 2015

[7] Competition and Markets Authority, (2016) Energy Market Investigation, Final Report, CMA, 2016

[8] PWC, 2014, *The road ahead Gaining momentum from energy transformation*, PWC global power and utilities. https://www.pwc.com/gx/en/utilities/publications/assets/pwc-the-road-ahead.pdf

[9] Bryant, S.T., Straker, K. and Wrigley, C., 2018. The typologies of power: Energy utility business models in an increasingly renewable sector. *Journal of Cleaner Production*, *195*, pp.1032-1046.

[10] Hawker, G., Bell, K. and Gill, S., 2017. Electricity security in the European Union—The conflict between national Capacity Mechanisms and the Single Market. *Energy Research & Social Science*, *24*, pp.51-58.

[11] Parag, Y. and Sovacool, B.K., 2016. Electricity market design for the prosumer era. *Nature Energy*, *1*(4), p.16032.

[12] Britton, J., Hardy, J., Mitchell, C., Hoggett, R (2019) Changing actor dynamics and emerging value propositions in the UK electricity retail market, IGov Working Paper, Available online, accessed March 2019 at: http://projects.exeter.ac.uk/igov/report-analysis-of-uk-electricity-system-actors/

[13] Burger, S., Chaves-Ávila, J.P., Batlle, C. and Pérez-Arriaga, I.J., 2017. A review of the value of aggregators in electricity systems. *Renewable and Sustainable Energy Reviews*, *77*, pp.395-405.

[14] Ward, A., Thomas, N., & Chazan, G. (2017). European utilities primed for consolidation in shift to renewables. *FT.Com,* Retrieved from http://0-search.proquest.com.wam.leeds.ac.uk/docview/1923885893?accountid=14664

[15] IEA (2017). *World energy investment 2017*. International Energy Agency, Paris

[16] Hall, S. and Roelich, K., 2016. Business model innovation in electricity supply markets: The role of complex value in the United Kingdom. *Energy Policy*, *92*, pp.286-298. https://doi.org/10.1016/j.enpol.2016.02.019

[17] Roelich, K., Knoeri, C., Steinberger, J.K., Varga, L., Blythe, P.T., Butler, D., Gupta, R., Harrison, G.P., Martin, C. and Purnell, P., 2015. Towards resource-efficient and service-oriented integrated infrastructure operation. *Technological Forecasting and Social Change*, *92*, pp.40-52.

[18] Helms, T., 2016. Asset transformation and the challenges to servitize a utility business model. *Energy Policy*, *91*, pp.98-112.

[19] Helms, T., Loock, M. and Bohnsack, R., 2016. Timing-based business models for flexibility creation in the electric power sector. *Energy Policy*, *92*, pp.348-358.

[20] White, L.V. and Sintov, N.D., 2018. Inaccurate consumer perceptions of monetary savings in a demand-side response programme predict programme acceptance. *Nature Energy*, *3*(12), p.1101

[21] Eid, C., Codani, P., Perez, Y., Reneses, J. and Hakvoort, R., 2016. Managing electric flexibility from Distributed Energy Resources: A review of incentives for market design. *Renewable and Sustainable Energy Reviews*, *64*, pp.237-247.

[22] Frei, F., Sinsel, S.R., Hanafy, A. and Hoppmann, J., 2018. Leaders or laggards? The evolution of electric utilities' business portfolios during the energy transition. *Energy policy*, *120*, pp.655-665.

[23] Williams, B., Waring, G., (2018) Consumer Engagement In The Energy Market 2018 Report on a survey of energy consumers Research conducted on behalf of Ofgem, GFK UK Social Research, Accessed online February 2019, available at: https://www.ofgem.gov.uk/system/files/docs/2018/10/consumer_engagement_survey_2018_report_0.pdf

[24] Flores Sandoval, M. and Waddams Price, C., 2018. The Role of Attitudes and Marketing in Consumer Behaviours in the British Retail Electricity Market. *The Energy Journal*, *39*(4), pp.153-179.

[25] Hortaçsu, A., S. A. Madanizadeh, and S. L. Puller (2017). "Power to Choose? An Analysis of Consumer Inertia in the Residential Electricity Market." *American Economic Journal: Economic Policy* 9(4): 192–226. https://doi.org/10.1257/pol.20150235.

[26] Defeuilley, C., 2009. Retail competition in electricity markets. *Energy Policy*, *37*(2), pp.377-386.

[27] Waddams Price, C., 2018. Back to the future? Regulating Residential energy Markets. *International Journal of the Economics of Business*, *25*(1), pp.147-155.

[28] Loewenstein, G., 1999. Experimental economics from the vantage-point of behavioural economics. *The Economic Journal*, *109*(453), pp.25-34.

[29] Frederiks, E.R., Stenner, K. and Hobman, E.V., 2015. Household energy use: Applying behavioural economics to understand consumer decision-making and behaviour. *Renewable and Sustainable Energy Reviews*, *41*, pp.1385-1394.

[30] Simon, H.A., 1955. A behavioral model of rational choice. *The quarterly journal of economics*, *69*(1), pp.99-118.

[31] D. Pichert, K.V. Katsikopoulos Green defaults: information presentation and pro-environmental behaviour J Environ Psychol, 28 (2008), pp. 63-73

[32] Deller, D, Waddams Price, C, Errington, E, Fletcher, A, Hargreaves, T, Harker, M, Longhurst, N, Reader, D & Turner, G 2018, *Fairness in Retail Energy Markets? Evidence from the UK*. Centre for Competition Policy.

[33] Frederiks, E.R., Stenner, K. and Hobman, E.V., 2015. Household energy use: Applying behavioural economics to understand consumer decision-making and behaviour. *Renewable and Sustainable Energy Reviews*, *41*, pp.1385-1394.

[34] Simon, H.A., 1955. A behavioral model of rational choice. *The quarterly journal of economics*, *69*(1), pp.99-118.

[35] Shafir, E., Simonson, I. and Tversky, A., 1993. Reason-based choice. *Cognition*, *49*(1-2), pp.11-36.

[36] Hobman, E.V., Frederiks, E.R., Stenner, K. and Meikle, S., 2016. Uptake and usage of cost-reflective electricity pricing: Insights from psychology and behavioural economics. *Renewable and Sustainable Energy Reviews*, *57*, pp.455-467.

[37] Eppler, M.J., Hoffmann, F. and Bresciani, S., 2011. New business models through collaborative idea generation. *International journal of innovation management*, *15*(06), pp.1323-1341.

[38] Rohrbeck, R., Konnertz, L. and Knab, S., 2013. Collaborative business modelling for systemic and sustainability innovations. *International Journal of Technology Management*, *63*(1/2), pp.4-23.

[39] Pieroni, M.P., McAloone, T. and Pigosso, D.A., 2019. Business model innovation for circular economy and sustainability: A review of approaches. *Journal of cleaner production*. *215*, pp.198-216.

[40] Burnet, F., 2019, Take Charge, An analysis of the domestic electric vehicle tariff market, Citizens Advice, Accessed Online January 2021, Available at: https://www.citizensadvice.org.uk/Global/CitizensAdvice/Energy/Take%20Charge%20-%20EV%20tariff%20report.pdf

[41] Hahnel, U.J., Herberz, M., Pena-Bello, A., Parra, D. and Brosch, T., 2020. Becoming prosumer: Revealing trading preferences and decision-making strategies in peer-to-peer energy communities. *Energy Policy*, *137*, p.111098.

[42] ESP Consulting, 2018, Retail Research into Customer Switching and Supply Disintermediation Final Report Disintermediation, July 2018, Accessed online May 2nd 2019 at: https://www.ofgem.gov.uk/system/files/docs/2018/07/retail_research_-_report_on_supply_disintermediation.pdf

[43] Brown, D., 2018. Business models for residential retrofit in the UK: a critical assessment of five key archetypes. *Energy Efficiency*, *11*(6), pp.1497-1517.

[44] Davis FD (1989) Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q 13(3):319–340

[45] Curtius, H.C., Künzel, K. and Loock, M., 2012. Generic customer segments and business models for smart grids. der markt, 51(2-3), pp.63-74.

[46] Fell, M.J., Shipworth, D., Huebner, G.M. and Elwell, C.A., 2015. Public acceptability of domestic demand-side response in Great Britain: The role of automation and direct load control. *Energy research & social science*, *9*, pp.72-84.

[47] Venkatesh, V. and Davis, F.D., 2000. A theoretical extension of the technology acceptance model: Four longitudinal field studies. Management science, 46(2), pp.186-204

[48] Rogers, E.M. (1995). Diffusion of Innovations. 4th ed., New York: The Free Press

[49] Ajzen, I. (1991). The Theory of Planned Behavior. Organization Behavior and Human Decision Processes, Academic Press, Inc. 179-211

[50] Pavlou, P.A., 2003. Consumer acceptance of electronic commerce: Integrating trust and risk with the technology acceptance model. International journal of electronic commerce, 7(3), pp.101-134

[51] Agarwal, R. and Prasad, J., 1998. A conceptual and operational definition of personal innovativeness in the domain of information technology. Information systems research, 9(2), pp.204-215

[52] Agnew, S. and Dargusch, P., 2017. Consumer preferences for household-level battery energy storage. *Renewable and Sustainable Energy Reviews*, *75*, pp.609-617.

[53] Xu, X., Chen, C.F., Zhu, X. and Hu, Q., 2018. Promoting acceptance of direct load control programs in the United States: Financial incentive versus control option. *Energy*, *147*, pp.1278-1287.

[54] B. Sütterlin, T.A. Brunner, M. (2011) SiegristWho puts the most energy into energy conservation? A segmentation of energy consumers based on energy-related characteristics *Energy Policy*, 39, pp. 8137-8152

[55] Albert A, Rajagopal R. Smart meter driven segmentation: what your consumption says about you. IEEE TransPower Syst 2013;28(4):4019–30. http://dx.doi.org/10.1109/TPWRS.2013.2266122

[56] B. Sütterlin, T.A. Brunner, M. SiegristWho puts the most energy into energy conservation? A segmentation of energy consumers based on energy-related characteristics *Energy Policy*, 39 (2011), pp. 8137-8152

[57] Moon, N. and McHugh, S. (2015) Energy Market Investigation. Technical Report on a survey conducted for the Competition and Markets Authority by GfK NOP. GfK. February 2015.

[58] Mazur, C., Hall, S., Hardy, J. and Workman, M., 2019. Technology is not a Barrier: A Survey of Energy System Technologies Required for Innovative Electricity Business Models Driving the Low Carbon Energy Revolution. *Energies*, *12*(3), p.428.

[59] Littlechild, S., 2019. Promoting competition and protecting customers? Regulation of the GB retail energy market 2008–2016. *Journal of Regulatory Economics*, *55*(2), pp.1-33.

[60] Barton, C., (2017) Home ownership & renting: demographics, House of Commons Briefing Paper Number CBP 7706, 9 June 2017 Home ownership & renting: demographics, House of Commons Library.

[61] Stenner, K., Frederiks, E.R., Hobman, E.V. and Cook, S., 2017. Willingness to participate in direct load control: The role of consumer distrust. *Applied energy*, *189*, pp.76-88.

[62] Perlaviciute, G. and Steg, L., 2014. Contextual and psychological factors shaping evaluations and acceptability of energy alternatives: integrated review and research agenda. *Renewable and Sustainable Energy Reviews*, *35*, pp.361-381.

[63] DECC (2012a) DECC Public Attitudes Tracking Survey – Summary of Key Findings. Department of Energy and Climate Change. September 2012.

[64] Demski, C., Butler, C., Parkhill, K.A., Spence, A. and Pidgeon, N.F. (2015) Public values for energy system change. Global Environmental Change, 34, pp.59-69

[65] Sehic, S., Ashworth, P. and Harris, J. (2017) Understanding the socio-economic challenges for energy storage uptake. The University of Queensland, Australia. March, 2017.

[66] DECC (2012b) DECC Public Attitudes Tracking Survey – Wave 2 Questionnaire. Department of Energy and Climate Change. September 2012.

[67] TNS BMRB (2016) Consumer engagement in the energy market since the Retail Market Review. 2016 Survey Findings. Report Prepared for Ofgem. August 2016.

[68] Waring, B., Silk, A. and Waring, G. (2017) Consumer Engagement in the Energy Market 2017. Report on a survey of energy consumers on behalf of OFGEM. GfK. September 2017.

[69] Henry, G.T. (1990) Practical sampling. Sage, Newbury Park, CA.

[70] DfWP (2017) Households Below Average Income: An analysis of the UK income distribution: 1994/95-2015/16. Department for Work and Pensions, London, UK.

[71] NRS (2018) Scotland's Census 2011, last accessed at http://www.scotlandscensus.gov.uk/ on 23/02/2018. National Records of Scotland, Edinburgh.

[72] ONS (2017) Census 2011, Data last accessed 27/02/2018 at https://www.nomisweb.co.uk. Office of National Statistics, London.

[73] De Vellis, R.F. (1991) Scale Development: Theory and Applications Applied Social Research. Method Series, Volume 26, Sage, Newbury Park, California

[74] Costello, A.B. and Osborne, J.W. (2005) Best Practices in Exploratory Factor Analysis: Four Recommendations for Getting the Most from Your Analysis. Practical Assessment Research and Evaluation, 10(7), July 2005.

[75] Gorsuch, R. L. (1983). Factor analysis (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

[76] Hair, J., Anderson, R., Tatham, R. and Black, W. (1998) Multivariate Data Analysis Prentice Hall: New Jersey

[77] Sarstedt, M. and Mooi, E. (2014) Cluster Analysis, A Concise Guide to Market Research. Springer, Berlin, Heidelberg

[78] Anable, J. (2005) Complacent Car Addicts or Aspiring Environmentalists? Identifying Travel Behaviour Segments Using Attitude Theory. Transport Policy, 12(1): 65-78.

[79] Milligan, G.W., Cooper, M.C. (1985) An examination of procedures for determining the number of clusters in a data set. Psychometrika 50 (2), 159-179.

[80] Hall, S., Mazur, C., Hardy, J., Workman, M. and Powell, M., 2020. Prioritising business model innovation: What needs to change in the United Kingdom energy system to grow low carbon entrepreneurship?. *Energy Research & Social Science*, *60*, p.101317. https://doi.org/10.1016/j.erss.2019.101317