SUSTAINABLE ENERGY AUTHORITY OF IRELAND

User engagement with demand flexibility and smart energy services

Results from an online experiment

SEAI Behavioural Economics Unit

Behavioural insights for policy: primary research

Rialtas na hÉireann
Government of Ireland

User engagement with demand side flexibility and smart energy services

Results from an online experiment

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Sustainable Energy Authority of Ireland
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Executive summary

Background

Periods of high electricity demand put pressure on the grid and can reduce the share of generation from renewable sources. One way to address the issue is to encourage demand side flexibility, i.e. time-shifting of demand so that it is more evenly distributed or aligns with periods of low grid emissions. The extent to which the public are aware of the issue, or how they feel about being asked to be time-flexible, is unknown. Smart energy services, such as meter data provision and time-based tariffs are examples of mechanisms to aid this flexibility.

This study uses an experimental design to:

- find engaging ways to frame the topic of smart energy and demand flexibility,
- find motivations most associated with intentions to reduce peak-period use and consider alternative tariffs.

We also investigate associations between these intentions and sociodemographic, lifestyle, and psychological factors.

Main Findings

People want insight into their energy use and report strong flexibility intentions:

- People were significantly more likely to choose smart energy from a list of topics when it was framed as providing the ability to understand use and control bills. And when asked to list benefits unprompted, the most common were related to insights, monitoring and bills.
- Positivity about smart energy and related intentions was high across the board. Factors most associated with greater intentions to be flexible were perceived fairness of being asked to shift consumption, supplier trust, and time availability.
- Some activities are more amenable to flexibility than others. For example, people were willing to time-shift most of their dishwashing and laundry activity, but generally willing to time-shift a smaller share of their cooking activity. However, because cooking is the most prevalent evening activity and many are willing to sometimes reduce peak cooking by time-shifting, batch-cook, or using air fryers rather ovens, there is large potential for flexibility in cooking activity as well as dishwashing, laundry, and water-heating, amongst others.

Environmental benefits of smart energy and demand flexibility are important to people, but largely unknown:

- About 3 in 4 people were unaware of the potential to increase the use of renewable energy.
- Awareness of this benefit was associated with greater intentions to reduce peak use, as well as consider time-based tariffs and (hypothetically) direct load control.

Current monetary incentives are inadequate:

- Those who stated reduced bills as a benefit did not have greater intentions to reduce peak use, which might be due to low expected savings.
- Most reported monetary savings as the most important benefit of smart energy, but about 71% thought the savings associated with time-based tariffs were smaller than they required to make the switch.

Time-shifting information can backfire; reported intentions to reduce overall peak consumption were slightly lower among those who read information compared to those that didn't. It is possible that knowing the benefits of time-shifting can somewhat reduce the perceived importance of overall consumption reduction.

We make the following recommendations based on the findings above:

Recommendations for all stakeholder groups

1. Focus communication campaign taglines on the ability to monitor use and control bills to effectively draw people to the topic and learn more about it.
2. Clearly communicate how and emphasise that flexibility can reduce grid emissions. Few people are currently aware of this benefit but those who are aware have the strongest intentions to engage.
3. Ensure the public is not left with the impression that time-shifting consumption is a substitute for reducing it; it should instead supplement it.
4. Communicate that there are several ways to engage – not everyone has time to make certain changes, but most will be able to do some. Promoting awareness of automated functions on appliances may also be beneficial. Additionally, a majority of people were willing to hypothetically cede control of appliances to suppliers, particularly if an opt-out mechanism is given.

ESBN and SEAI

5. Test, develop, and promote effective ways of showing people when and how much electricity they are using and inform them when is best to do so. People want this information, and evidence – including in an Irish context – for the general effectiveness of in-home energy use displays and indicators in reducing consumption (especially, but not only at peak) is strong.

Suppliers and regulators

6. Find ways to increase the competitiveness of supplier tariff offerings. Current peak to off-peak ratios are slight and incentives to shift are small for anyone without an EV or ability to adopt day-night tariffs. Attempts to engage people with demand flexibility through monetary promises may be dubious in the current context, and open to backfire if these promises are not fulfilled. In the context of CRU's mandate to protect consumers, regulation is required to ensure that fair opportunities to benefit from flexibility are provided to all customers.
7. Provide risk-free mechanisms for consumers to switch tariffs. For example, ToU tariff uptake would likely increase if customers were guaranteed not to pay more per kWh used for an initial period. The subsequent effectiveness of ToU tariffs in reducing peak consumption would also be improved because greater ratios between peak and off-peak rates (the most important factor in their effectiveness) could be offered, thus making the desired outcomes substantially more likely than they currently are.

1. Introduction

1.1. Background

Electricity demand fluctuates across the day. Periods of high demand – or "peaks" – are problematic for multiple reasons. One is that they make it harder to increase the share of renewable generation, because when demand is high, fossil fuels are required to bridge the gap, while wind and solar supply are less reliable. Current energy storage technology is not adequately advanced to retain enough wind and solar supply from times when it is plentiful. A more viable option is to is to try to manage demand so that it is more evenly distributed across the day and aligns better with renewable generation.

The most notable peak in electricity demand in Ireland tends to occur in the evening, generally from around 5pm to 7pm. About half of this peak demand is residential.[1] ESB Networks has run campaigns that reward users for reducing peak-time activity ("Beat the Peak"; and "Is this a good time?")[2]. But outside of these initiatives and promotion of non-standard tariffs, it is unclear to what extent the public at large are aware of peaks and their consequences for the grid and generation emission factors. Asking people to think about when they use electricity is a significant shift from only considering how much – it requires a much greater level of active and involved engagement. Smart meters enable electricity users to see what they are using and when (and ESB Networks' nationwide roll-out of smart meters is about 80% complete). But along with this capability, a degree of openness to doing activities at different times is required. We refer to this as demand flexibility. A more formal definition describes demand flexibility as "a change with respect to a 'counterfactual' or 'baseline' profile" of consumption.[3]

SEAI is working to make demand flexibility easier for people to understand and engage with through the development of a "Smart Energy Users' Hub," a platform where users will be able upload their meter data, learn how to use it, and to engage with smart energy more broadly. To help inform this and other initiatives, SEAI's Behavioural Economics Unit is working to understand the factors and activities that underlie timing of energy use. This study investigates what people currently understand about demand flexibility and uses an experimental design to find the most effective ways to frame the topic, such that people want to learn more and engage. We also measure the strength of different motivations they might have for doing so.

1.2. What does it mean to be demand flexible?

Demand flexibility is not one unitary behaviour; it is instead (an openness to) changing how or when one uses electricity, which encompasses a very wide range of behaviours. It is not easy to categorise these into subtypes. Grunewald & Diakonova (2018) make a useful distinction between "appliance led" and "practice led" forms of demand flexibility but note that this distinction can often be fuzzy depending on the behaviour in question.[3]

For our purposes, it is enough to list ways in which people can engage in demand flexibility. People can:

- shift the time at which appliances are run (with or without the use of timers and/or smart technology)
- substitute appliance type (e.g. using an air fryer instead of an oven)
- do the activity by hand (e.g., air dry clothes rather than using a tumble dryer)
- or sometimes avoid doing an activity at all.

People can also – or will be able to in future – cede some control to their supplier. Signing up for a time-of-use (ToU) tariff, that provides different price signals at peak, shoulder, and off-peak times is ultimately a reward mechanism as opposed to demand flexibility itself. But it is also generally used as a measure of engagement with demand flexibility and is an action of interest also.

[1] Eirgrid (2022). Ireland Capacity Outlook 2022-2031. https://cms.eirgrid.ie/sites/default/files/publications/EirGrid_SONI_Ireland_Capacity_Outlook_2022-2031.pdf
[2] ESB Networks: https://www.esbnetworks.ie/who-we-are/beat-the-peak/is-this-a-good-time
[3] Grunewald, P., & Diakonova, M. (2018). Flexibility, dynamism and diversity in energy supply and demand: A critical review. *Energy Research & Social Science, 38*, 58-66. https://doi.org/10.1016/j.erss.2018.01.014

Some of the above actions are carried out not for the purpose of demand flexibility specifically but instead for reasons of timesaving, convenience, or more general demand reduction. Certain authors have argued that flexibility should be more tightly circumscribed to exclude those cases. We are less strict for this study as our concerns are more pragmatic, and less definitional: what we aim to investigate is the broad degree of openness to any actions or decisions that shift electricity from or reduce it at a "baseline" time of day.

1.3. Engagement with demand flexibility

1.3.1. Framing of benefits

Most efforts to increase demand flexibility have involved trying to move people to tariffs that incentivise consumption reduction during certain times. When surveyed, people in Ireland tend to respond positively to time-varying rates,[4] but real-world uptake of ToU tariffs is low.[5] In a systematic review of engagement with demand flexibility, Parrish et al. (2020) note that financial benefits are usually stated as most important,[6] but evidence for the effectiveness of ToU tariffs for changing consumption behaviour is mixed.[7,8,] It is possible that monetary benefits are stated most often simply because those are the benefits most known about as opposed to them having the greatest potential for motivation. If people remain unaware of additional benefits to flexibility, then the savings associated with ToU tariffs remain the only well-known and advertised benefit, then those savings would need to be large to carry this burden and have the required widespread effects.

A trial conducted by the Commission for Regulation of Utilities (CRU) in 2011[9] (when it was the Commission for Energy Regulation) found significant effects on consumption, but the differences in peak and off-peak rates of the tariffs that they tested were all larger than current (May 2025) market offerings; the highest day to peak ratio currently available is 1.39. The size of the difference between peak rates and off-peak rates is a crucial factor in the effectiveness of these tariffs – smaller differences provide much smaller potential for savings and are less effective, if at all.[10] Given that peak to off-peak rate ratios in the Irish market are so small, attempts to engage people with demand flexibility through monetary promises may be dubious in the current context, and open to backfire if these promises are not fulfilled.

A related benefit of smart energy services on a surer footing, however, is the insight into consumption and control over bills that they can provide. Indeed, the CRU Smart Metering trial mentioned above found that the ToU tariffs were substantially more effective in reducing peak demand in groups who were given an electricity monitor and in-home display.[9] Similar benefits of in-home displays or energy-consumption indicators have been found in a range of different settings.[11,12,13,14] But prior motivation and attitudes are essential moderators of the effectiveness of these devices.[15]

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[4] Barjaková, M., et al. (2024). Effective communication of time–of–use electricity tariffs: Plain and simple. *Utilities Policy*, *90*, 101798. https://doi.org/10.1016/j.jup.2024.101798

[5] Nicolson, M. L., Fell, M. J., & Huebner, G. M. (2018). Consumer demand for time of use electricity tariffs: A systematized review of the empirical evidence. *Renewable and Sustainable Energy Reviews*, *97*, 276-289. https://doi.org/10.1016/j.rser.2018.08.040

[6] Parrish, B., Heptonstall, P., Gross, R., & Sovacool, B. K. (2020). A systematic review of motivations, enablers and barriers for consumer engagement with residential demand response. *Energy Policy, 138*. https://doi.org/10.1016/j.enpol.2019.111221

[7] Lavin, C. & Julienne, H. (2025). Household activities underlying residential electricity demand: who does what during the evening peak? Forthcoming in the *Journal of Energy Efficiency*.

[8] Burns, K., & Mountain, B. (2021). Do households respond to time-of-use tariffs? evidence from Australia. *Energy Economics*, *95*, 105070. https://doi.org/10.1016/j.eneco.2020.105070

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[10] Faruqui, A., Sergici, S., 2013. Arcturus: international evidence on dynamic pricing. *The Electricity Journal. 26* (7), 55–65. https://doi.org/10.1016/j.tej.2013.07.007

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[14] McKerracher, C., & Torriti, J. (2013). Energy consumption feedback in perspective: integrating Australian data to meta-analyses on in-home displays. *Energy Efficiency*, *6*(2), 387-405. https://doi.org/10.1007/s12053-012-9169-3

[15] Oltra, C., et al. (2013). A qualitative study of users' engagement with real-time feedback from in-house energy consumption displays. *Energy Policy*, *61*, 788-792. https://doi.org/10.1016/j.enpol.2013.06.127

Environmental benefits of demand flexibility have received little attention by comparison.[6] People do demonstrably value power system emissions reductions,[16] and research has shown that environmental framing can be more effective than monetary framing in promoting pro-environmental intentions[17] and engaging younger people with ToU tariffs.[4] Another study found no difference in outcome between participants for whom ToU tariffs were framed (a) solely in terms of savings and (b) in terms of both savings and environmental benefits.[18] However, across the sample, the actual perception that enrolling in the programme would contribute to environmental positives was the strongest predictor of enrolment.

In sum, while the public appear to be positive in general when asked about smart energy services, it is as yet unclear how best to frame their benefits to drive engagement. Moreover, what initially draws people to the topic most effectively may not be the same as what holds their attention or affects their subsequent behaviour – particularly given that many will be unaware of some benefits and not others until they read about them.

1.3.2. Fairness, flexibility capital and capacity

While the environmental benefits of smart energy will benefit everyone (by and large), the monetary benefits may not. It is important to remember that when asking people to shift consumption, and then rewarding them for it, some are more easily able to do so than others.[19] For example, people with certain illnesses or disabilities will have less access to potential financial reward.[20] Further, accessibility to low carbon technologies that can enable flexibility potential is not equal due to high investment costs and as such, there is potential for flexibility to deepen existing economic inequality.

Separately, it is important to remember that many people have a poor understanding of what activities are most energy-intensive, their own consumptions patterns, and the nature of market tariffs. They are very often unable to choose the best tariff for themselves.[21]

Another factor that affects a person's ability or capacity to be flexible is their routine. The ways that routines affect flexibility are not always straightforward. For instance, flexible working hours enable demand flexibility, and more time spent outside the home might make flexibility in the timing of household activity more difficult, if the time spent at home coincides with peaks or when grid emissions are high.[8] Parents and certain shift workers will likely be less flexible in their time-of-use than others. Many household practices are tied to routine, constrained by social aspects, time-sensitive, and interwoven with habits. This compounds the issues of fairness around asking people to change the timing of their activities and has led some to caution against too much optimism that enough people will do so.[22]

A related issue around fairness is the source of the need for demand side flexibility. We mentioned earlier that residential use accounts for about half of evening peak demand, but a sizeable portion ‐ and one of the primary sources of grid pressure ‐ comes (increasingly) from data centre consumption.[23] In the context of climate action (amongst others) most people are conditional co-operators ‐ they will do what they perceive as their fair share so long as they think others are doing so too; this is more likely when the system in which they are acting has fair rules and consequences for those who don't follow them.[24]

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[16] Ruokamo, E., Kopsakangas-Savolainen, M., Meriläinen, T., & Svento, R. (2019). Towards flexible energy demand–Preferences for dynamic contracts, services and emissions reductions. *Energy Economics, 84*, 104522. https://doi.org/10.1016/j.eneco.2019.104522

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[20] White, L.V., Sintov, N.D., (2020). Health and financial impacts of demand-side response measures differ across sociodemographic groups. *Nat. Energy* 5, 50–60. https://doi.org/10.1038/s41560-019-0507-y

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[22] Friis, F., & Christensen, T. H. (2016). The challenge of time shifting energy demand practices: Insights from Denmark. *Energy Research & Social Science*, *19*, 124-133. https://doi.org/10.1016/j.erss.2016.05.017

[23] Friends of the Earth (2024) https://www.friendsoftheearth.ie/publications/data-centrres-and-the-carbon-budgets-prof-hannah-daly-dec-20/

[24] EPA (2024) https://www.epa.ie/publications/monitoring--assessment/climate-change/encouraging-cooperation-in-climate-collective-action-problems.php

In Ireland, data centres use what would be considered by reasonable people as a disproportionate amount of energy. Awareness of this might reduce perceptions of fairness and the likelihood that a given person will partake in the beneficial actions. Justice and fairness perceptions have been shown to be important for intentions to be flexible with the timing of EV charging.[25]

1.3.3. Characteristics of information and communications

Generally speaking, people have poor intuitions about the energy intensity of different activities.[26,27,28] It is also the case that some household activities are more amenable to flexibility than others.[29,30,31] Taken together, these two facts suggest that information and communications about demand-side flexibility that are activity-specific will be more beneficial than information and communications that are general. Indeed, climate communications in general are most effective when they provide specific actions for people to take as opposed to merely stating the broad goals. In other words, they should include an action-perspective. For instance, rather than stating that household activity or consumption could be curtailed at certain times, information that provides specific means and mechanisms should be more effective in producing action.[32]

1.4. Aims and research questions

Meaningfully increasing the share of generation that comes from renewables requires demand side flexibility and engagement with smart energy services. But it is unclear what, if anything, people in Ireland currently think about the topic, whether they know the benefits of flexibility, how open they might be to it, and the strongest motivations they might have for engaging with it. Moreover, there are a multitude of ways in which to engage; preferred ways in which to be flexible might vary between the many different activities that use electricity.

This work aims to shed light on these evidence gaps. We used a multi-stage experimental design, in which participants respond to different framings of the topic of smart energy and different versions of information about it. By randomly assigning which framing or version a participant sees and assessing differences between participant groups in subsequent responses, we can better understand what is effective for driving engagement.

We investigate the following research questions:

1) Does framing the topic of smart energy in terms of (a) collective environmental and energy security benefits or (b) consumption insights and monitoring & control of bills benefits change how much people's attention is drawn to the topic (as measured by their likelihood of choosing it from a list of potential topics to read about), compared with when no benefits are mentioned upfront?

2) When smart energy information is framed in terms of collective environmental and energy security benefits, compared to when the same information is framed in terms of consumption insights and control of bills benefits:
    a. is the level of engagement with the information different?
    b. are intentions to be flexible with the timing of electricity use and engage with smart services and products different?

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[32] De Vries, G. (2020). Public communication as a tool to implement environmental policies. *Social Issues and Policy Review*, *14*(1), 244-272. https://doi.org/10.1111/sipr.12061

3) Are flexibility intentions different when people are given specific actions that people can take compared to when more general advice is presented?

4) Does information about substantial electricity demand of data centres, by changing perceptions of fairness in being asked to be time-flexible, influence intentions to be flexible with the timing of electricity use?

In addressing these questions, the study aims to inform communications and programmes geared towards promoting demand side flexibility.

2. Method

2.1. Sampling and data collection

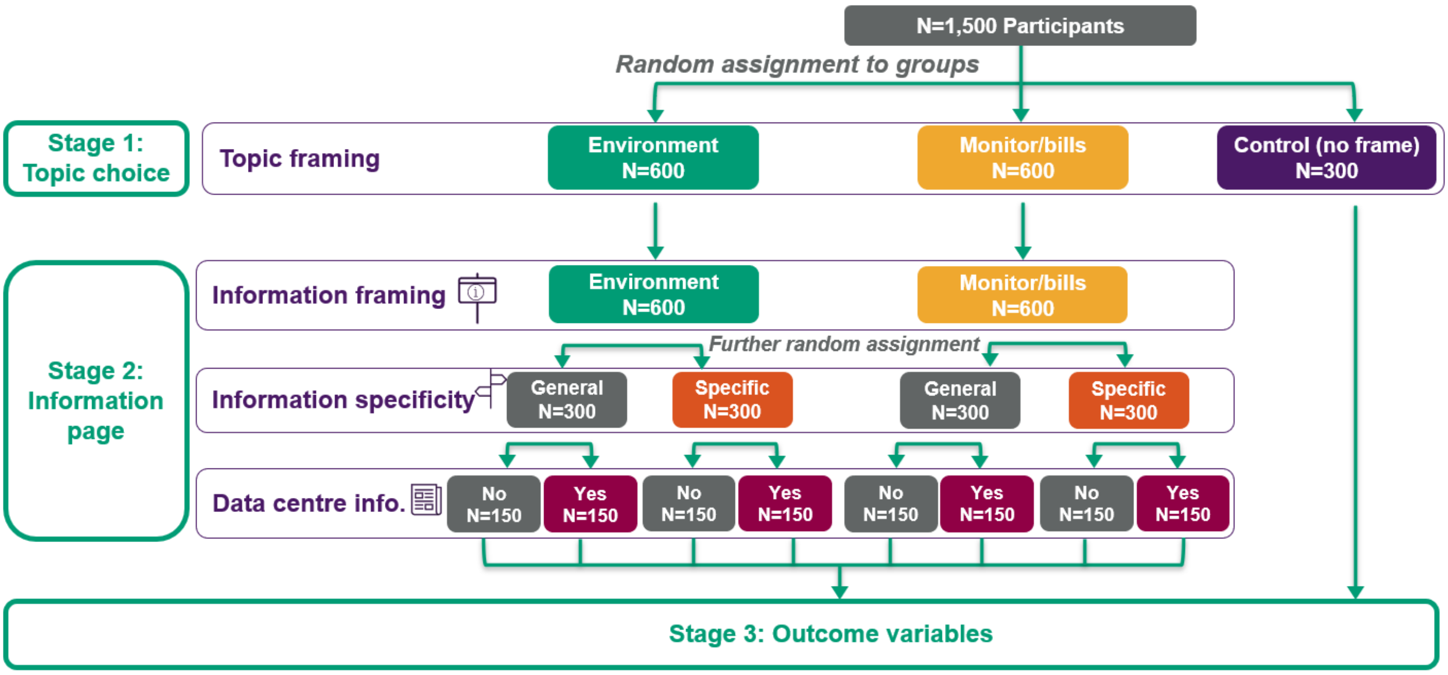
A sample of 1,500 participants was recruited from the online panel of a market research company over the course of a week in May 2024. The sample was selected to be approximately nationally representative of the adult Irish population in terms of gender, age, geographical region, and social grade. The study was programmed using Gorilla Experiment Builder[33] and sent to participants electronically. They could complete it on a computer, tablet, or smartphone and were paid a financial incentive (€4) for their time.

2.2. Study design

The study was a three-stage experiment, as outlined in Figure 1. Participants were first asked to select energy related topics to learn more about, they then read further information about the topic of smart energy in particular, and finally they responded to a series of questions designed to gauge their level of engagement, perceptions and intentions, as well as factors that might influence these. Further detail on all three stages is given below.

Participants were randomly assigned to one of three experiment groups throughout the study. For the first group, the topic of smart energy was framed in terms of environmental benefits. For the second, the ability to understand their energy use and control bills was emphasised. We refer to these two groups as the treatment groups. The third group was a control group for whom the topic was not framed in any particular way, and who were not shown the information page.

Figure 1. Schematic summary of the study design.



[33] Anwyl-Irvine, A.L. et al. (2020). Gorilla in our midst: An online behavioral experiment builder. Behavior research methods, 52(1), 388-407. https://doi.org/10.3758/s13428-019-01237-x

2.2.1. Stage 1 – Topic selection

Stage 1 was designed to answer our first research question about which framing is most effective for drawing people to the topic of smart energy. Participants were shown a page with three different energy-related topics. One of them was the topic of interest to the study, which we displayed as "Smart energy". The others were "Nearly zero energy buildings" and "Community electricity generation" - we refer to these latter two as the distractor topics. Participants were instructed to click on the topic that they were most interested in to learn more. When a participant selected a topic, they were shown a brief two-line summary before being brought back to the original page again where they had to choose a second topic to learn more about. [34] As a measure of how well frames draw people to the topic, we recorded the order of selection of the smart energy topic (first, second or last). This was our *initial engagement* stage.

Experimental manipulations

Benefits framing

All participants did the task as described above but were randomly assigned to see the topic of smart energy framed in one of three distinct ways:
1) in terms of its environmental benefits (treatment group 1),
2) in terms of its monitoring & control of bills benefits (treatment group 2), or
3) not framed in terms of benefits at all (control group).

For each group, the distractor topics had alternative framings, randomly assigned to each of the two topics. For example, in the control group, the distractor topics were framed in terms of environmental benefits and monitoring/bills benefits at random. In addition, the presentation order of topics themselves was randomised.

Table 1 details how smart energy was framed under each condition. An example of the full topic selection page that participants viewed can be seen in Appendix A.

Table 1. Framing of the smart energy topic under each experimental condition.

Condition	Topic description
Control group	Smart energy – the way we use energy is changing.
Treatment group 1 (Environmental benefits)	Smart energy – small changes we can all make for a cleaner, more reliable energy supply.
Treatment group 2 (Monitoring, insights & bills benefits)	Smart energy – understand your energy use and take control of your bills.

2.2.2. Stage 2 – Information page

In stage 2, participants in the treatment groups were presented with a page of information about smart energy, framed in the same way as it had been in stage 1. Participants in the control group did not view the information page and instead went straight to stage 3.

The information page included basic information on what smart meters are, what they allow users to see and do, the benefits of reducing use at peak times, and how to do so. There were also two boxes that participants could click on to reveal further information about time-of-use tariffs and technologies that facilitate demand flexibility. We recorded whether participants chose to click on these boxes. We also recorded the amount of time each participant spent reading the information.

[34] Participants who selected the smart energy topic were presented with the following before moving to the next stage: *As the need for electricity grows in Ireland, we need to be smarter about how and when we use it. Smart energy refers to the use of smart devices and services (like smart meters) that help us use energy more efficiently.*

Experimental manipulations

As with the topic choice task, different groups of participants saw different versions of the information page. Three aspects of the page were varied:

1. The types of benefits that were emphasised and foregrounded (in line with the framing in stage 1)
2. Whether information about the electricity consumption of data centres was present or not; and
3. Whether the advice on how to reduce household consumption during the evening peak period was general or specific in nature.

There were two variations of each of the three aspects, and we varied them orthogonally. This resulted in eight (2 x 2 x 2) different versions of the information page. Examples of the information pages are shown in Appendix B. The manipulations are further described below.

Benefits emphasised

All versions of the page contained the same information about the benefits of smart energy, but we varied which type of benefits were emphasised and given prominence on the page, in order to investigate our second research question. For each participant, these were consistent with their stage 1 treatment: for treatment group 1, environmental benefits were emphasised and given spacing prominence. For treatment group 2, the monitoring and control of bills benefits were emphasised.

Specificity of actions provided

In order to investigate our third research question, we also manipulated the specificity of possible demand flexibility actions included in the information. Half the sample saw a list of specific actions they can take, for example waiting until later to turn on the dishwasher, the other half saw only general recommendations to change electricity consumption patterns.

Presence of data centre information

In order to investigate our fourth research question, half the sample saw a version of the information page that included a fact about data centres: “data centres were responsible for 18% of Irelands electricity consumption in 2022, about the same as from all urban homes combined.” This was intended to reduce this group’s perceived fairness of being asked to change their own behaviour.

2.2.3. Stage 3 – Outcome measures and other variables

In stage 3, participants responded to a series of other questions from which remaining outcome measures were constructed. The treatment groups answered questions about their impressions of the information and likelihood to tell others about it. With the exception of those questions, all participants – treatment and control participants – answered all of the questions in this stage. We also included an attention check.

Primary outcome measures: engagement, general intentions and comprehension

We measured topic *engagement* using 7-point ratings scales for 1) the relevance of smart energy to participants personally, 2) their perception of the importance of reducing electricity use at peak times, and 3) their interest in knowing how much electricity their household uses and when.

Participants then rated their likelihood to reduce evening peak by 1) doing fewer activities, 2) shifting timing of use of appliances, and 3) using more efficient appliances. These were our *general intention* measures. Next, participants indicated whether they would switch to a time-of-use tariff or sign up to a ‘direct load control’ contract.[35] Both of these were explained in the questions.

After asking participants to list the main benefits of smart energy (see next section), we then presented a set of multiple-choice questions about smart energy services. Responses to these questions formed our *comprehension* measure. The answers to all of these were contained in the information that the treatment groups had read. The control group answered the same set of questions.

[35] Direct load control (DLC) is when a supplier has the ability to curtail a load by stopping a household from switching on an appliance in the home at a given time, if electricity supply is short. Typically, DLC contracts limit this ability to a few times a month and to one or two appliances. A financial reward is given to the customer, who will generally have the option to opt-out of a given DLC request or event.

Secondary outcome measures: specific preferences, intentions and stated motivations

Prior to the comprehension questions, participants were asked to list the main benefits of smart energy services in an open text response box. We coded responses into five categories: monetary, control/insight, environmental, energy security, other.

Following the comprehension questions, participants reported the frequency with which they use various electrical appliances such as an electric oven, other electrical cooking appliances, dishwasher, washing machine, tumble dryer, iron, immersion, electric shower, and electric heaters at peak times (5 pm to 7 pm). An attention check was incorporated into this task.[36] They then indicated the extent to which they might change the timing of each if it were a little cheaper, better for the environment, or helped avoid an outage. Participants who used an oven at peak indicated the proportion of times they would substitute it with an air fryer. Participants who cooked at peak indicated the extent to which they might batch cook (and therefore cook less frequently). Participants who used a tumble dryer at peak indicated the extent to which they might use alternative clothes drying methods. The response options for these questions about potential changes were "yes – every time", "yes – most times", "yes – occasionally", and "no". We also measured perceived effort involved in changing the timing of each activity on 7-point scales.

We then ask participants about the importance to them of different motivations ("saving money", "reducing carbon emissions", and "lowering the chance of outages") to use less electricity at peak times. Participants then indicated how much money they thought they could save by using less at peak if they switched to a time-of-use tariff as well as indicating the level of savings that would prompt them to do so (for those who had not already switched).

Other measures

The final section of the survey contained questions on psychological and sociodemographic factors that could be related to engagement with demand flexibility.

On 7-point scales, participants indicated:

- their own understanding of how to save energy in day-to-day life.
- how much spare time they typically have and how flexible they perceive their daily routines to be.
- how worried they are about climate change, cost of living, and energy/fuel shortages.
- their level of trust in energy-related bodies.
- how fair they think it is to ask people to change their consumption patterns.
- how conscious they were of their peak-period use before the study.

Finally, they provided household and socio-demographic information including relevant technologies owned, meter and tariff types.

2.3. Analysis

To test our primary hypotheses, we used regression modelling. Specifically, for research question 1, to test the effect of framing on topic choice, we modelled the order of choice of the smart energy topic using an ordinal logistic regression in which the predictor variable was experimental condition. We controlled for the presentation order of the topics. We also included a set of sociodemographic variables in all models: gender, age, education, social grade, income, living situation, and tariff type.

For research question 2a, to test whether presentation and framing of information about smart energy increases engagement about the topic, we ran two ordinal logistic regressions. The first modelled a categorised version of our composite *engagement* measure. The second model used a categorised version of our *comprehension* measure, which we had conceptualised as another form of engagement with the information. For both, experimental frame condition was the primary predictor variable.

[36] Among the list of questions about frequency of appliance use between 5pm and 7pm, a statement read "Select "Less often" to show you are reading carefully." Participants who did not select that option were notified that they failed the attention check and were removed from the study.

In addition to the sociodemographic variables, we added variables to represent pre-existing awareness of smart energy, time flexibility, perceived fairness of being asked to change timing of activity, understanding of energy-saving at home, awareness of benefits (monetary, environmental, grid security) to this and all subsequent models.

For research question 2b, to test whether presentation and framing of information about smart energy increases intentions to be flexible with the timing of electricity use and engage with smart services, we first modelled our *general intentions* measure, again using an ordinal logistic model. We also modelled likelihood to consider a direct load control contract if available using the same model type and independent variables, and we modelled likelihood to consider a ToU tariff, amongst those who did not report having one, using a binary logistic regression.

To investigate the remaining research questions about whether a) data centre information (and thus fairness) and b) the specificity of action advice affected intentions, we added the corresponding experiment group variables to the general intentions model.

All measures, hypotheses and associated analyses were pre-registered.[37]

[37] https://oecd-opsi.org/bi-projects/smart-energy-services-demand-flexibility-engagement-and-preferences/

3. Results

This section addresses each of our research questions in turn. Following a brief overview of relevant sample characteristics, it first describes the results of the topic choice task (stage 1 of the study) to assess effect of framing on initial engagement. It then looks at effects of framing and type of information on the level of engagement with the information pages (stage 2) and reported intentions. It then outlines the levels of specific peak activities reported by the sample, the level of intended change for each one, and the associated perceived effort. We also describe some other measures where appropriate, such as trust, perceptions of fairness, levels of climate worry, and perceived benefits and motivations for demand flexibility.

3.1. Sample characteristics

About 26% of participants reported having a standard meter, while 55% said they had a smart meter installed, which – based on roll-out figures from ESB Networks – indicates that a number of people with smart meters are unaware that they have one. Another 8% said they had a day/night meter, 7% a pay-as-you-go meter, while 4% did not know. One in five participants with a smart meter said they had downloaded or looked at their meter data.

The majority of participants were on a standard flat tariff (58%), while 25% were on a time-based tariff of some type (13% reported being on a night-saver tariff; 5% on a time-of-use tariff; 3% on a special EV tariff, and 5% with a free weekend day tariff). About 10% didn't know what type of tariff they were on. About 10% of participants had solar PV and another 8% had thermal solar. About 5% of participants reported having some battery storage. Finally, 7% of participants owned an EV.

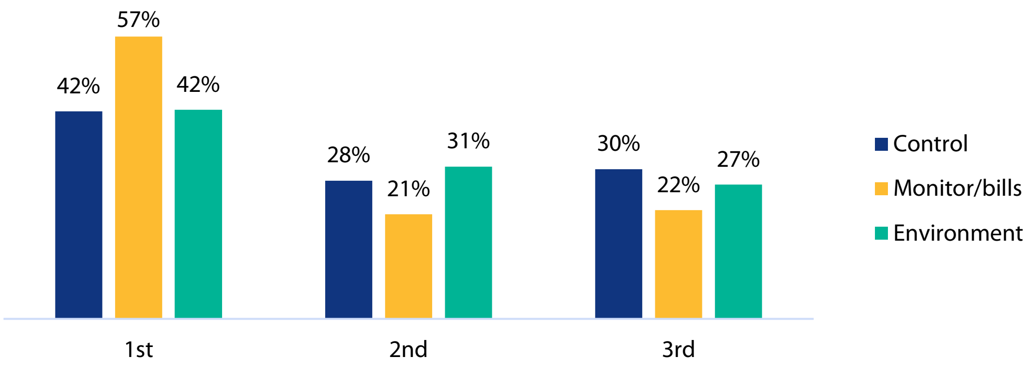
For a full breakdown of sample characteristics in terms of sociodemographic and household composition variables, and energy-related technology owned, see Appendix C.

3.2. Initial engagement with the topic of smart energy

Stage 1 investigated the effect of framing smart energy on the likelihood of choosing to learn more about the topic (research question 1). Participants were asked to select a topic from a list of three to read more about, one of which was smart energy. The topics were each framed in one of three ways according to our three experimental conditions. We recorded the order in which smart energy was chosen and assessed whether the order was different between the three framing groups.

Overall, smart energy was more popular than the other two topics. In the control group (where no framing was applied), it was chosen first by 42% of participants (Figure 2 below). The same proportion chose it first in the environmental benefits condition. Participants in the monitoring, insights & bills benefits condition were significantly more likely to choose it first – 57% did so. Full regression results are shown in Appendix D.

Figure 2. Choice order of smart energy topic by experiment condition.

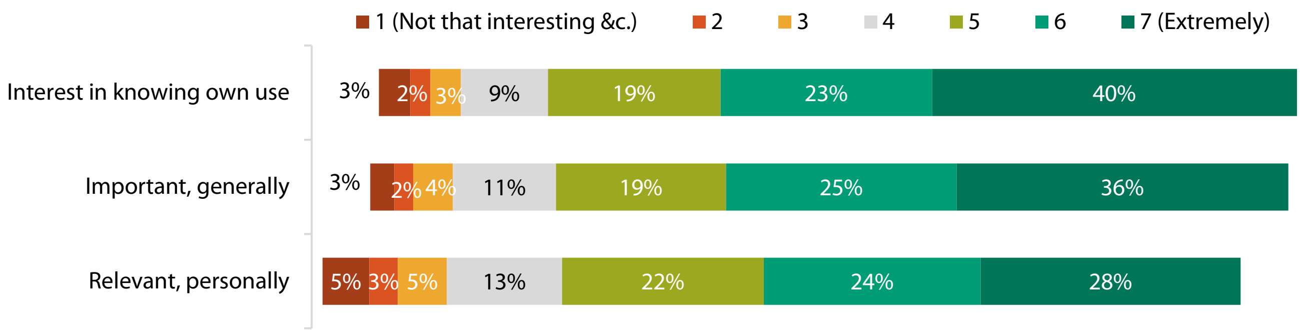


3.3. Continued engagement with information about smart energy

3.2.1. Ratings of relevance, importance, and interest

We constructed multiple different measures of engagement with the information (to address research question 2a). For the first, we took the average of each participant's responses when asked 1) how relevant they felt it was to them, 2) how important reducing peak use is, and 3) how interested they are in knowing how much their own household uses and when. The responses to each of the questions are shown in Figure 3 below.

Figure 3: Participant ratings of a) their interest in knowing about their own consumption, b) how important they think the topic is, and c) how relevant they think it is to them personally.



Participants indicated high levels of engagement – the median for each score was 6. We categorised the averaged variable into three levels for modelling: <=5 was low; >5 but<6.5 was medium; and 6.5+ was high.

Modelling results are summarised in Table 2 below. There were no statistically significant differences between participants in the control group (who did not see the information) and participants in either of the framing conditions (or between the latter; full regression model outputs are shown in Appendix E). The initial heightened engagement with the monitoring, insights & bills frame in stage 1 did not follow through to stage 2 then – if anything, engagement with the information in stage 2 was higher in the environmental benefits condition. Males had lower scores on average on the engagement measures compared to females. So did the youngest group compared to the oldest, and people who lived alone compared to people who lived with others.

3.2.2 Comprehension of information

The second way we measured engagement with information was recording the number of comprehension questions that participants got right. We asked participants questions about accessing off-peak rates, how often smart meters record data, the benefits of smart energy services (before we asked them to rate their importance), energy consumption of data centres, and comparative consumption of air fryers and ovens. All of the relevant information had been contained in the information pages. All questions and responses are shown in Appendix F.

Naturally, participants in the control group had fewer correct answers on average compared to participants who saw the information. Participants in the ABC1 social grade, in the highest income bracket, and who were educated to degree level scored higher than those in the C2DEF, lowest income bracket, and those without a degree, respectively (model 2, Table 2). The youngest group scored worse than the older groups. This was mostly accounted for by time spent reading the information (see model 3, Table 2).

Table 2. Results of ordinal regression model of engagement variables. Full results are in Appendix E.

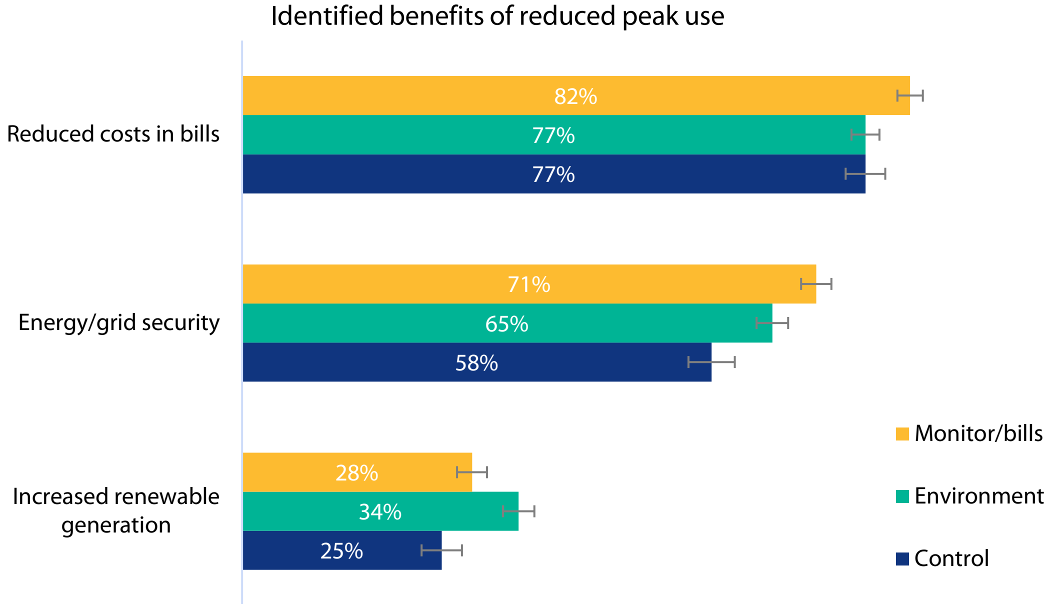
		Model 1: Composite engagement	Model 2: Knowledge score	Model 3: Knowledge among readers
Frame (ref.= Monitor benefits)	Control group		-	n/a
	Environment benefits			
Gender	Male	-		
Age (ref.= 18 - 34)	35 - 54		+	
	55+	+	+	
Education	Degree		+	+
Social grade	C2DEF		-	-
Income (ref.= < 40 k)	40 - 80 k	+		
	80 k +		+	+
Living situation (ref.= single)	Couple	+	-	-
	Family	+		-
	Others	+		-
	Previous awareness	+	+	
	Reading time[38]	n/a	n/a	+

+ positive relationship; — negative relationship

There was no overall significant difference in performance between participants in the two different framing conditions, but people in the environmental benefits condition were more likely to correctly identify the renewable generation share benefit (Figure 5). Identification of this benefit was low overall. Most people correctly identified the potential for reduced bills, and 66% overall identified the potential grid benefit, 58% in control group. Participants in the Monitor/bills groups were more likely to identify the grid security and bills benefits.

[38] At an average reading speed, the information page would have taken approximately a minute or slightly more to read in full. Using that as a rough guide, 57% of participants likely read all or most of the information, 29% partially read it to some extent, while 14% skimmed or skipped through it. There were no differences between experimental groups in time spent on the information page. Males and younger people were more likely to skip through or skim read compared to females and older groups, respectively.

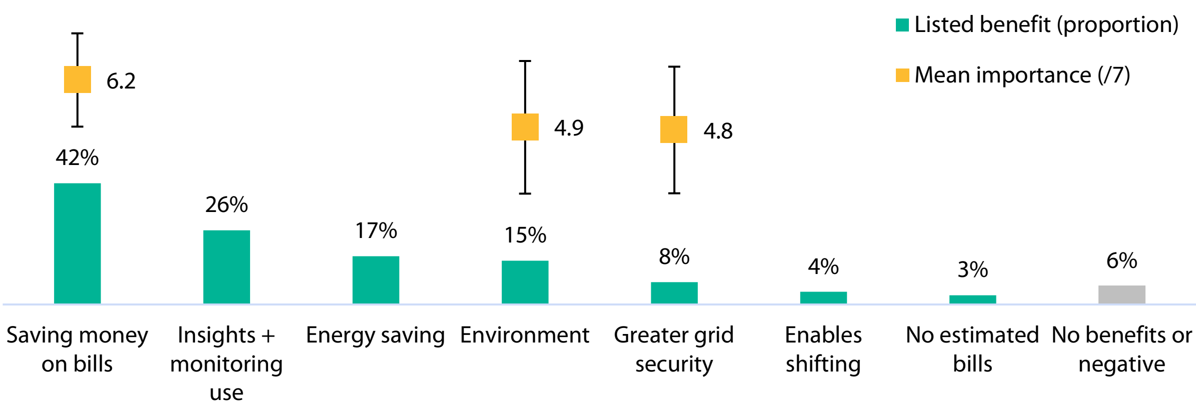
Figure 4. Proportions of sample, by experimental condition, who correctly identified each of three benefits of reducing peak use.



3.2.3 Perceived importance of smart energy benefits

To assess what is most cognitively available to people in terms of smart energy benefits - or in other words what stands out to them - we asked participants (before the above task of identifying them from a given list) to list benefits unprompted in open text boxes. We also asked them to rate the importance of three benefits - a) reduced grid emissions (environment), b) saving money on bills, and c) reduced chance of outage/greater grid security - on 7-point scales. Responses to both questions are summarised in Figure 4. Experimental condition had no effect on the likelihood to list any given benefit or on the perceived importance of any of the three participants rated. Monetary factors were the most commonly mentioned benefit in open text responses. They were also given highest importance ratings. Very few people (~15%) mentioned environmental factors when asked to list benefits, and fewer still mentioned avoiding shortages or grid security. The ability to monitor use and save energy were more common. Only 6% of open text responses were negative about smart energy services or listed no benefits.

Figure 5. Benefits listed by participants in open text boxes and mean importance ratings (on a 7-point scale) for environmental, monetary, and grid security factors. Error bars are standard deviations.



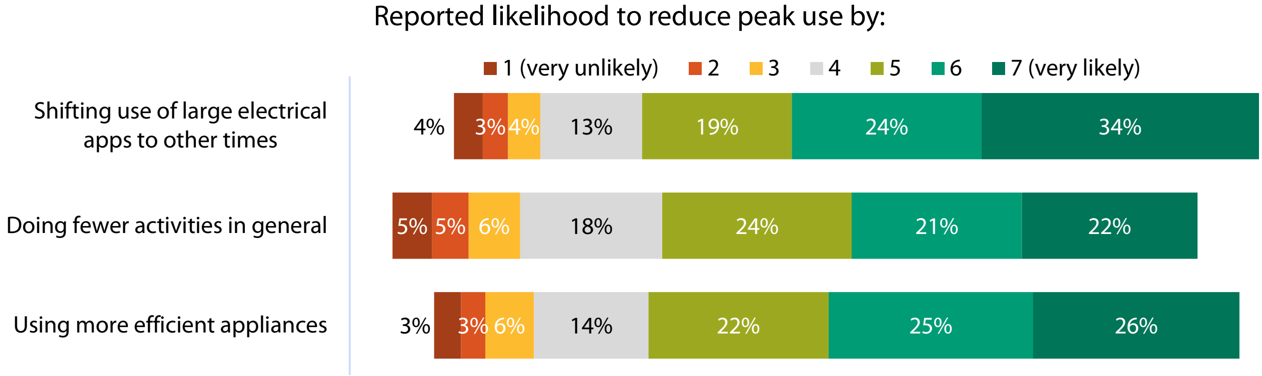
3.4. Intentions

We measured intentions to be flexible and engage with smart services in three different ways to address research questions 2a, 3, and 4: 1) behavioural intentions to shift or shave peak demand; 2) likelihood to consider switching to a time-of-use tariff; and 3) hypothetical likelihood to consider a direct load control contract.

3.4.1. Behavioural intentions to be flexible with demand

We constructed a flexibility intention score by taking the average reported likelihood to consider using less at peak by a) doing fewer activities in general, b) shifting use of large appliances to other times; and b) using more energy efficient appliances. The distributions for each are shown in Figure 6. Overall, intentions were highly positive. Doing fewer activities was the least popular intention – intentions to time-shift appliances were much higher.

Figure 6. Reported intentions to reduce peak period consumption by a) shifting use of appliance to off-peak times, b) doing fewer activities in general, and c) using more efficient appliances.



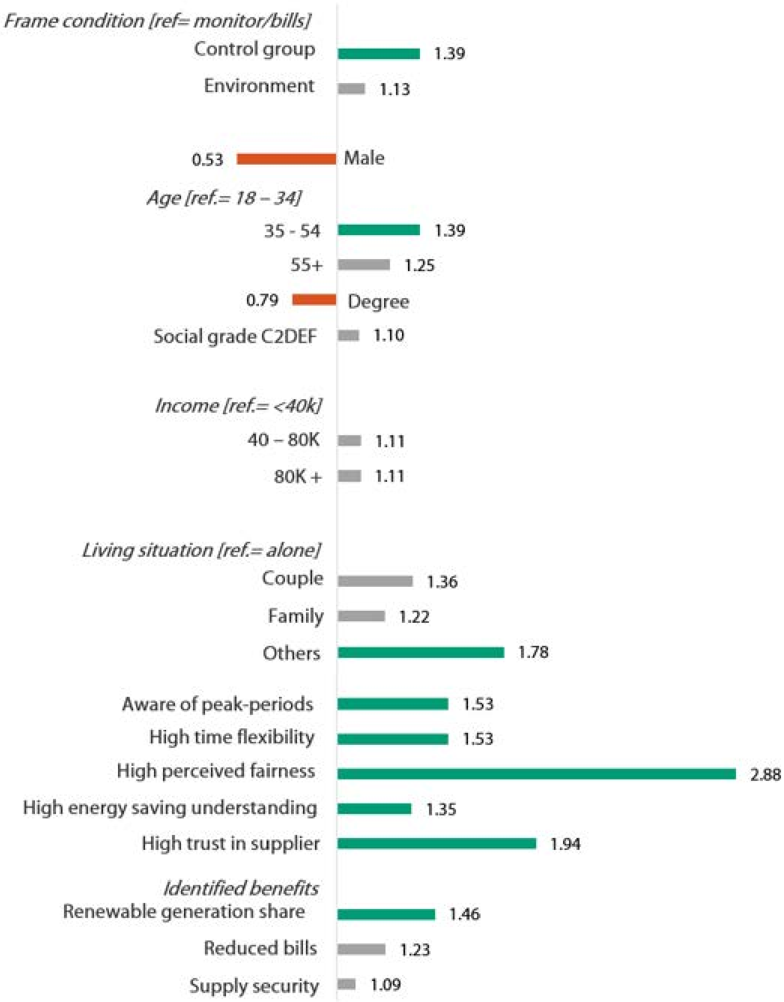
For modelling, we categorised the average score into three levels: low (<4.5), medium, and high (6+). Males and young people reported lesser intentions to be flexible than females and the middle age group (see Figure 7 below; for full regression model outputs, see Appendix G).

We also added our psychological measures to this model,[39] all of which had sizable influences – broadly speaking they showed larger associations with intentions than sociodemographic characteristics. In particular, people who perceived being asked to be flexible as fair and people who trusted their suppliers to provide impartial information had significantly stronger intentions compared to people who felt it was unfair and those who did without high trust in suppliers.

Further, people who indicated a high degree of ability to choose the times of day at which they do things had significantly higher intentions to be flexible with demand. People who had correctly identified the benefit of flexibility to the share of renewables in the comprehension section were significantly more likely to have greater intentions than those who did not identify that benefit. Perceiving a benefit of reduced bills or energy security did not make a difference to these intentions.

[39] Responses to these measures are shown in Appendix H.

Figure 7. Results of ordinal regression model of intentions to reduce peak use. Values shown are odds ratios (a measure of the difference in odds of the outcome between groups). Statistically significant associations are shown in green and red (positive and negative, respectively); non-significant values are in grey.



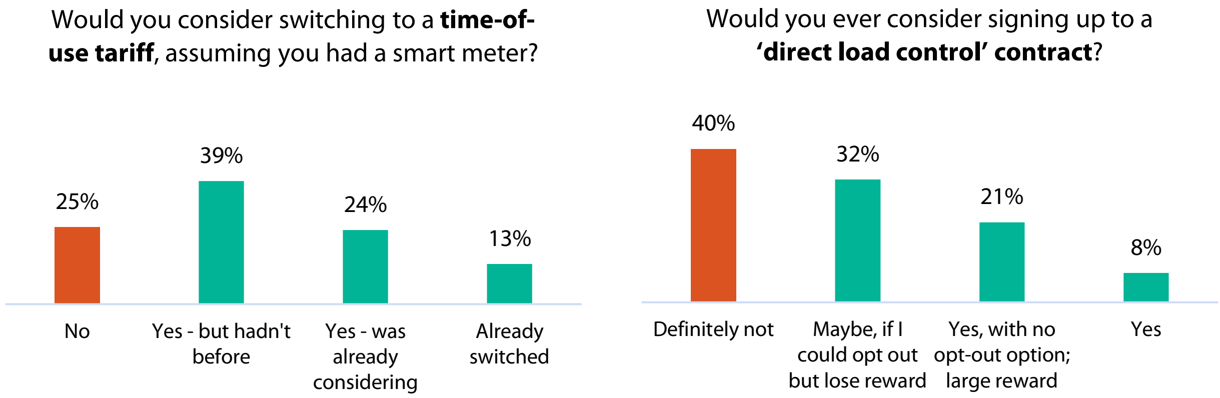
In terms of framing and emphasis, compared to the control group, participants in the Monitor/bills group had lower intention scores on average, indicating that seeing the information was detrimental to intentions to be demand flexible. On further investigation, using separate models for each of the three intention outcomes, this difference was only statistically significant for the intention to do fewer activities in general. There was no difference between the control group and the environmental benefits group.

We added the additional experimental group variables – information about data centre consumption and specificity of action advice – to investigate research questions 3 and 4. Neither manipulation had a significant effect on behavioural intentions to be flexible. We also checked for a (pre-registered) interaction between frame and data centre conditions, which was not present. Full model results are in Appendix G.

3.4.2. Intentions to switch tariff and consider direct load control contracts

Overall, participants were open to TOU tariffs (Figure 8, left) – only a quarter of participants said they would not consider switching to one. Unlike the behavioural intentions above, framing condition made no difference to this (Appendix I); neither did age, income, gender, or social grade. Participants who lived with others were more likely to consider a switch. As with behavioural intentions, perceived fairness of being asked to change consumption timing was the most influential factor on people's intentions, and trust in suppliers was also highly associated with likelihood to consider switching. Knowing that demand flexibility can increase the share of renewable generation was also associated with increased likelihood to consider a TOU tariff. In contrast to intentions to reduce peak use, correctly identifying the potential for reduced bills was significantly associated with intention to change tariff.

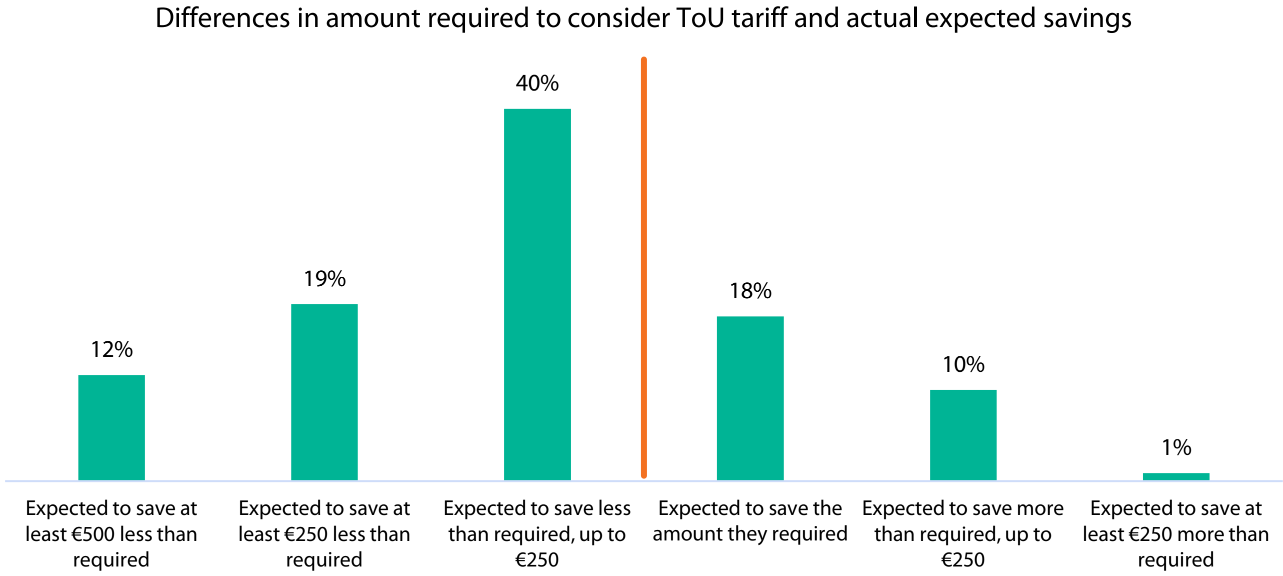
Figure 8. Intentions to make contract changes.



Overall, participants were less open to direct load control (Figure 8 above, right) – two in five said they would not consider it. Participants aged 55+ were significantly less likely to be open to it compared to the youngest group. Fairness, trust, and knowing that the share of renewables could be increased were again associated with greater openness.

To investigate perceived monetary benefits of ToU tariffs specifically, we asked participants to indicate how much money they thought they could save by switching to one. We also asked what amount of savings would make them consider a switch. Perhaps surprisingly given the prominence of monetary factors as perceived benefits, most people (~71%) expected to save much less by switching tariff compared to the amounts that would prompt them to do so (Figure 9). The average amount people expected a ToU to save them was €182. The average response to the question of how much would prompt them to switch was €368.

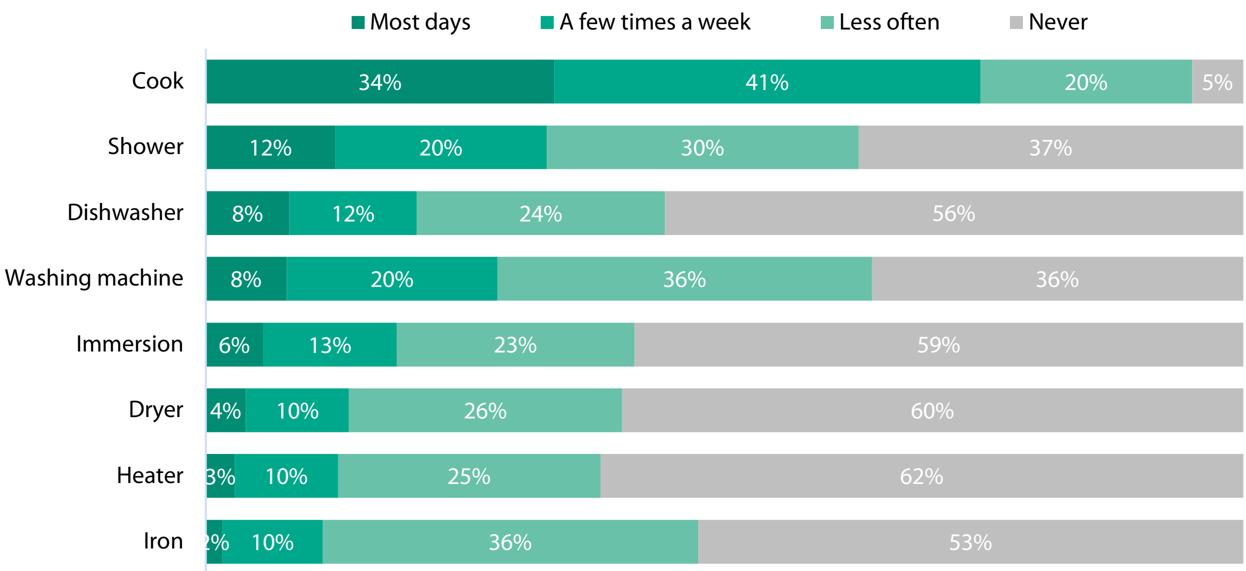
Figure 9. Bar chart showing levels of difference between savings expectations of switching to a ToU tariff compared to required amounts to consider switching. Participants in the negative groups to the left of the red line expected lesser savings than would prompt them to make a switch. Participants to the right of the red bar thought they would save at least as much by switching as they would require to do so.



3.5. Current peak-period consumption and intention to change

We asked participants how often they did various activities during the evening peak period (see Figure 10). Unsurprisingly, cooking (using an electric oven, hob, grill, or fryer) was the most commonly reported peak-period activity. More than a third of participants reported doing so most days, and a further 41% reported doing so a few times a week. For the rest of the activities that we asked about (dishwashing, using the washing machine, dryer, iron, immersion, shower, and electric heater), few people reported doing so every evening. More than half the sample never used the dishwasher, dryer, iron, immersion, or heaters during the peak period.

Figure 10. Reported frequency of use of electrical appliances during the evening peak (5pm – 7pm).



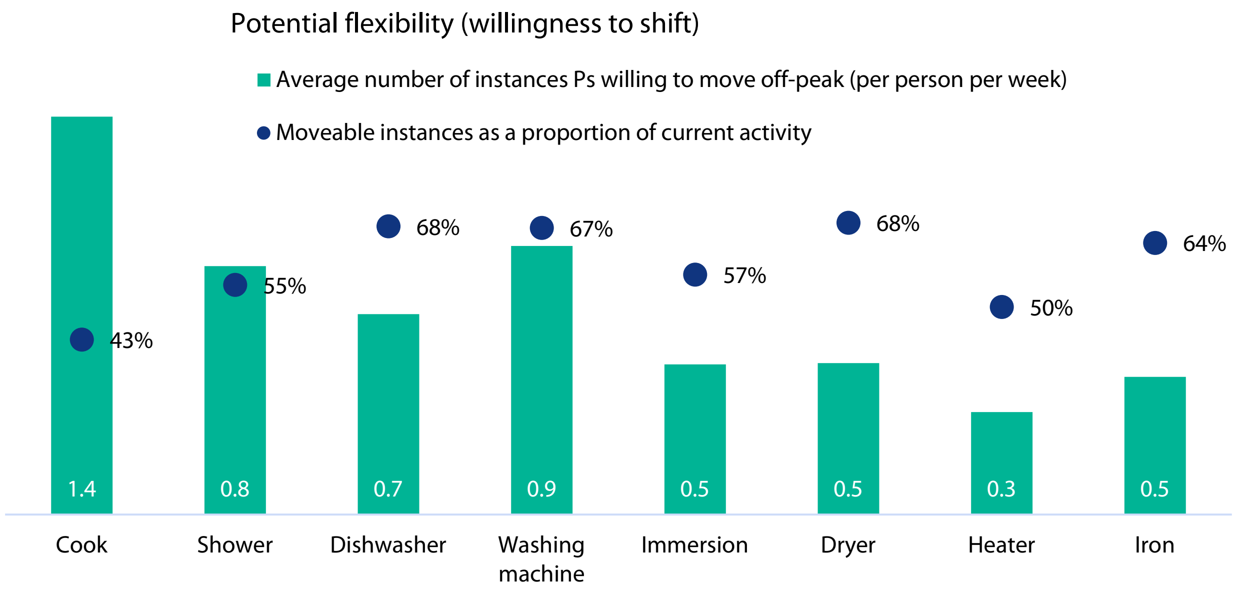
3.5.1. Willingness to shift

We then asked participants if they would consider shifting each activity if it were a little cheaper, better for the environment, or helped avoid outages. We only asked about activities relevant to each participant; we didn't ask participants if they would shift the timing of activities that they said they never do during the peak period. Participants were generally open to shifting activities to outside peak hours. Willingness to time-shift responses for each activity can be view in Appendix J1. Less than a fifth of participants indicated they would not change the time at which they cooked. Very few participants indicated that they would not at least sometimes change the timing of each of the activities they did. The most common response across the activities was "most times" – accounting for roughly a third of responses for each.

To illustrate what these responses mean in terms of potential reductions in peak use in a given week, we quantified the responses by assigning a corresponding number of instances to each category. We first summed all the instances to get a population weekly level of activity. We used these current activity levels to assign numbers to the willingness to shift responses to produce population level estimates of the potential instances of each activity that could be time-shifted. (Detail on these calculations are in Appendix J2.) Finally, we divided each by 1,500 (the total number of participants) to calculate the activity peak loads per person in the population that might be avoided (Figure 11).

Cooking is the least flexible activity that we measured in terms of the proportion of it that people are willing to move. However, because it is by far the most common evening peak activity and people are willing to shift some instances of it, it has most flexibility potential in absolute terms. The activity with next most potential in terms of number of instances is washing machine use, followed by showering, and dishwasher use. When factoring in the energy intensity of activities, the flexibility potential of cooking is again worth highlighting.

Figure 11. Approximate flexibility potential of different activities.

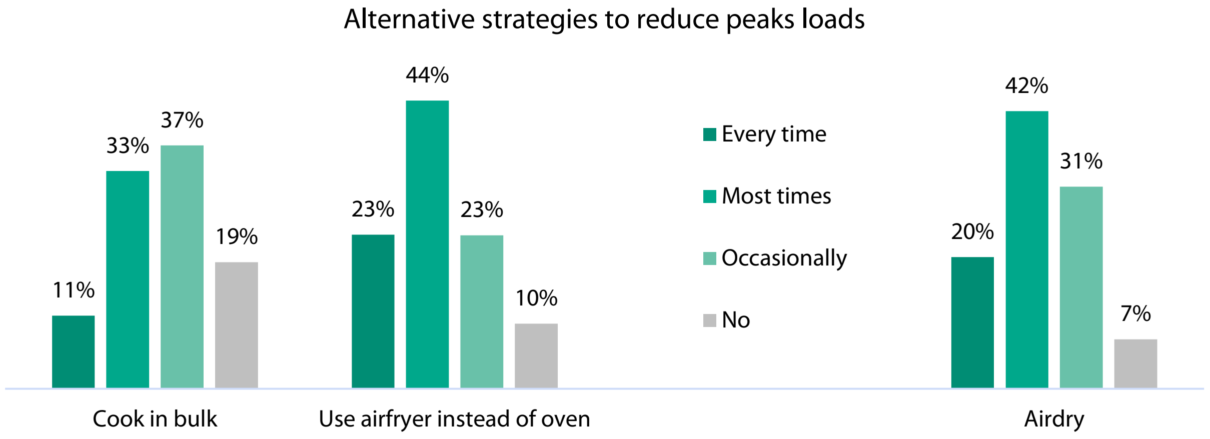


3.5.2. Willingness to reduce peak loads through other means

There are alternative ways to reduce peak loads besides simply moving the time at which one conducts an activity. With regard to cooking, people can batch cook and reduce the instances of cooking during peak times. They can also use efficient appliances such air fryers in place of ovens. Another way to alleviate peak loads is to allow clothes to air dry after washing instead of using a tumble dryer. We asked participants who indicated they at least sometimes cook, cook using an oven, and use a tumble during the evening peak whether and to what extent they would be willing to engage in the listed alternatives (Figure 12 below).

Of these three actions, people were most averse to batch-cooking – nearly a fifth said they would not do so. However, the majority of people said they would, at least occasionally. Substituting an air fryer for an oven was a popular option with two thirds of evening peak oven users reporting willingness to do so most times or always. Only 7% of people who ever use a tumble dryer at peak said they would not cease to do so.

Figure 12. Proportions of relevant samples willing to reduce evening peak loads by a) cooking in bulk; b) using an airfryer instead of an oven; and c) air drying clothes instead of using a tumble dryer.



4. Discussion

4.1. Attitudes towards smart energy and demand flexibility intentions are positive

A large majority of participants responded positively to smart energy services and demand flexibility. Both engagement and intention response distributions were heavily skewed towards the higher ends of the scales: most people thought the topic was highly important, relevant to them, and intended to use less at peak. In open text responses to a question asking about benefits, only 6% of participants said that there were none that mattered to them.

When we asked participants about time-shifting different specific household activities, responses again were positive but there was some variation between activities. Research efforts to identify flexibility potential of specific activity have been made previously. Our own prior in-depth time-of-use work has shown that cooking activity is responsible for a huge proportion of peak load. This finding is again reinforced in the current results. Others have suggested that cooking is an activity with relatively low flexibility, given its assumed social, routine, habit, and timing constraints. Our findings support this to an extent: it was the activity with the lowest percentage rate of willingness to change. However, because cooking is by far the most common peak activity, even though it has the least flexibility in a proportional sense, it has the largest in an absolute sense. The approximate number of instances people were willing to move away from peak was larger than the number of instances of any other activity. Additionally, batch-cooking and substituting an air fryer for an oven were popular alternatives to time-shifting to reduce peak period cooking loads.

Participants were highly willing to time-shift all of the activities that we asked about in the current study away from the evening peak at least some of the time. Not all activities can be moved by everyone all of the time. Some activities have less potential and have smaller electrical loads than others. Further, people have different preferences for reducing peak loads in terms of whether they time-shift activities, use different appliances, or simply do less overall. Taken together, these points suggest that no activity should be ignored. Instead, communications should point to the fact that there are options suitable for everyone, with different means of pursuing each. We have published a comprehensive set of actions and roadmaps to help people do this, and to help policymakers reduce barriers in the way.[40]

One potential way to make flexibility more automatic for people in the future is through direct load control, where an energy-user allows the supplier the ability to switch off a given appliance in the home remotely. Clearly, this would come with a potential loss of autonomy. However, the householder will generally have the option to opt out of any given request to switch off. The majority of participants – three in five – were open to this idea, which is quite high given that it is not a widely discussed one. Older participants were more wary of it, and naturally, fairness and supplier trust were particularly important to people in this context. Further work is required to delve into this specific matter in more detail, to assess different instantiations of direct load control, comparing for example, acceptability of supplier operated vs aggregator operated versions. In general, people were more open to ToU tariffs, though the picture here is less straightforward than it might appear. We discuss attitudes towards tariffs in more detail further below.

4.2. Ability to monitor use and control bills draws people to learn more

Our first research question was about how to motivate people to learn more about smart energy services. We showed different groups of participants different framings of smart energy and measured whether any of them increased the likelihood of choosing it. The framing that performed best at initially engaging people with the topic was one that emphasised the benefits of being able to monitor electricity use and control bills. It is a promising way to introduce the topic in awareness and marketing campaigns.

[40] SEAI (2025). Behavioural insights for electricity demand flexibility: barriers and enablers to behaviour change and engagement with smart energy services. https://www.seai.ie/data-and-insights/behavioural-insights/publications

Additionally, more of our results suggest people want to know about their consumption. The most common benefits that participants listed (without prompt) were related to insights, monitoring, and bills. And the average rating response when asked about interest in knowing about use and timing was 5.7 out of 7.

However, while the group who saw the topic of smart energy framed in terms of ability to monitor use and control bills were more likely to choose it sooner, they did not engage more with the subsequent information compared to the other groups. Further, their intentions to reduce peak use by time-shifting were no higher, even though the information they saw said that smart energy services would allow them to control bills and, when combined with a time-of-use tariff, reduce them. It should be noted, however, that this finding in no way suggests that greater insight into one's energy use would not help to reduce it. People cannot shift their use until they know what it is, and people's intentions were already high across the board – there was little room for the information to improve them further.

As mentioned in the introduction, there is strong evidence that when people are able to monitor their electricity use, they then reduce it, including in an Irish context. [41,42,43,44] In sum, the finding that people are drawn by the insights aspect of smart energy services, combined with the large body of work that shows effectiveness of in-home displays, suggests that promotion of some form of the latter would be beneficial.

4.3. Current monetary incentives are insufficient

The lack of effect of emphasising bill-related aspects of smart services on intentions to reduce peak use warrants further comment. Current efforts to engage people with time-shifting are based largely on monetary benefits to service users, for example, through time-of-use tariffs. Our results show that it is not enough to emphasise this benefit, particularly while potential savings are not very high for most people. Previous research suggests that the size of the difference between peak and off-peak rates is what matters in whether time-of-use tariffs are effective in shifting behaviour.[45] Currently, in Ireland, these differences are small – at the time of writing, the largest peak-rate to day-rate ratio was 1.39, which is smaller than the smallest ratio tested in the CRU smart metering trial (for comparison, the largest was over 3). There are night rates with much better incentives, but for the most part, aside from people on certain working schedules for example, only groups with technologies such as EVs and smart appliances can take advantage of those. In our study, people reported monetary savings as the most important benefit of smart energy, but about 71% thought the savings associated with ToU tariffs were smaller than their required threshold to make the switch.

Perhaps counterintuitively, the majority of participants who had not already switched to a ToU tariff said they would consider switching to one. It is possible that people answered this question as a hypothetical on some level – they may have been indicating that they would consider a ToU tariff if the price was right. This would explain the consistent overestimation of ToU tariff adoption by surveys relative to real-world uptake mentioned in the introduction.[46] Previous surveys have not asked for expectations and requirements in the way that we did.

Given that a) people rate monetary savings as highly important, b) require greater savings to switch tariff structure than they expect, and c) current monetary incentives for shifting to off-peak times are small and peak to off-peak ratios are much smaller than those used in trials, suppliers need to provide greater rewards for flexibility, if they genuinely care about shifting consumption patterns. In the meantime, other benefits should be emphasised to the public, as opposed to pushing monetary benefits that are small when extant.

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[46] Nicolson, M. L., Fell, M. J., & Huebner, G. M. (2018). Consumer demand for time of use electricity tariffs: A systematized review of the empirical evidence. *Renewable and Sustainable Energy Reviews*, *97*, 276-289. https://doi.org/10.1016/j.rser.2018.08.040

4.4. Environmental benefits of demand flexibility are important to people

Increasing the share of the electricity that is generated from renewable sources is the primary reason (alongside grid security) that demand flexibility is important. But at least three quarters of people are unaware of this benefit, and only ~15% mentioned it unprompted. For comparison, 65% and 77% respectively, identified grid security and money savings as benefits.

This is hugely important in light of the results of our models – being aware of the environmental benefit was a consistent predictor of intentions to reduce peak use, unlike being aware of the monetary or grid security benefits. Further, it was associated with higher likelihood to consider both switching to a ToU tariff, and the perhaps more extreme option of direct load control. In contrast, identifying reduced bills as a benefit was associated only with ToU tariff consideration and not direct load control**.** Increasing awareness that flexibility can increase the share of renewable generation is an important aim.

4.5. Time-shifting information can backfire

Overall, showing people information about smart energy services did not have the desired effect on people's intentions around demand flexibility. Although the information had a positive effect on people's knowledge, participants in the control group were just as likely to report intentions to shift consumption. Indeed, they were also statistically significantly more likely than the monitoring, insights & bills group to do so by reducing absolute activity. This makes sense when considering that, for many, the knowledge that they can save energy or on money simply by changing the time at which they use something is new and means that they do not need to reduce overall use to the same degree as before for the same impact. Of course, in the context of rising demand and the need to reduce it, this is something that needs to be carefully avoided. It is crucial that messaging around smart energy and time-shifting leaves people in no doubt that absolute levels of consumption need to be kept to a minimum, and that time-shifting alone is not the aim.

4.6. Positivity about smart energy is predicted by perceived fairness, trust, and time availability

As mentioned, participants on the whole were positive about smart energy and reported strong intentions to engage. Some sociodemographic characteristics were associated with stronger intentions to reduce peak use: being middle aged, a woman, and living with other people that were not family or a partner. Income did not matter, and neither social grade. But psychological factors mattered more, both for intentions to reduce peak use and to consider alternatives tariffs. In particular, perceived fairness in being asked to time-shift was the strongest predictor of intentions. Interestingly, while telling people about the consumption of data centres in Ireland made a small difference to perceptions of fairness of being asked to flexible in energy use, the information itself did not contribute significantly to intentions.

Level of trust in electricity suppliers to provide trustworthy information was similarly important. Participants who were less trusting of their suppliers exhibited lesser intentions to engage. Strong regulation of supplier practices in the area is important, as is the need to communicate this so that customers are aware of supplier obligations. A potential way for suppliers to increase trust is to provide risk-free tariff options to consumers. For example, suppliers could offer a ToU plan in which they guarantee for the first number of months that customers do not pay more for the amount of electricity they used than they would have on their old plan. This would have the added benefit of encouraging switching.

Finally, and unsurprisingly, time availability was also a consistent predictor of intentions. Automated flexibility mechanisms will likely be important. But moreover, it serves to reinforce the point that communications should not ignore any particular activity or way of being flexible. It will be important to make sure people know about alternatives to time-shifting such as such as batch-cooking (a time-saving mechanism), using more efficient appliances such as air fryers in place of ovens, and using eco settings on the appliances they run during peak periods.

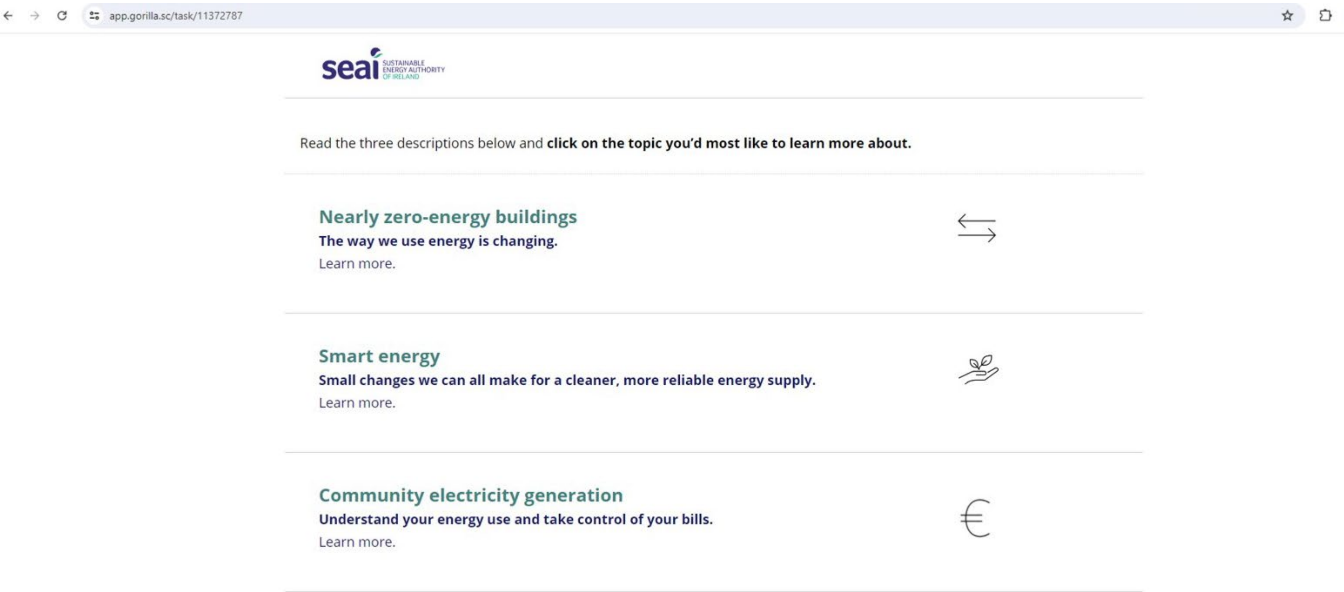
4.7. Conclusion

Consistent with previous studies, we found a high degree of positivity among our sample towards smart energy services. Historically, that has not translated to comparable real-world behaviour, at least in terms of ToU tariff uptake. Here, we identified messages that effectively increased engagement with the topic. Framing of smart energy in terms of consumption monitoring, insights & bills made people more likely to choose it from a list of topics. And making people aware of the potential to increase the share of renewable generation was associated with greater intentions to shift peak use and consider alternative tariff options. Currently, very few people are aware of this benefit, which contrasts with widespread awareness of the small monetary incentives which are less consequential. To translate these findings into greater flexibility, greater awareness of environmental benefits should be communicated, and much stronger monetary incentives should be developed. At the same time, making it easier to access high quality insights about their own consumption will serve to engage people to act on these motivations.

Appendices

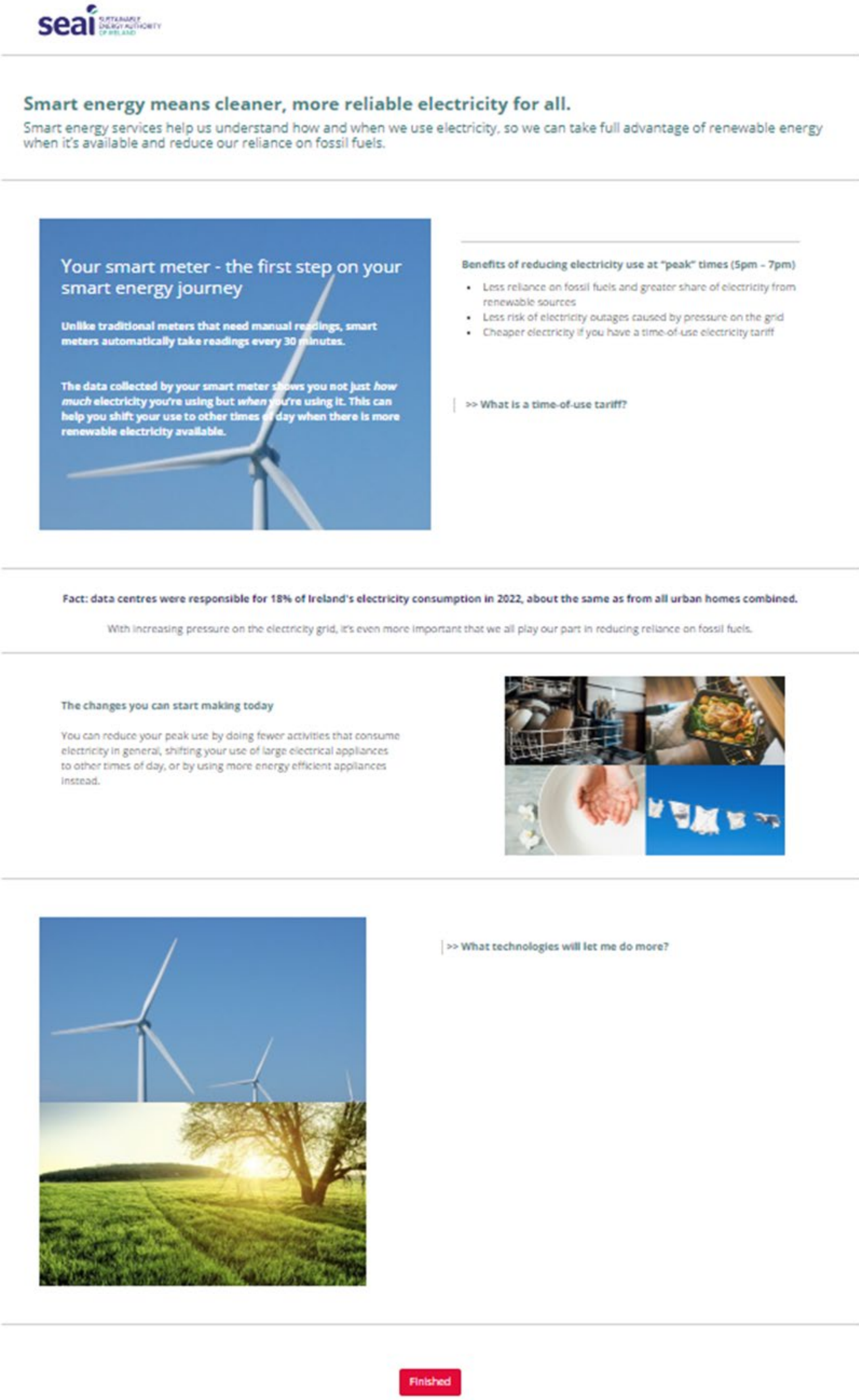
Appendix A – Stage 1 example page

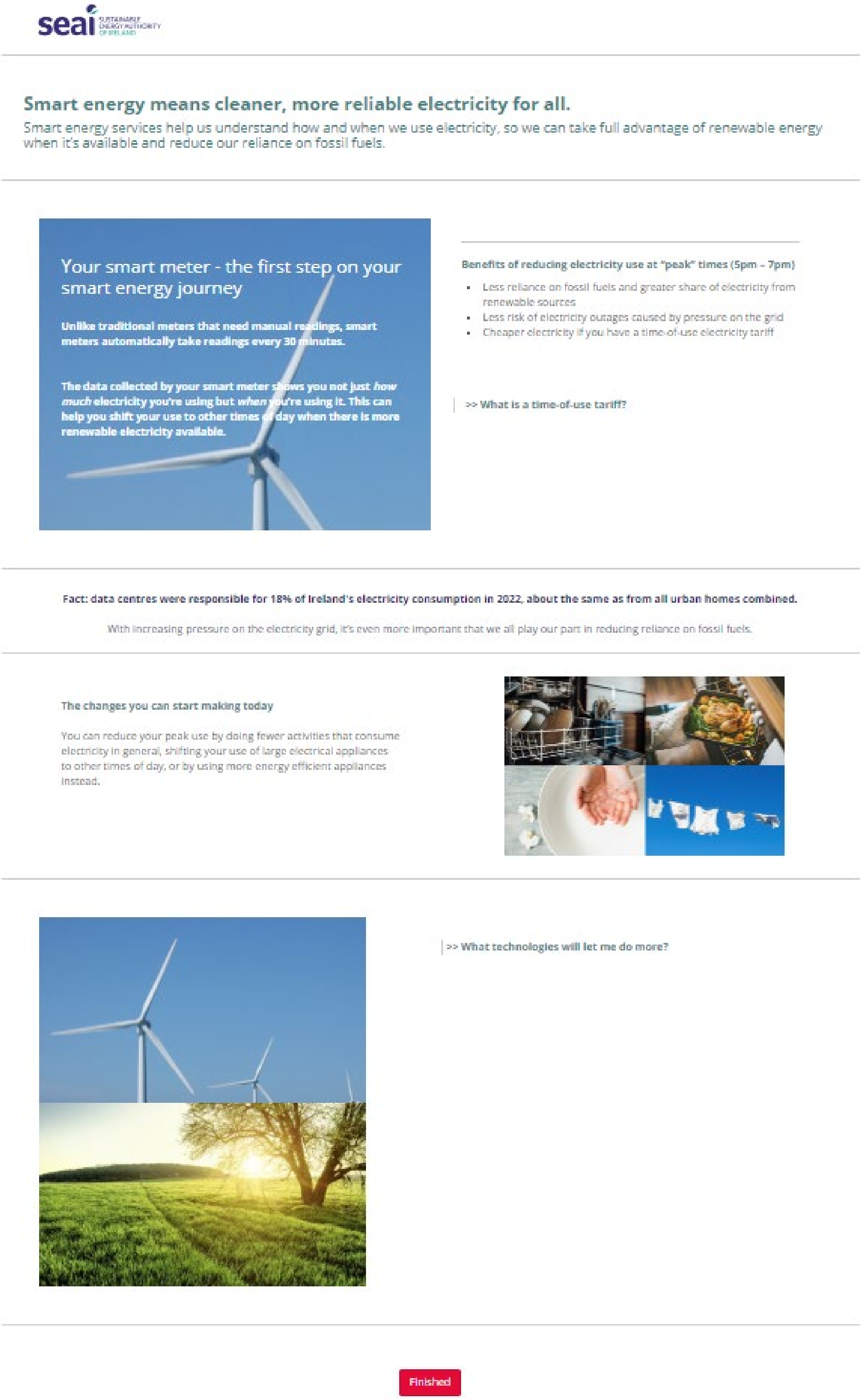
Below is a screenshot from the experiment – it shows the Stage 1 choice task for participants in environmental benefits treatment group.



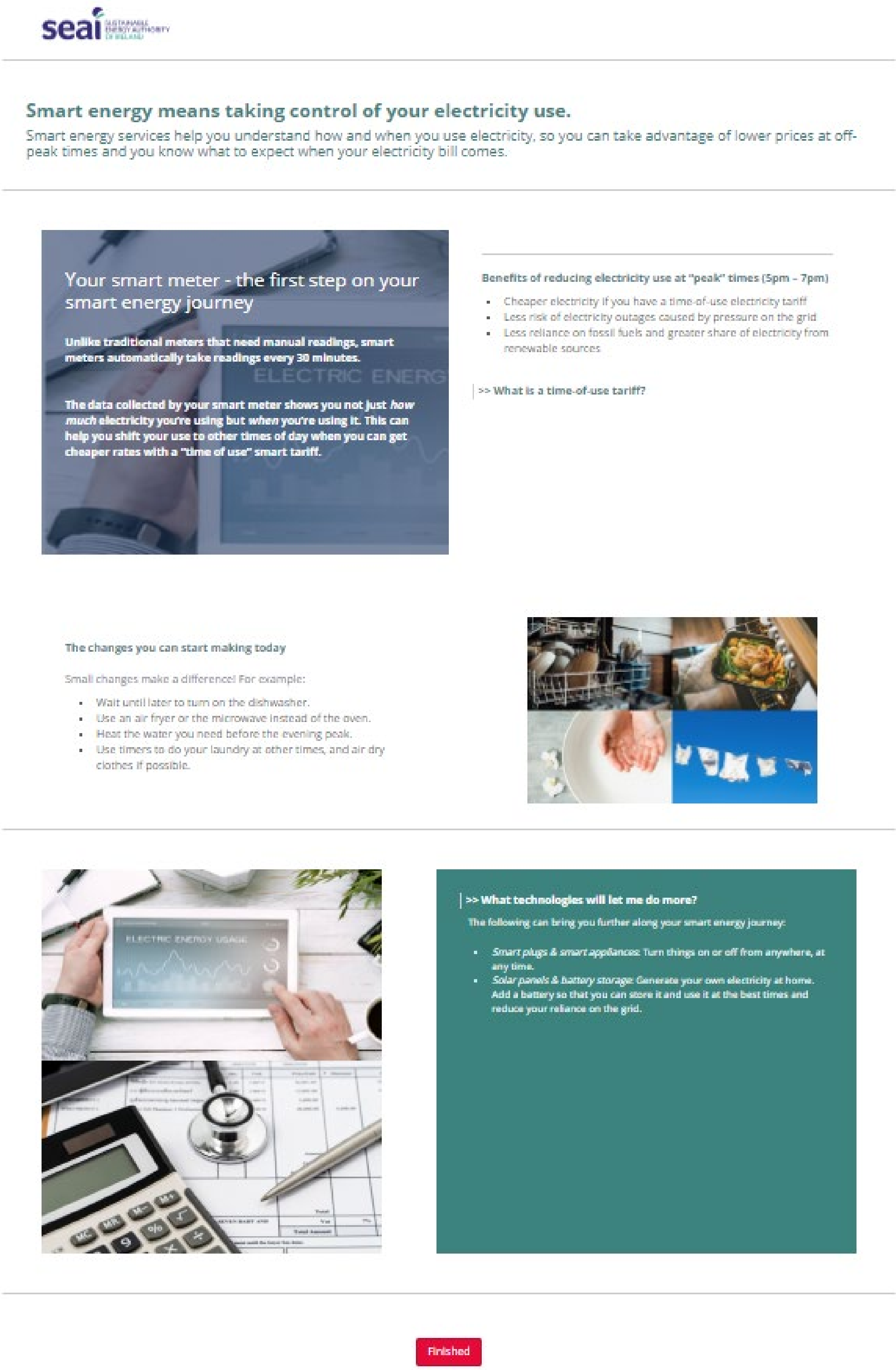
Appendix B – Stage 2 information pages

Example (1 of 2) information page that emphasised environmental benefits, included data centre consumption information, and presented general advice about smart energy.





Example (2 of 2) information page that emphasised monitoring, insights & control of bills, did not include data centre consumption information, and provided specific actions to engage in smart energy.


seai
Smart energy means taking control of your electricity use.
Smart energy services help you understand how and when you use electricity, so you can take advantage of lower prices at off-peak times and you know what to expect when your electricity bill comes.
Your smart meter - the first step on your smart energy journey
Unlike traditional meters that need manual readings, smart meters automatically take readings every 30 minutes.
The data collected by your smart meter shows you not just how much electricity you're using but when you're using it. This can help you shift your use to other times of day when you can get cheaper rates with a "time of use" smart tariff.
Benefits of reducing electricity use at "peak" times (5pm – 7pm)
Cheaper electricity if you have a time-of-use electricity tariff
Less risk of electricity outages caused by pressure on the grid
Less reliance on fossil fuels and greater share of electricity from renewable sources
>> What is a time-of-use tariff?
The changes you can start making today
Small changes make a difference! For example:
Wait until later to turn on the dishwasher.
Use an air fryer or the microwave instead of the oven.
Heat the water you need before the evening peak.
Use timers to do your laundry at other times, and air dry clothes if possible.
>> What technologies will let me do more?
The following can bring you further along your smart energy journey:
Smart plugs & smart appliances: Turn things on or off from anywhere, at any time.
Solar panels & battery storage: Generate your own electricity at home. Add a battery so that you can store it and use it at the best times and reduce your reliance on the grid.
Finished

Appendix C – Sample characteristics

Individual

Table 3: Sociodemographic characteristics of the sample

		Proportion
Gender	Female	55.6%
	Male	44.2%
	Other	0.2%
Age	18 - 34	24.1%
	35 - 54	42.7%
	55+	33.2%
Region	Dublin	25.1%
	Leinster	27.9%
	Munster	28.3%
	Connacht	13.7%
	Ulster	5.1%
Area type	Urban	62.9%
	Rural	37.1%
Social grade	ABC1	48.3%
	C2DEF	51.7%
Education	Degree	38.1%
	No degree	61.9%
Employment	Employed/student	69.9%
	Homemaker/carer	9.7%
	Retired/not working	20.5%

Household

Table 4: Household characteristics of the sample

		Proportion
Household gross annual income	<40k	36.1%
	40k - 80k	35.1%
	80k+	20.5%
	Not disclosed	8.3%
Living situation	Alone	14.5%
	Couple	25.6%
	Family	53.3%
	Unrelated/Mix	6.6%
Under 18s in households	No	64.3%
	Yes	35.7%
Over 65s in household	No	73.3%
	Yes	26.7%
Person with chronic illness or disability in household	No	72.5%
	Yes	27.5%
Dwelling type	Detached house	40.4%
	Semi-detached/end of terrace house	34.1%
	Terraced house	15.2%
	Apartment/flat/bedsit	9.9%
	Mobile home/caravan/temporary building	0.3%
Tenure	Own home outright	32.8%
	Own home with loan/mortgage	31.7%
	Renting (private landlord)	18.4%
	Renting (local authority or housing association)	8.9%
	Living rent-free (e.g. with parents or friends)	8.1%
	No fixed address	0.1%

Metering and technology

Table 5: Meter & tariff types and technology owned by participants

		Proportion
Meter type	Standard (24 hour) meter	26.0%
	Day & night meter	8.0%
	Smart meter	54.8%
	Pay as you go	7.5%
	Don't know	3.7%
Tariff type	Standard (you pay the same price for all times of day)	58.5%
	Night-saver (you pay less for night-time use)	12.8%
	Time-of-use (you pay different amounts for different times of day)	5.3%
	Smart EV tariff	2.7%
	Free Saturday/Sunday tariff	4.7%
	Pay as you go	6.2%
Supplier	Electric Ireland	49.9%
	Bord Gáis Energy	18.1%
	SSE Airtricity	11.9%
	Energia	10.7%
	Don't know	1.3%
	Other	8.1%
Technology owned/installed	Solar PV	9.9%
	Solar thermal	8.3%
	Battery storage	4.9%
	Heat pump	14.8%
	EV	7.2%

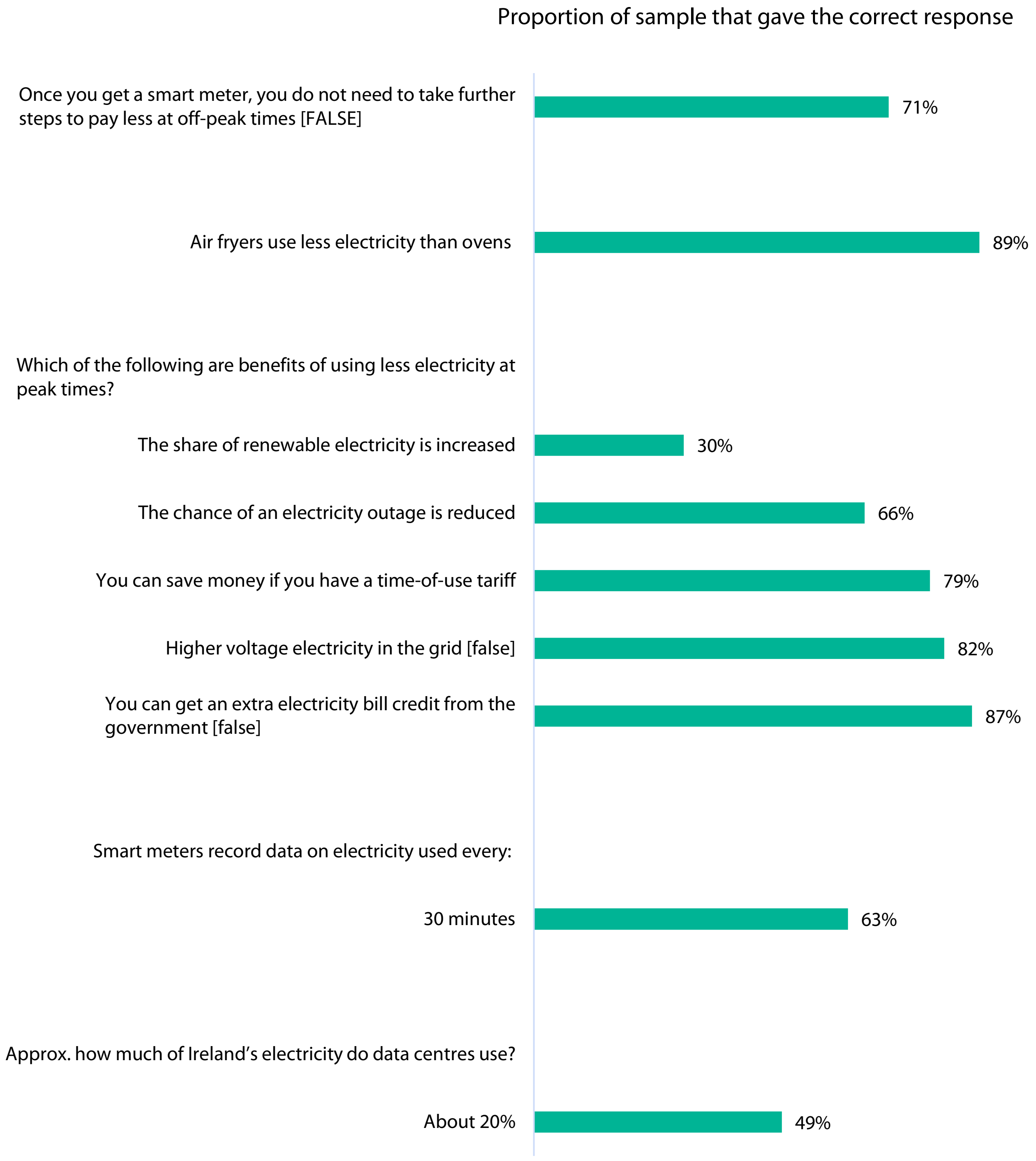
Appendix D – Results of ordinal logistic regression model of likelihood to choose smart energy topic sooner

	B (SE) OR	p value
Frame (ref.= control)		
Environment benefits	0.12 (0.13) **1.12**	0.377
Monitoring benefits	0.64 (0.14) **1.9**	**0.000**
Male	-0.08 (0.1) **0.92**	0.413
Age (ref.= 18 - 34)		
35 - 54	0 (0.13) **1**	0.972
55+	0.16 (0.14) **1.17**	0.282
Degree	-0.24 (0.11) **0.79**	**0.035**
Social grade C2DEF	-0.03 (0.11) **0.97**	0.787
Income (ref.= < 40 k)		
40 - 80 k	0.01 (0.13) **1.01**	0.955
80 k +	0.45 (0.16) **1.56**	**0.005**
Living situation (ref.= single)		
Couple	0.2 (0.17) **1.22**	0.237
Family	0.08 (0.16) **1.08**	0.628
Others	0.21 (0.24) **1.23**	0.371
Standard/PAYG tariff (ref.= time varying)	-0.03 (0.12) **0.97**	0.804
Previous consideration of peak	0.02 (0.03) **1.02**	0.616
Presentation order	0.54 (0.06) **0.58**	**0.000**
Observations	*1,500*	

Appendix E – Results of regression model of engagement variables

	B (SE)	B (SE)	B (SE)
	Model 1 (ordinal): Composite engagement	Model 2 (linear): Knowledge score	Model 3 (linear): Knowledge among readers
Frame (ref.= Monitor benefits)			
Control group	0.17 (0.13) p=0.22	-0.6 (0.11) p=<0.001	
Environmental benefits	0.21 (0.11) p=0.06	-0.06 (0.09) p=0.51	-0.04 (0.08) p=0.60
Male	-0.3 (0.1) p=0.003	-0.05 (0.08) p=0.54	0.14 (0.09) p=0.11
Age (ref.= 18 - 34)			
35 - 54	0.24 (0.13) p=0.07	0.4 (0.1) p<0.001	0.04 (0.11) p=0.72
55+	0.53 (0.14) p=<0.001	0.63 (0.11) p<0.001	0.19 (0.12) p=0.12
Degree	-0.01 (0.11) p=0.90	0.25 (0.09) p=0.004	0.21 (0.09) p=0.03
Social grade C2DEF	-0.02 (0.11) p=0.86	-0.21 (0.09) p=0.01	-0.19 (0.09) p=0.05
Income (ref.= < 40 k)			
40 - 80 k	0.29 (0.13) p=0.02	0.08 (0.1) p=0.40	0.03 (0.1) p=0.79
80 k +	0.18 (0.15) p=0.25	0.32 (0.12) p=0.01	0.24 (0.13) p=0.07
Living situation (ref.= single)			
Couple	0.36 (0.17) p=0.03	-0.28 (0.13) p=0.04	-0.3 (0.14) p=0.04
Family	0.41 (0.16) p=0.01	-0.24 (0.13) p=0.06	-0.23 (0.14) p=0.09
Others	0.91 (0.24) p=<0.001	-0.34 (0.19) p=0.07	-0.47 (0.2) p=0.02
Standard/PAYG tariff (ref.= time varying)	0.01 (0.12) p=0.93	0.21 (0.09) p=0.02	0.1 (0.1) p=0.30
Previous consideration of peak	0.48 (0.04) p=<0.001	0.06 (0.02) p=0.01	0.02 (0.03) p=0.37
Reading time (<15 seconds)			
15 - 44 seconds			0.94 (0.14) p<0.001
45 - 90 seconds			1.55 (0.14) p<0.001
>90 seconds			1.78 (0.14) p<0.001
Observations	*1,500*	*1,500*	*1,159*

Appendix F – Comprehension questions



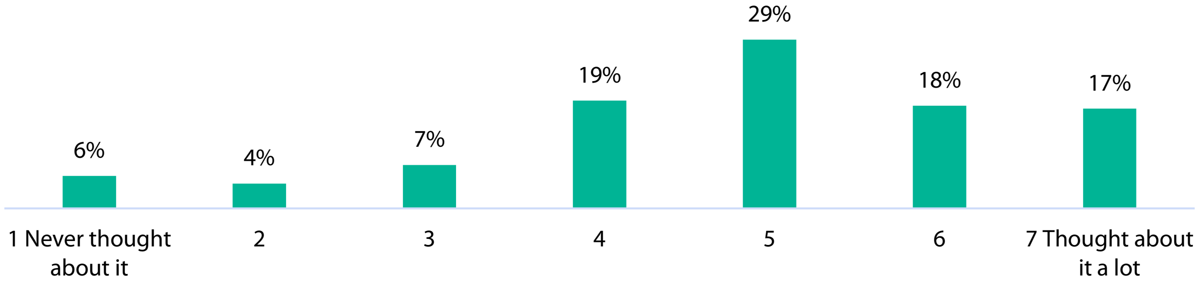
Appendix G – Results of ordinal regression models of intentions to be flexible

Model 1 shows associations between composite intention and demographic variables, household variables, and experiment condition. Model 2 adds psychological variables. Model 3 excludes the control group to assess influence of additional manipulations – provision of data centre information and specificity of advice presented.

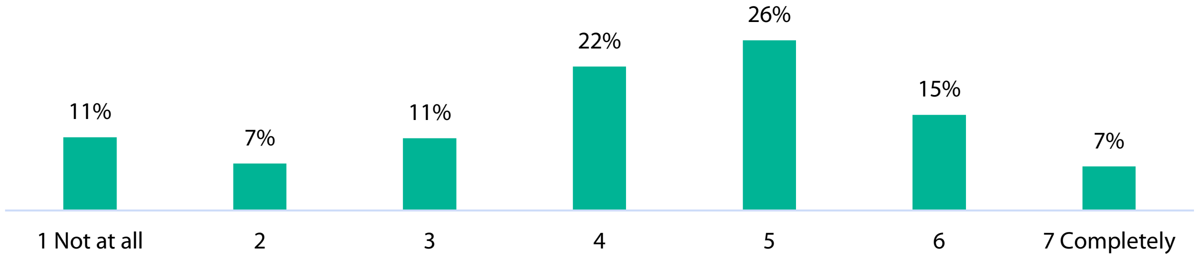
	Model 1	Model 2	Model 3
	B (SE)	*B (SE)*	*B (SE)*
Frame (ref.= Monitor benefits)			
Control group	0.26 (0.13) p=0.045	0.33 (0.14) p=0.02	
Environmental benefits	0.14 (0.11) p=0.20	0.12 (0.12) p=0.29	0.2 (0.17) p=0.23
Male	-0.53 (0.10) p<0.001	-0.63 (0.11) p<0.001	-0.64 (0.12) p<0.001
Age (ref.= 18 - 34)			
35 - 54	0.34 (0.13) p=0.01	0.33 (0.14) p=0.02	0.4 (0.16) p=0.01
55+	0.69 (0.14) p<0.001	0.22 (0.15) p=0.14	0.21 (0.17) p=0.22
Degree	-0.07 (0.10) p=0.52	-0.24 (0.12) p=0.04	-0.25 (0.13) p=0.06
Social grade C2DEF	0.15 (0.11) p=0.16	0.1 (0.12) p=0.40	0.06 (0.13) p=0.63
Income (ref.= < 40 k)			
40 - 80 k	0.15 (0.11) p=0.24	0.11 (0.13) p=0.43	0.11 (0.15) p=0.47
80 k +	0.12 (0.15) p=0.41	0.11 (0.16) p=0.52	0.07 (0.19) p=0.69
Living situation (ref.= single)			
Couple	0.22 (0.17) p=0.18	0.3 (0.18) p=0.09	0.3 (0.2) p=0.14
Family	0.15 (0.16) p=0.33	0.2 (0.17) p=0.24	0.18 (0.19) p=0.35
Others	0.46 (0.24) p=0.05	0.58 (0.26) p=0.03	0.8 (0.3) p=0.01
Standard/PAYG tariff (ref.= time varying)	-0.51 (0.11) p<0.001	-0.08 (0.12) p=0.5	-0.04 (0.14) p=0.8
Previous consideration of peak		0.42 (0.04) p<0.001	0.43 (0.04) p<0.001
Time-flexible		0.42 (0.11) p<0.001	0.51 (0.13) p<0.001
Hi perceived fairness		1.06 (0.12) p<0.001	1.15 (0.13) p<0.001
Hi energy save understanding		0.3 (0.12) p=0.01	0.41 (0.14) p<0.001
Hi supplier trust		0.66 (0.12) p<0.001	0.6 (0.13) p<0.001
Renewable generation		0.38 (0.12) p=0.001	0.39 (0.13) p=0.003
Reduced bills		0.21 (0.13) p=0.11	0.12 (0.15) p=0.42
Grid security		0.09 (0.11) p=0.44	0.07 (0.13) p=0.58
Data centre information			0.23 (0.17) p=0.16
Action specific info			0.04 (0.12) p=0.76
Environmental benefits frame*Data centre info			-0.16 (0.23) p=0.49
Observations	*1,500*	*1,500*	*1,199*

Appendix H – Psychological measures

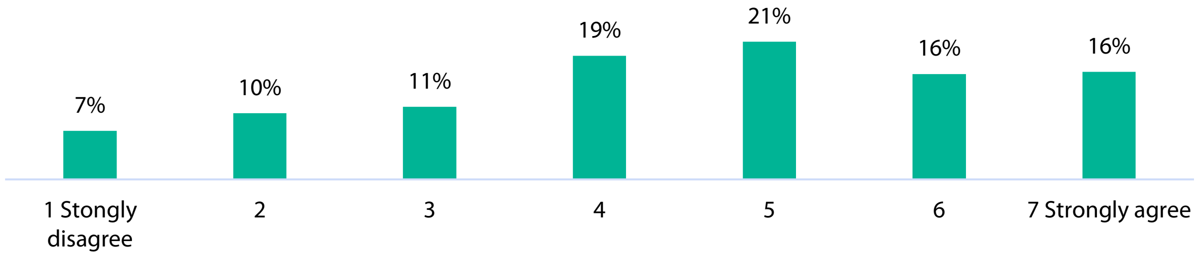
[previous awareness] In general, before taking part in this survey, how conscious were you of reducing your electricity use at peak times?



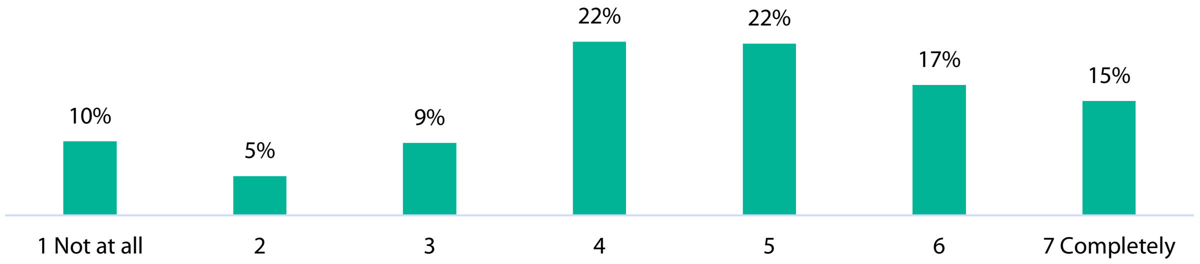
[supplier trust] How much do you trust your electricity supplier to provide impartial and accurate information about smart energy and time-of-use tariffs?



[time flexibility] My daily routine is flexible – I'm able to choose the times I do my different tasks or activities.



[fairness] Do you think it is fair that people are asked to change the timing of their electricity use?

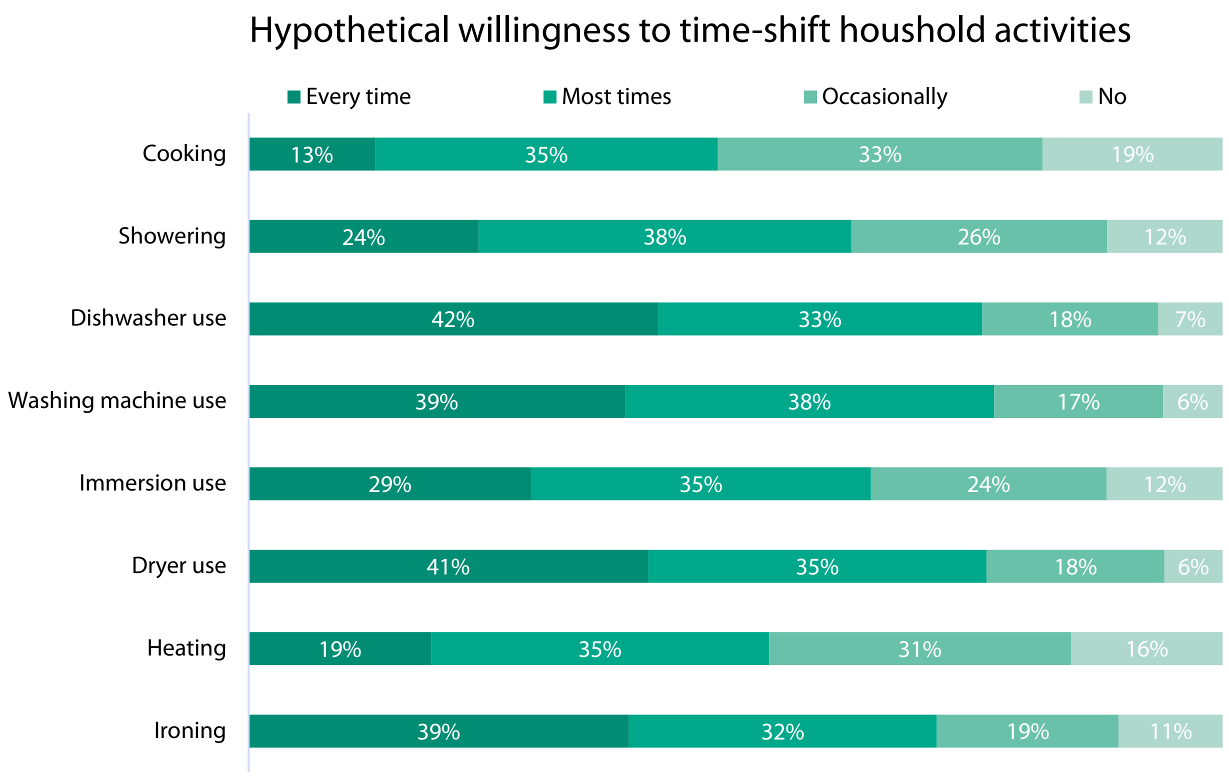


Appendix I – Regression results of models of likelihood to consider ToU tariff and direct load control

	TOU tariff	Direct load control
	B (SE)	*B (SE)*
Frame (ref.= Monitor benefits)		
Control group	0.01 (0.2) p=0.98	-0.08 (0.14) p=0.57
Environment benefits	-0.06 (0.16) p=0.72	-0.01 (0.11) p=0.93
Male	0.12 (0.15) p=0.43	0.11 (0.1) p=0.30
Age (ref.= 18 - 34)		
35 - 54	0.19 (0.19) p=0.32	-0.12 (0.13) p=0.34
55+	-0.05 (0.22) p=0.83	-0.48 (0.15) p=0.001
Degree	-0.13 (0.17) p=0.45	0.12 (0.11) p=0.27
Social grade C2DEF	0.08 (0.17) p=0.65	0.09 (0.11) p=0.41
Income (ref.= < 40 k)		
40 - 80 k	-0.3 (0.19) p=0.11	0.05 (0.13) p=0.70
80 k +	-0.21 (0.23) p=0.36	-0.13 (0.15) p=0.39
Living situation (ref.= single)		
Couple	0.55 (0.24) p=0.03	0.23 (0.17) p=0.18
Family	0.52 (0.23) p=0.03	0.1 (0.16) p=0.55
Others	1.42 (0.41) p=0.0006	0.43 (0.24) p=0.07
Previous consideration of peak	0.07 (0.05) p=0.15	0.11 (0.03) p=0.002
Time-flexible	0.03 (0.16) p=0.82	0.17 (0.11) p=0.12
Hi perceived fairness	1.21 (0.16) p<0.001	0.97 (0.11) p<0.001
Hi supplier trust	0.7 (0.16) p<0.001	0.4 (0.12) p<0.001
Renewable generation	0.4 (0.17) p=0.02	0.42 (0.11) p<0.001
Reduced bills	0.67 (0.17) p<0.001	0.17 (0.12) p=0.17
Grid security	0.16 (0.16) p=0.31	-0.13 (0.11) p=0.24
Standard/PAYG tariff (ref.= time varying)		-0.14 (0.12) p=0.23
Observations	*1,308*	*1,500*

Appendix J – Willingness to time-shift specific activities

Appendix J1 – Participant responses



Appendix J2 – Method of calculation of quantified flexibility potential

To illustrate what these responses mean in terms of potential reductions in peak use in a given week, we quantified the responses by assigning a corresponding number of instances to each category. We assigned a 5 to each participant who said they did an activity on "most days" - the (conservative) assumption being that people who said they did an activity most days did it 5 times a week on average. We assigned a 3 to those who said "a few times a week", and a 1 to those who said "less often". Next, we assigned numbers to the willingness to change responses as follows: if a participant said they would move every instance of their activity away from the peak, we assigned a 5 to those who did the activity most days, a 3 to those who did it a few times a week, and 1 to those who did it less often - i.e. the same value as their activity score (or their activity score divided by 1). If they said they would shift most times, then we divided their activity by 1.5 to calculate an approximate number of instances they were willing to time-shift. And if they said they would occasionally move an instance we divided their current activity by 3.

We then summed the resulting values for each activity to see how many instances could hypothetically be shifted away from the evening peak. Finally, we divided each by 1,500 (the total number of participants) to calculate the activity peak loads per person in the population that might be avoided.

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