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Efficient ways of communicating time-of-use electricity tariffs in Ireland: Plain and simple

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Abstract: With the ongoing rollout of smart meters in Ireland, time-of-use (ToU) tariffs are currently being introduced as a new way to pay for electricity. Such tariffs can bring important benefits to both consumers and society, in terms of reduced electricity bills and CO2 emissions, respectively. At the same time, some consumers may find it more difficult to benefit from ToU tariffs than others. Communication around ToU tariffs thus needs to explain both benefits and challenges successfully; it needs to encourage ToU uptake, while enhancing comprehension. This paper presents results from a pre-registered experiment that pre-tested behaviourally-informed communications on ToU tariffs. A large, representative sample of consumers (n=1,300) viewed an experimentally manipulated primer on ToU tariffs before completing a series of tasks to measure their views, objective comprehension, and tariff choices. In general, consumers were positive towards ToU tariffs, viewing monetary savings as a primary benefit. Environmental framing of information enhanced positivity among younger participants. Comprehension and choice quality were rather modest, but improved when tariff examples were presented in a plain table, compared to 24h clock formats. This finding is important as the latter are commonly used in the market. The study demonstrates the benefit of experimentally pre-testing policy interventions.

Keywords: time-of-use tariffs; consumer choice; policy pre-testing; behavioural economics

JEL Codes: C99, D12, D83, Q41

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INTRODUCTION

Peak electricity demand is a serious problem for power grids. It increases risks of outages and has negative cost and environmental implications. At peak demand times, less cost-effective and less efficient power plants may need to be used in order to meet the demand, resulting in spikes of wholesale electricity prices and possibly more CO_2 emissions (Torriti, 2017).

A way of dealing with the problem is through "demand side management", i.e., encouraging residential consumers to move their energy consumption away from peak times. One specific option is "dynamic pricing", whereby changes in wholesale electricity prices are reflected in consumers' tariffs, creating a financial incentive to reduce electricity demand at peak times. An example is a time-of-use tariff (hereafter ToU tariff), which charges different prices at different times of day. The success of ToU tariffs in smoothing electricity consumption will depend on whether consumers take up ToU tariffs, whether they choose an appropriate tariff for their pattern of domestic consumption, and whether they adjust that pattern in response to the incentives built into the tariff.

The present study, commissioned by the Commission for Regulation of Utilities (CRU), Ireland's energy regulator, consisted of an experimental pre-test of a simple, behaviourally-informed information intervention. The large online study was pre-registered with Open Science Framework (OSF)[1] and involved a representative sample of 1,300 consumers in Ireland. In collaboration with CRU, the research team designed a set of one-page "primers" to help consumers to understand how ToU tariffs work and to choose an appropriate tariff. These were experimentally manipulated and randomly assigned. We then tested respondents' comprehension and their ability to match a tariff to a usage pattern, as well as eliciting preferences for ToU versus other tariffs. The overall aim was to pre-test primers to inform agreements between the regulator and providers about how best to assist consumers to make the transition to ToU tariffs. Thus, the study is an example of empirically informed regulation (Sunstein, 2011).

Background

In order to avail of ToU tariffs, consumers first need a smart meter installed, which provides more precise data on their electricity consumption. Rollout of smart meters has been a worldwide phenomenon in the recent years. In Europe, the European Parliament and the European Council introduced Directive 2009/72/EC in 2009, which set targets for 80 % of customers across all EU member states to have an electricity smart meter by 2020, unless the result of a Cost Benefits Analysis (CBA) in a given country was negative (EUETS, 2016). According to the most recent benchmarking report by the European Commission (2020), only a small number of countries had achieved greater than 60% penetration for electricity smart meters. It is expected that "most countries will reach a wide-scale roll-out in the period 2020-2025".

In Ireland, the CRU (previously the Commission for Energy Regulation, CER) has carried out a CBA, conducted technology trials to pilot the technology, and undertaken initial customer

[1] Pre-registration available at: https://osf.io/tw3pg

behaviour trials. The initial CBA published in 2011 assessed 12 options for the rollout of smart meters and found a net present value (NPV) ranging from positive €282 million to negative €181 million, with a positive NPV on eight of these options. Overall payoff was sensitive to the assumed residential demand response, however (Commission for Energy Regulation, 2011a). In other words, if the demand response expected from consumers was lower than expected due to smaller behavioural responses, or lower uptake of ToU tariffs, this would reduce the NPV of the project. It is clear that encouraging significant uptake of appropriate ToU tariffs is central to delivering the main benefits from the smart metering program.

In 2017, the CRU published an updated CBA for the smart meter rollout which estimated the value of rolling out electricity smart meters on a phased basis. The 2017 CBA made different assumptions about TOU uptake, assuming that uptake would be 36% of residential customers initially, rising to 95% once flat tariffs were removed from the market, which was assumed to take place by 2026 (Commision for Regulation of Utilities, 2017).

As of March 2021, 248,397 smart meters had been installed across Ireland, with the remaining 2,050,000 to be installed by 2024 (McGuinness, 2021). Using the number of meter points reported in the benchmarking report (2,200,000), and the latest figures for the numbers of smart meters rolled out in Ireland (248,397), Ireland's current smart meter penetration is approximately 11%. This estimate means that Ireland ranks approximately 13th out of the 28 EU countries included in the benchmark report. The technical go-live for ToU tariffs took place on the 26th of February 2021. Since then, some energy suppliers in Ireland have begun to offer ToU tariffs to households (Flynn, 2021).

As of the end of May 2021, less than 700 households signed up for the "Standard Smart Tariff"[2] in Ireland, while over 10,000 switched to a different ToU tariff, suggesting a slow start. Overall, potential take-up is presently difficult to gauge.

A recent review of 27 studies from six countries found that the median uptake of ToU tariffs is 29%, with substantial variation in estimates (from 0 to 96%). Measures of hypothetical willingness to switch consistently produce higher estimates than measures of commercial uptake. Opt-out programs result in much higher uptake than their opt-in counterparts (Nicolson et al., 2018).

Psychological factors are certainly at play when it comes to taking up new tariffs. Status quo bias makes people stick to what they currently have. Risk aversion may make consumers prefer flat over ToU tariffs, as the latter initially introduce more uncertainty about bills (Hobman et al., 2016). Similarly, if consumers know they can either save money with ToU tariffs by changing their behaviour, or lose it by not changing behaviour, loss aversion may make them more reluctant to take up these tariffs, as they will weigh the possibility of losing money more heavily (Nicolson et al., 2018). All these mechanisms would suggest a tendency not to switch to ToU tariffs, despite potential benefits.

Some evidence suggests that once consumers are on ToU (or other dynamically priced) tariffs, they do indeed benefit. They shift electricity usage to cheaper periods (or use less electricity overall) and hence save money on bills (Commission for Energy Regulation, 2011b; Faruqui and Sergici, 2013; U.S. Department of Energy, 2016). However, there is substantial variation

[2] The Standard Smart Tariff is the ToU tariff that all providers have to offer and it is the one used in the current study as an example.

in demand side response (Faruqui and Sergici, 2013), largely due to two important factors. The first is specific tariff design. Dynamically priced tariffs, such as critical peak pricing or rebates seem to be better at encouraging behaviour change than static ToU tariffs[3]. The former tend to have higher peak to off-peak price ratios and consumers seem to react to this (Faruqui and Sergici, 2013; U.S. Department of Energy, 2016). The second factor is the presence of "enabling technologies", such as programmable thermostats or in-home displays (Commission for Energy Regulation, 2011b; Faruqui and Sergici, 2013; U.S. Department of Energy, 2016) that provide consumers with feedback on their usage; making it easier to see how and when electricity is being used. How such feedback is given to consumers also matters. If information is salient and presented in terms of losses from using more electricity rather than gains from using less, reduction in electricity usage is more pronounced (Bager and Mundaca, 2017). Also, framing the benefits of saving energy in terms of health outcomes rather than money outcomes leads to increased savings sustained for longer time periods (Asensio and Delmas, 2016).

Benefits from ToU tariffs may also differ for various groups of consumers. A recent pilot study from the US found that ToU tariffs result in disproportionately higher electricity bills for households with elderly or disabled members (White and Sintov, 2020). A study from the UK points to another important issue, which is that people's lifestyles and timing of certain activities put them at (dis)advantage when switching to ToU tariffs. This means that some people may find it hard to reap benefits of ToU tariffs (e.g. a single mother that works on shifts), while others will find it easier (Torriti and Yunusov, 2020). Consumers seem to be aware of this potential problem. In a study showing vignettes that described people on peak pricing tariffs, participants reacted negatively to the perceived inequitable impact of such tariffs (Murtagh et al., 2014).

In summary, uptake in Ireland will likely depend on how ToU tariffs are designed, but is likely to depend also on psychological factors. Given the benefits ToU tariffs can bring to individuals and society, uptake may need to be encouraged. At the same time, not all consumers will easily benefit from these tariffs, so the impact on consumer comprehension and decision-making needs to be tested and monitored. Effectively communicating both benefits and challenges of ToU tariffs will be crucial.

Objectives

Given the above, CRU mandated use of "Time-of-Use Primers" (Commission for Regulation of Utilities, 2019). These are information sheets sent by energy providers to all households with a smart meter installed. Such primers need to explain what ToU tariffs are, how they work, what their potential benefits for the consumer are, and to provide contact details for consumers to get more information.[4] The goal is to enhance consumers' understanding and encourage engagement with ToU tariffs. CRU also pledged to create a prototype of a ToU primer, giving the providers a choice of using the prototype or their own primer.

[3] (Static) ToU tariffs divide the day into different time-periods with varying prices. Both time-periods and price rates are determined in advance and remain constant. Critical peak pricing is based on 'events' when wholesale electricity prices are the highest. Consumers are informed about these usually just one-day in advance. Critical peak rebates (or peak time rebates) include an incentive that is paid to consumers if they reduce demand at certain times (Nicolson et al., 2018).

[4] It is worth noting that the primers focus on static ToU tariffs only.

This pre-registered study was designed in close collaboration with the CRU and its aim was to develop and pre-test different versions of the prototype ToU primer, using insights from behavioural science to create effective communication.

Behavioural experiments have been used increasingly over the past few years as a tool to pre-test interventions. They allow policymakers to understand which policy option works best and hence to avoid potentially costly mistakes (Lunn and Robertson, 2018). Pre-tests have been successfully used both in Ireland (e.g. in the context of new legislation on calorie posting on restaurant menus (Robertson and Lunn, 2020)) and internationally, including in the context of smart meters (AECOM, 2011).

The main focus of our behavioural pre-test was to design communications to enhance consumers' comprehension of ToU tariffs and help them to make better decisions. In particular, it answered the following research questions:

(1) Do some features of ToU primers make consumers more aware of the features of ToU tariffs than others?

(2) Do some format features of ToU primers make consumers better understand the features of ToU tariffs than others?

(3) Do some features of ToU primers make consumers better able to identify "good" tariffs than others?

These capture different steps leading to a successful tariff choice – attending to the most important messages about ToU tariffs, remembering the main points, understanding their meaning and implications, and finally, putting this into practice when making the decision.

A second area of focus of the study is consumers' engagement with ToU tariffs, represented by the following research question:

(4) Do some features of ToU primers make ToU tariffs more appealing than others?

In other words, we tested whether presenting information in a certain way induces more positivity towards ToU tariffs and a higher likelihood of choosing them.

The study aimed to answer one final research question:

(5) Do the effects of different primers differ by age and socio-economic status?

This is important in light of the previously mentioned findings on potentially unequal outcomes for different consumer groups.

HOW TO COMMUNICATE INFORMATION ABOUT TOU TARIFFS?

Two streams of relevant scientific literature were reviewed to inform the design of the current study: (1) literature on communication of benefits of energy efficient technologies and new

electricity tariffs to increase their take-up; (2) communication that leads to a better understanding of these new tariffs or information more broadly.

Communicating benefits

Anything that saves energy brings about at least two types of benefits – personal benefits for the consumer, i.e., monetary savings, and broader societal benefits, i.e., positive environmental impact. Both affect consumers, but in different ways – monetary benefits increase extrinsic motivation, while environmental benefits tap into intrinsic motivation. Consequently, focusing on one or the other in communication may affect its efficiency, and communicating both may produce interaction effects between the two types of motivation (Schwartz et al., 2015).

Evidence on whether monetary or environmental framing of information works better is mixed, as illustrated by the following results. People are more likely to (hypothetically) enrol in energy saving programs if only the environmental benefits are communicated, as opposed to just monetary, or both (Schwartz et al., 2015). This result points towards crowding-out of intrinsic motivation when extrinsic motivation is introduced. If people do something for environmental (intrinsic) reasons, telling them they can also save money (providing extrinsic motivation) may backfire. In a similar vein, emphasising environmental benefits (as opposed to no emphasis) of load restrictions[5] in (hypothetical) contracts leads marginally more people to be willing to accept these restrictions (Broberg et al., 2021). A somewhat different result has been found in an experiment studying hypothetical decisions to get a heat pump or a "normal", less energy efficient heating system. Information provided to participants in this study was manipulated in two ways – it either included social norm information or not, and was framed either in monetary or environmental terms. The results show that in the absence of normative information, emphasising financial benefits made participants more likely to choose the heat pump, but framing made no difference when normative information was provided. Moreover, social norms had an effect both on hypothetical choice and on stated likelihood of getting a heat pump in real life (Hafner et al., 2019).

Evidence is unclear when it comes to ToU tariffs specifically. Few studies have tested the effects of environmental framing, while others included only a monetary frame or did not specify the framing used (Nicolson et al., 2018). A recent study from the UK did look at the effects of framing (financial vs environmental, and gain vs loss) on stated likelihood to switch to ToU tariffs and did not find any significant impact (Nicolson et al., 2017). Another study from Israel reached the same conclusion – there was no significant difference in stated willingness to switch to a ToU tariff or perceived benefits based on the framing (monetary or environmental and energy security) used (Parag, 2021).

Communicating energy-related information to enhance comprehension

One way of finding out what effective communication should look like is asking people directly how information should be presented so that they can benefit from it the most (with the caveat that people may misjudge what it is that makes them understand better). A qualitative study from the UK followed exactly this idea and asked people about their preferences for feedback

[5] Load restrictions mean that consumers are capped on their electricity usage in certain time periods. Consumers get compensated for the inconvenience of this.

on energy usage (Simcock et al., 2014). Participants in this study perceived that contextualised information (e.g. giving examples of different appliances and their energy consumption) would aid understanding. Participants also stated that any information provided should be easy to understand (e.g. energy usage should be expressed in € amounts instead of kWh) and come from a trustworthy source.

Experimental studies are another tool to look at the issue of effective communication of energy-related information. An online experiment conducted in the UK tested ways of presenting the benefits and requirements of smart battery storage. Experimental manipulations involved a "frequently asked questions" (FAQ) format, salient warnings, visual cues (icons) or a decision tree. Overall comprehension was improved the most when visual cues and a decision tree were used, while FAQ format proved useful for understanding of environmental benefits specifically (Reiner et al., 2020).

Scientific literature on the link between communication and comprehension of ToU tariffs is limited. Studies conducted to date focused on one specific element – visual presentation of a ToU tariff. A case study from Canada tested people's comprehension of ToU tariffs if these were represented by a "linear 24-hour clock" or a "circular 24-hour clock". Comprehension and recall improved with the linear representation (BE Works, 2019). A more recent study conducted in Ireland revealed that such linearised representation was actually associated with worse understanding and recall of features of ToU tariffs, compared to a simple table (Belton and Lunn, 2020).

Given this limited scope of existing research about communication of ToU tariffs, the current study also uses insights from other domains to design interventions. For instance, the following are all factors that aid understanding and recall of information: simple language (Kim and Kim, 2015), categorisation of information (Kessels, 2003) and use of topic headings (Lorch et al., 1993), infographics (Lunn et al., 2020).

How are ToU tariffs communicated at present?

While a review of scientific literature on communication of energy-relevant information provides insights and helps to identify gaps in knowledge, the design of experimental manipulations for the present study was also informed by commercial practice in the market. The scope here is twofold: (i) use scientific knowledge to create effective communication, but also (ii) design materials that are usable in the commercial settings.

We reviewed online communication of energy providers in some of the most developed markets offering ToU tariffs: the US, Canada, and Australia. We also looked at major price comparison websites from the UK and Ireland that sought to explain day-night tariffs, which have been available for some time in both countries and serve as a useful proxy of domestic types of communication.[6]

We identified one provider offering an information sheet very similar to what ToU primers in Ireland could look like (Essential Energy, 2021). The sheet divides information into sections – providing explanation of what ToU tariffs are, how they work, specifying the tariffs offered

[6] Examples of providers and price comparisons websites reviewed are provided in the text. Full list is available from the authors on request.

and giving an example of one, showing possible savings with these tariffs and providing contact information. The example ToU tariff is presented as a 24h clock with different colours for different time-bands and associated rates. Potential savings are also shown visually in a bar graph.

A lot of providers use short, animated videos instead to explain what ToU tariffs are and how they work (e.g. Central Hudson, 2021; Consumers Energy, 2021). In contrast, price comparison websites tend to be more text-based. A common practice is to use the FAQ format (e.g. Moynihan, 2015).

When it comes to presenting benefits of ToU tariffs, emphasising monetary savings is the most widespread approach (e.g. Central Hudson). However, providers talk about environmental benefits as well (e.g. Southern California Edison, 2021). Some even touch other points such as better control over consumption and bills, or use a collective framing to encourage adoption of ToU tariffs (e.g. Consumers Energy, 2021).

A common way to provide examples of ToU tariffs is via 24h clocks, whether circular or linear (e.g. Essential Energy, 2021; Hydro Ottawa, 2021; Southern California Edison, 2021). These are usually colour-coded, for instance using red, amber and green to represent different time-periods, from the most to the least expensive (e.g. Hydro Ottawa, 2021).

Finally, if the need to change behaviour in order to benefit from ToU tariffs is explained, usually it is done by showing what happens if a certain percentage of usage is shifted (e.g. Central Hudson, 2021), but also by using examples of household electrical appliances (e.g. Moynihan, 2015).

These insights from commercial settings were used together with findings from the scientific literature to create the experimental manipulations for the current study.

EXPERIMENTAL DESIGN

The study was conducted online with a sample of 1,300 participants recruited by a market research company. It lasted around 20 minutes and participants were paid a flat fee for taking part. An extra incentive was offered for questions with objectively correct answers, to ensure proper engagement with the more cognitively demanding tasks.[7] The sample was broadly representative of the Irish population in terms of gender, age, region and social group.

The study used a between-subject fully factorial (2 x 2 x 2) design. Participants were randomly split into 8 groups, each exposed to a different version of a ToU primer. All primers included information on what ToU tariffs are, why they are being introduced, potential savings, a post-it note encouraging consumers to get in touch for more information, a section describing the benefits of ToU tariffs, as well as an example of a ToU and a flat tariff. Each ToU primer also

[7] Participants could opt into participating in a raffle to win a 100€ virtual credit card. They would then receive an extra entry to the raffle for each correct answer to the knowledge questions.

included logos of relevant Irish energy authorities (CRU and the Sustainable Energy Authority of Ireland) and a logo of a fictitious energy provider "Éire Power". Primers were written on one page (landscape oriented), so all information was accessible at once. Participants could view the primer for as long as they wanted, with the option to zoom into different parts of it for better readability.

Afterwards they answered a series of questions and tasks measuring their (i) perceptions of the ToU primer and ToU tariffs, (ii) tariff preferences and ability to select the best tariff for themselves, (iii) understanding of ToU tariffs and recall of features of the primer, (iv) ability to match a tariff to a given electricity usage profile, and (v) personal and household characteristics (socio-demographic and electricity-related).

Experimental manipulations

The eight primers were created by manipulating three aspects of the primer – framing, format and exemplification of benefits. Another feature – visual presentation of example tariffs – was manipulated orthogonally to others.

Framing

All ToU primers had information on both monetary and environmental benefits of ToU tariffs, but we manipulated which of these received primacy and emphasis. For instance, the opening paragraph of the primer in the monetary frame read:

"[…] By shifting when you use electricity, from more expensive to cheaper times, you can lower your bill. This helps the environment too, because shifting to these times will allow more electricity to come from renewable sources."

In the environmental frame, the same paragraph went as follows:

"[…] By shifting when you use electricity, from more expensive to cheaper times, you can help the environment, because it will allow more electricity to come from renewable sources. This helps to lower your bill too."

Format

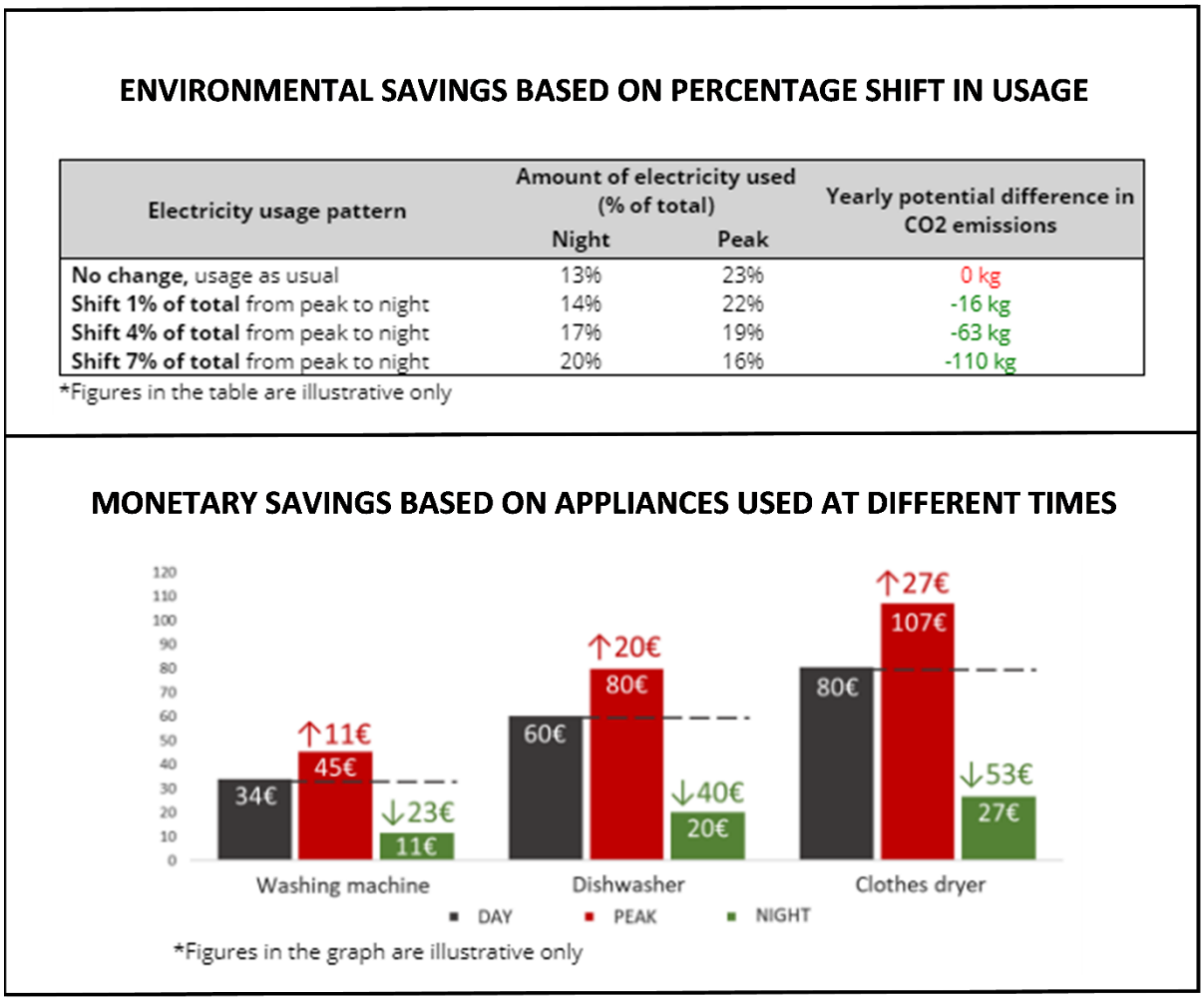
Half of the primers were presented in the FAQ format, i.e., were structured around different questions concerning ToU tariffs. The other half included more graphical elements, such as icons, bullet points and graphs instead of tables (Figures A1 to A8 in Appendix A). Information content was held constant across the formats.

Benefits

Potential savings associated with ToU tariffs were exemplified either by what happens if a certain percentage of total usage is shifted from peak hours to night hours or by usage of certain appliances at different times during the day. They matched other manipulations as well, i.e., they were in a table or a graph based on the primer's format and the savings were either in € amounts or in kg of CO_2 avoided based on the framing of the primer.[8] Examples of these manipulations are in Figure 1.

[8] A note on how the exact figures were calculated is relevant here. In order to produce tables and graphs presented in the primer, we needed: (1) average yearly household electricity usage in Ireland, (2) breakdown of electricity usage by time-period, (3) unit electricity costs in different time-bands, (4) realistic estimate of

Figure 1. Benefits experimental manipulations.

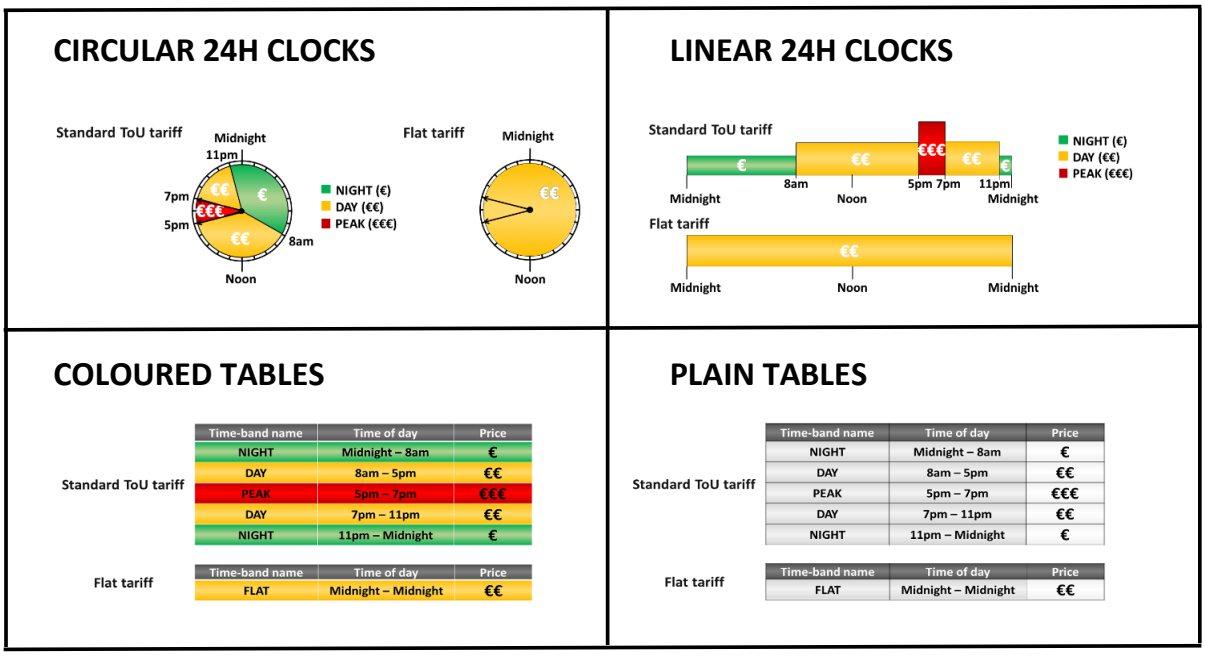


Tariff examples

Tariff examples were presented in one of four visual ways – a colour-coded 24h circular clock, a colour-coded linear 24h clock with differently-sized boxes based on rates, a colour-coded table with time-price pairs in its rows and a plain table. All four are shown in Figure 2.

behaviour change (i.e., amount of electricity shifted from peak to off-peak periods), (5) examples of appliances that use substantial amount of electricity, are present in many households and can be used overnight, (6) average electricity consumption of such appliances, and (7) estimate of CO_2 emissions related to electricity usage. CRU provided us with figures for (1), (2) and (7). (3) was determined based on current unit electricity prices in Ireland for flat and day-night tariffs and discussions with CRU, as no estimates of ToU tariff costs existed. The unit costs used in the experiment were such that if the behaviour did not change, ToU tariffs would lead to minor losses for consumers. This was to emphasise the point that ToU tariffs are not automatically beneficial and actions from consumers may be needed to save money or CO_2 emissions. Data on appliances ((5) and (6)) were taken from a large electricity usage survey conducted in the UK (Zimmermann et al., 2012) as to the best of our knowledge, similar data do not exist for Ireland. Finally, estimates of possible behaviour change (4) were based on international scientific literature about residential demand response to ToU tariffs (e.g. Faruqui and Sergici, 2013; U.S. Department of Energy, 2016).

Figure 2. Tariff example manipulations.



We did not have any directional hypotheses about our experimental manipulations. We did hypothesise, however, that the environmental framing would be more efficient for younger people and those that hold a university degree and pre-registered these hypotheses on OSF (https://osf.io/tw3pg).

Experimental tasks

Subjective questions

Immediately after seeing the primer, participants were asked ten questions about their perceptions and opinion of the primer and ToU tariffs. All questions were measured on 1-7 response scales. The aim of this task was to provide a subjective measure of people's positivity towards ToU tariffs and how this changes with experimental manipulations.

Following the question about participants' general opinion about ToU tariffs (on a scale from 1 = "Very bad idea" to 7 = "Very good idea"), we asked them to write down reasons for this opinion in an open text box to get an additional measure of positivity.

Subjective choice task

Participants were then presented with three tariffs (flat, day-night and ToU) and asked to choose the best one for their own household, the one they would be "most likely to choose in real life". The visual presentation of the tariffs was matched to that of the primer seen earlier. The order of options was randomised at the participant level and prices were the same that we used to calculate the benefits presented in the primer. The task had a twofold objective: (1) to assess the likelihood of choosing each type of tariff (i.e., a different measure of positivity towards ToU tariffs) and (2) to measure choice quality (by choosing the cheapest tariff). To be able to assess choice quality, we collected information on participants' electricity usage by

time-period later in the study and used this to calculate the cost of each tariff. This method is imperfect, because consumers may choose a tariff on the assumption that they will amend their usage pattern. An alternative would have been to ask participants to choose a tariff to match their current usage, but this is arguably less realistic than asking them to pick what they would "choose in real life". We return to this issue when interpreting the results.

Multiple-choice questions (MCQs)

Participants were asked ten MCQs aimed at objectively measuring comprehension. Five questions probed understanding of ToU tariffs (e.g. consequences of no change in behaviour when switching to a ToU tariff, best time to use electricity with a ToU tariff) and five measured recall of certain features of the primer (e.g. duration of peak period, specific amount of savings presented).

Objective choice task

Six vignettes (short scenarios) were used to measure the ability to match a usage profile to a tariff. Three scenarios were narrative, describing electricity usage of a household throughout the day, and three were numerical, providing a percentage breakdown of electricity usage in different time-periods. Participants chose between the same tariffs as in the subjective choice task, presented in the same visual way. There was one correct answer that was the cheapest tariff for the usage profile described.

Electricity-related and socio-demographic questions

In the final part of the study, we gathered information on how the participants use electricity in their household. This included an outline of usage during the day, ownership of certain "green" technologies (e.g. electric/hybrid vehicle, heat pump) and other household electrical appliances (together with perceived easiness of using these during the night), information on main heating source, current electricity tariff, experience with switching tariffs or providers in the past and "environmental friendliness"[9]. Standard socio-demographic information was also collected, complemented by questions on working from home in the context of the current COVID-19 pandemic.

RESULTS

Our data analysis followed closely the pre-registration on OSF. Participants who viewed the primer too quickly, always gave the same answer to the knowledge questions or declined participation in the raffle were excluded from the analysis. All results are robust to using different exclusion criteria[10], unless explicitly stated otherwise.

[9] To assess their environmental friendliness, we asked participants about their overall lifestyle – they could answer they do everything in an environmentally-friendly way, most of the things, quite a few things, one or two things or nothing.

[10] Robustness checks were performed with stricter exclusion criteria based on response times for the primer viewing task and the whole experiment. In particular, these criteria used higher response time thresholds for inclusion in the sample, so further restricted the sample size used in the models.

Results are presented separately for different outcome measures and then are discussed together in the final part of the paper.

Positivity towards ToU tariffs

Overall, participants seemed quite positive about ToU tariffs. As Table B1 in Appendix B shows, the mean score was above 5/7 for eight questions, and above the mid-point of the response scale for the remaining two.

Correlation between all pairs of subjective variables was positive and moderate to strong (range 0.22 to 0.81), which allowed us to sum the answers and create an overall positivity score. The score was then standardised.

Table 1 contains results of linear regressions with this positivity score as a dependent variable. Model 1 uses only experimental manipulations as regressors and shows that none of them had a significant effect on people's overall positivity towards ToU tariffs. Model 2 adds the hypothesised interaction term between age and framing. Younger participants are significantly less positive about ToU tariffs than those aged 40-60, but this difference diminishes if environmental benefits are emphasised. The interaction effect becomes more marginal if stricter exclusion criteria are used, however. Model 3 adds individual characteristics as control variables. These include both socio-demographic (gender and education) and electricity-related characteristics (multiple measures of potential ability to benefit from ToU tariffs, a measure of lack of pro-environmental attitude, experience with switching either tariffs or providers, and knowledge and engagement with electricity tariffs).[11] The model confirms the above result.

To analyse positivity towards ToU tariffs measured by open text answers, we developed a coding framework based on pilot data. It contained 18 categories (seven were about positive points of ToU tariffs, six about the negatives, four were more balanced and one was for people that did not really answer the question). More than one category could be used to code each answer. Two coders categorised the answers independently. Average agreement on all categories was "substantial" according to the classification by Landis and Koch (1977) (96.8% agreement, κ=0.69), while there was some variation in the individual categories (Table B2 in Appendix B). All disagreements were resolved by discussion.

We grouped participants into those that listed only positives of ToU tariffs, only negatives, both (or were unsure) and neither (i.e., did not answer the question) and found that many more listed only the positives rather than the negatives (59.6% vs 10.6%) or provided more balanced answers (15.6%). This was not impacted by experimental manipulations.

[11] All electricity-related variables are binary. Variables for the ease of washing machine use at night, number of electrical appliances and confidence about usage are based on median split of the original measures.

Table 1. OLS regression models of positivity towards ToU tariffs.

	Model 1	Model 2	Model 3
Environmental frame *(ref. Monetary)*	-0.007	-0.126	-0.111
	(0.057)	(0.094)	(0.087)
Graphical format *(ref. FAQ)*	-0.063	-0.067	-0.070
	(0.057)	(0.056)	(0.052)
Appliance benefits *(ref. Percentages)*	0.077	0.089	0.099*
	(0.057)	(0.056)	(0.052)
Tariff examples *(ref. Plain table)*:			
Circular clock	0.126	0.139*	0.083
	(0.081)	(0.080)	(0.074)
Linear clock	0.107	0.111	0.111
	(0.080)	(0.079)	(0.074)
Coloured table	0.059	0.081	0.054
	(0.081)	(0.080)	(0.074)
Age *(ref. 40-60)*:			
Under 40		-0.338***	-0.262***
		(0.096)	(0.091)
60+		0.155	0.111
		(0.095)	(0.089)
Frame * Age:			
Environmental * Under 40		0.262*	0.282**
		(0.138)	(0.128)
Environmental * 60+		0.097	0.124
		(0.135)	(0.125)
Degree			0.056
			(0.055)
Male			-0.163***
			(0.052)
Using washing machine at night *(ref. Hard)*:			
Easy			0.676***
			(0.055)
Already using at night			0.570***
			(0.094)
Number of appliances above median			0.196***
			(0.061)
Not environmentally friendly			-0.187***
			(0.057)
Experience with switching			0.096*
			(0.056)
Confidence in knowing usage			0.109*
			(0.058)
Constant	-0.034	0.008	-0.362***
	(0.076)	(0.092)	(0.109)
N	1,213	1,213	1,213
Adj. R-squared	0.000	0.027	0.167

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Looking at individual items more in detail (Figure B1 in Appendix B), we see that the most common responses provided were positive – possibility of saving money with ToU tariffs (42.8%) and their benefits for the environment (30.1%). None of the experimental conditions had a significant effect on the likelihood of listing potential monetary savings, but frame and format manipulations significantly impacted the likelihood of listing the environmental benefits. If participants saw the environmentally framed primer, they were much more likely to mention the environmental benefits (35.2% vs 25.0%, p<0.001 on the standard test of

proportions) and the opposite happened if the format was graphical compared to the FAQ (25.2% vs 35.0%, p<0.001). Another item that changed with experimental manipulations was perceived control over one's electricity usage and bill – people were more likely to list this item in the monetary frame condition (13.1% vs 9%, p=0.022).

Table 2 presents logistic regression models of likelihood of listing monetary savings (Models 1 and 2) or environmental benefits (Models 3 and 4) and confirms the above findings also when controlling for other individual characteristics (Models 2 and 4).

Table 2. Logistic regression models of likelihood of listing monetary benefits (Models 1&2) and environmental benefits (Models 3&4) of ToU tariffs.

	Saving money		Good for environment	
	Model 1	Model 2	Model 3	Model 4
Environmental frame *(ref. Monetary)*	-0.087	-0.075	0.494***	0.530***
	(0.116)	(0.119)	(0.127)	(0.130)
Graphical format *(ref. FAQ)*	-0.176	-0.203*	-0.479***	-0.492***
	(0.116)	(0.120)	(0.127)	(0.130)
Appliance benefits *(ref. Percentages)*	0.010	0.017	0.054	0.016
	(0.116)	(0.120)	(0.127)	(0.130)
Tariff examples *(ref. Plain table)*:				
Circular clock	0.069	0.063	-0.148	-0.207
	(0.164)	(0.169)	(0.178)	(0.182)
Linear clock	0.060	0.093	-0.253	-0.268
	(0.164)	(0.168)	(0.179)	(0.183)
Coloured table	-0.092	-0.066	-0.104	-0.110
	(0.166)	(0.171)	(0.179)	(0.182)
Age *(ref. 40-60)*:				
Under 40		-0.244		0.281*
		(0.156)		(0.168)
60+		0.332**		0.136
		(0.143)		(0.159)
Degree		-0.026		0.259*
		(0.125)		(0.134)
Male		-0.205*		-0.175
		(0.120)		(0.130)
Using washing machine at night *(ref. Hard)*:				
Easy		0.651***		0.487***
		(0.127)		(0.137)
Already using at night		0.564***		-0.082
		(0.213)		(0.245)
Number of appliances above median		0.118		0.087
		(0.139)		(0.150)
Not environmentally friendly		0.134		-0.522***
		(0.131)		(0.148)
Experience with switching		0.089		0.055
		(0.129)		(0.140)
Confidence in knowing usage		-0.211		-0.201
		(0.133)		(0.145)
Constant	-0.175	-0.511**	-0.772***	-0.955***
	(0.156)	(0.237)	(0.169)	(0.255)
N	1,213	1,213	1,213	1,213
Log-likelihood	-825.997	-798.307	-726.255	-706.517

Standard errors in parentheses; coefficients reported as log odds

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In summary, participants are positive about ToU tariffs. They value mostly monetary savings (older participants even more so). If environmental benefits are emphasised, participants are more likely to mention these in an open text box (not at expense of monetary benefits, but as a complement to them) and younger participants' positivity increases. A FAQ format makes mentioning environmental benefits more likely as well.

The next section presents results for a different measure of positivity towards ToU tariffs – the likelihood of choosing one.

Hypothetical choices

When asked to make a tariff choice for themselves, participants were most likely to choose the ToU tariff (43.3%, compared to 29% choosing a day-night tariff and 27.7% choosing a flat tariff), confirming their positive attitude described in the previous section. Choices were very similar for both types of framing, format, and ways of presenting benefits, but participants were less likely to choose a ToU tariff when linear clocks were used to show tariff examples (35% vs 46.1%, p=0.001 on the Pearson's chi-squared test comparing the linear clock condition against other three conditions pooled).

We ran logistic regressions with ToU choice as a binary dependent variable, shown in Table 3. As previously, Model 1 uses only the treatment variables as regressors, Model 2 adds the interaction between frame and age, and Model 3 adds individual characteristics as control variables.[12] The negative effect of the linear clock is robust to model specification. Once framing is interacted with age, its effect becomes significant – the environmental frame leads to a lower likelihood of choosing a ToU tariff among participants aged 40-60 but has a strongly positive effect on younger people. This is consistent with the result about overall positivity and with our pre-registered hypothesis.

Apart from preferences, we assessed choice quality in this task too. Hypothetical choices were benchmarked against participants' self-reported electricity usage in different time-periods, allowing us to calculate the cheapest tariff for each participant based on current usage. Overall, 37.9% of participants chose the cheapest tariff and the likelihood of choosing it did not vary significantly across any of the conditions (Models 4 and 5 in Table 3). The primary reason for this low figure is that for most participants (76%) the flat tariff was cheapest, but many nevertheless opted for the ToU tariff. It is therefore possible that they anticipated change in behaviour after transferring to a ToU tariff. The proportion choosing the cheapest tariff would then depend on whether individuals accurately predict future behaviour. In any case, choices did not differ across conditions.

[12] All individual characteristics are the same as before, except for that representing knowledge and engagement with electricity tariffs – we now use the type of tariff participants are currently on (flat / day-night / don't know).

Table 3. Logistic regression models of likelihood of choosing the ToU tariff (Models 1-3) and the cheapest tariff (Models 4&5) in the hypothetical choice task.

	ToU tariff choice			Cheapest tariff choice	
	Model 1	Model 2	Model 3	Model 4	Model 5
Environmental frame *(ref. Monetary)*	-0.130	-0.423**	-0.431**	-0.036	-0.053
	(0.117)	(0.198)	(0.203)	(0.119)	(0.122)
Graphical format *(ref. FAQ)*	-0.021	-0.016	-0.004	-0.057	-0.057
	(0.117)	(0.117)	(0.121)	(0.119)	(0.122)
Appliance benefits *(ref. Percentages)*	0.135	0.140	0.164	0.057	0.093
	(0.117)	(0.117)	(0.121)	(0.119)	(0.122)
Tariff examples *(ref. Plain table)*:					
Circular clock	0.240	0.228	0.200	-0.114	-0.082
	(0.164)	(0.165)	(0.169)	(0.169)	(0.173)
Linear clock	-0.354**	-0.378**	-0.367**	-0.041	-0.026
	(0.167)	(0.168)	(0.172)	(0.167)	(0.172)
Coloured table	0.094	0.105	0.103	0.059	0.068
	(0.165)	(0.166)	(0.170)	(0.168)	(0.173)
Age *(ref. 40-60)*:					
Under 40		-0.245	-0.267		-0.098
		(0.201)	(0.211)		(0.157)
60+		0.048	0.024		-0.233
		(0.197)	(0.203)		(0.149)
Frame * Age:					
Environmental * Under 40		0.571**	0.641**		
		(0.290)	(0.298)		
Environmental * 60+		0.331	0.383		
		(0.282)	(0.290)		
Degree			0.280**		0.059
			(0.127)		(0.128)
Male			-0.124		0.255**
			(0.122)		(0.124)
Using washing machine at night *(ref. Hard)*:					
Easy			0.702***		-0.811***
			(0.128)		(0.132)
Already using at night			0.746***		0.069
			(0.220)		(0.216)
Number of appliances above median			0.190		0.060
			(0.141)		(0.143)
Not environmentally friendly			-0.120		-0.125
			(0.132)		(0.134)
Experience with switching			0.133		0.148
			(0.131)		(0.133)
Current tariff *(ref. Flat)*:					
Day-night tariff			0.397**		0.102
			(0.165)		(0.166)
Don't know			0.250		-0.292*
			(0.159)		(0.165)
Constant	-0.261*	-0.201	-0.865***	-0.451***	-0.244
	(0.157)	(0.191)	(0.256)	(0.159)	(0.246)
N	1,213	1,213	1,213	1,213	1,213
Log-likelihood	-821.486	-818.304	-790.032	-804.237	-774.610

Standard errors in parentheses; coefficients reported as log odds

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

MCQs

On average, participants answered 5.93/10 MCQs correctly (SD=1.99). The questions were designed to focus on different aspects of understanding (five on comprehension and five on recall), so the detailed results are presented for these subsets separately.

As for recall, 2.53/5 questions were answered correctly, on average (SD=1.27). Performance was similar across groups seeing different frames and formats of the primer. However, participants who saw possible savings based on a percentage shift in usage recalled significantly more than those who saw them with examples of appliances (2.67 questions correct, SD=1.27 vs 2.40, SD=1.27; $p<0.001$ on Wilcoxon rank-sum test). It is important to note here that only one question probed recall of specific savings and in fact, it is that question only that produces the effect of benefits manipulation (58.3% got it right in the percentage shift condition vs 28.2% in the appliances condition, $p<0.001$ on the standard test of proportions). Not only is this effect statistically significant, but its magnitude is noteworthy as well – the likelihood of recalling the correct savings amount doubles if percentage shift is used instead of appliances. Finally, recall was better if a linear clock was used compared to the plain table (2.63 questions correct, SD=1.28 vs 2.43, SD=1.29; $p=0.053$ on Wilcoxon rank-sum test). The effect remains similar if we only look at the three recall questions that were related to this manipulation (1.93/3 questions correct, SD=0.94 vs 1.77, SD=0.97; $p=0.041$).

We ran ordered logistic regressions to look at the effects more closely. Models 1-3 in Table 4 confirm the negative effect on recall of benefits exemplified with appliances and the positive effect of the linear clock.[13] Moreover, Model 2 reveals that the circular clock also aids recall, but only for people without a university degree, while backfiring for degree holders. The effect is robust to controlling for other individual characteristics (Model 3).

Performance on comprehension questions was higher than on recall questions, with 3.39 answered correctly on average (SD=1.16). This was not affected by format or benefit manipulations. Framing seems to have had a marginal effect, with the monetary frame being associated with better comprehension (3.45/5 questions correct, SD=1.14 vs 3.33, SD=1.18; $p=0.077$). Tariff example presentation had an effect, but in the opposite direction than for recall. Participants who saw a plain table answered more questions correctly than those in any other condition (3.55, SD=1.13 for plain table vs 3.38, SD=1.16 for coloured table, $p=0.079$; 3.33, SD=1.16 for linear clock, $p=0.017$; 3.32, SD=1.19 for circular clock, $p=0.018$).

Again, we ran ordered logistic regressions to look more closely at the above findings.[14] The effect of framing vanished when control variables were added to the models (Models 5 and 6 in Table 4). The negative effect of tariff representations also changed based on specification. It turned out to be driven just by younger people, who struggled with both clock representations, but more so with the linear clock (Models 5 and 6).

To sum up, participants were better at answering questions about understanding, rather than recall of ToU tariff features. Recall of specific savings was substantially better if a percentage change in usage was used to illustrate these. While it looks like linear clock presentation also helped recall, the circular clock backfired for participants with a university degree. At the same

[13] The effect of the linear clocks becomes more marginal if stricter exclusion criteria are used.

[14] The dependent variable was recategorized due to a failure to compute Brant test for Models 5 and 6 in Table 4, by merging the two lowest categories. Results are robust to this recategorization.

time, both of these manipulations were harmful for comprehension compared to the plain table, especially for younger participants.

Before discussing this somewhat contradictory result, we present findings for the objective choice task, which can be understood as another measure of comprehension.

Table 4. Ordered logistic regression models of recall (Models 1-3) and comprehension (Models 4-6).

	Recall			Comprehension		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Environmental frame *(ref. Monetary)*	0.116	0.115	0.147	-0.192*	-0.167	-0.153
	(0.104)	(0.104)	(0.105)	(0.106)	(0.107)	(0.107)
Graphical format *(ref. FAQ)*	0.125	0.153	0.150	0.125	0.155	0.164
	(0.104)	(0.105)	(0.105)	(0.106)	(0.107)	(0.107)
Appliance benefits *(ref. Percentages)*	-0.374***	-0.403***	-0.423***	0.100	0.094	0.089
	(0.104)	(0.105)	(0.106)	(0.106)	(0.106)	(0.107)
Tariff examples *(ref. Plain table)*:						
Circular clock	0.200	0.570***	0.531***	-0.361**	-0.139	-0.135
	(0.148)	(0.194)	(0.196)	(0.152)	(0.248)	(0.249)
Linear clock	0.274*	0.462**	0.443**	-0.339**	0.044	0.030
	(0.147)	(0.190)	(0.192)	(0.150)	(0.250)	(0.253)
Coloured table	0.058	0.298	0.221	-0.263*	-0.222	-0.251
	(0.149)	(0.196)	(0.199)	(0.153)	(0.245)	(0.248)
Degree		0.997***	0.852***			0.618***
		(0.216)	(0.220)			(0.114)
Tariff examples * Degree:						
Circular clock * Degree		-0.875***	-0.859***			
		(0.303)	(0.306)			
Linear clock * Degree		-0.359	-0.303			
		(0.303)	(0.304)			
Coloured table * Degree		-0.581*	-0.515*			
		(0.302)	(0.305)			
Age *(ref. 40-60)*:						
Under 40			0.333**		0.911***	0.902***
			(0.137)		(0.278)	(0.281)
60+			-0.457***		-0.162	-0.190
			(0.128)		(0.252)	(0.255)
Tariff examples * Age:						
Circular clock * Under 40					-0.843**	-0.890**
					(0.379)	(0.380)
Circular clock * 60+					-0.054	-0.184
					(0.361)	(0.363)
Linear clock * Under 40					-1.008***	-1.026***
					(0.380)	(0.381)
Linear clock * 60+					-0.335	-0.374
					(0.352)	(0.355)
Coloured table * Under 40					-0.538	-0.587
					(0.381)	(0.382)
Coloured table * 60+					0.236	0.128
					(0.359)	(0.362)
Male			0.176*			0.137
			(0.107)			(0.110)
Using washing machine at night *(ref. Hard)*:						
Easy			0.332***			0.216*
			(0.113)			(0.114)
Already using at night			0.593***			0.243
			(0.191)			(0.201)

Number of appliances above median			-0.273**			0.189
			(0.123)			(0.128)
Not environmentally friendly			-0.176			-0.134
			(0.114)			(0.116)
Experience with switching			0.178			0.180
			(0.114)			(0.116)
Current tariff *(ref. Flat)*:						
Day-night			-0.054			-0.261*
			(0.144)			(0.150)
Don't know			-0.343**			-0.403***
			(0.138)			(0.142)
_cut1	-3.050***	-2.674***	-2.671***	-2.765***	-2.588***	-2.275***
	(0.193)	(0.210)	(0.264)	(0.176)	(0.225)	(0.269)
_cut2	-1.160***	-0.767***	-0.731***	-1.602***	-1.419***	-1.084***
	(0.147)	(0.171)	(0.235)	(0.154)	(0.208)	(0.255)
_cut3	0.058	0.473***	0.549**	-0.395***	-0.201	0.178
	(0.143)	(0.170)	(0.234)	(0.147)	(0.203)	(0.252)
_cut4	1.248***	1.685***	1.805***	1.546***	1.774***	2.221***
	(0.147)	(0.176)	(0.240)	(0.156)	(0.212)	(0.262)
_cut5	2.721***	3.176***	3.329***			
	(0.175)	(0.201)	(0.259)			
N	1,176	1,176	1,176	1,176	1,176	1,176
Log-likelihood	-1,914.580	-1,897.458	-1,868.806	-1,703.926	-1,691.925	-1,662.815

Standard errors in parentheses; coefficients reported as log odds

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Objective choice

On average, participants chose the correct tariff for 3.44/6 scenarios (SD=1.40), which can be seen as a sign that this task was hard for them (considering that guessing at random would yield 2/6 correct answers).

As with the MCQs, results from this task are broken down into two parts – narrative and numerical vignettes.

The average performance for narrative vignettes was 1.91/3 correct answers (SD=0.91). The presentation of the tariff example provided influenced performance in this task, resulting in the highest scores for participants who saw a plain table (2.02 correct answers for plain table, SD=0.93, vs 1.90 for coloured table, SD=0.88, p=0.056; 1.85 for linear clock, SD=0.89, p=0.012; 1.90 for circular clock, SD=0.94, p=0.11). Ordered logistic models (Models 1 and 2 in Table 5) support this result, which is in line with the finding about comprehension measured by the MCQs, even though there the negative effect of clock representations was confined to younger participants.

Participants performed worse on numerical vignettes. On average, 1.52/3 numerical vignettes were answered correctly (SD=0.88) and there were no significant effects of experimental manipulations (Models 3 and 4 in Table 5).

Table 5. Ordered logistic regression models of objective choice in narrative vignettes (Models 1&2) and numerical vignettes (Models 3&4).

	Narrative vignettes		Numerical vignettes	
	Model 1	Model 2	Model 3	Model 4
Environmental frame *(ref. Monetary)*	-0.131	-0.100	0.045	0.056
	(0.107)	(0.108)	(0.108)	(0.108)
Graphical format *(ref. FAQ)*	0.058	0.072	0.078	0.109
	(0.107)	(0.108)	(0.108)	(0.109)
Appliance benefits *(ref. Percentages)*	0.179*	0.141	0.063	0.038
	(0.107)	(0.109)	(0.108)	(0.109)
Tariff examples *(ref. Plain table)*:				
Circular clock	-0.247	-0.314**	0.195	0.171
	(0.154)	(0.155)	(0.152)	(0.153)
Linear clock	-0.380**	-0.379**	0.158	0.157
	(0.152)	(0.153)	(0.152)	(0.153)
Coloured table	-0.284*	-0.357**	-0.103	-0.166
	(0.154)	(0.156)	(0.154)	(0.155)
Age *(ref. 40-60)*:				
Under 40		0.234*		0.292**
		(0.140)		(0.141)
60+		-0.522***		-0.302**
		(0.133)		(0.132)
Degree		0.235**		0.385***
		(0.114)		(0.115)
Male		-0.038		0.058
		(0.109)		(0.110)
Using washing machine at night *(ref. Hard)*:				
Easy		0.240**		0.011
		(0.115)		(0.115)
Already using at night		0.267		0.549***
		(0.201)		(0.202)
Number of appliances above median		-0.025		-0.096
		(0.126)		(0.127)
Not environmentally friendly		-0.127		0.135
		(0.118)		(0.118)
Experience with switching		0.215*		0.147
		(0.119)		(0.119)
Current tariff *(ref. Flat)*:				
Day-night		-0.353**		-0.424***
		(0.151)		(0.150)
Don't know		-0.218		-0.217
		(0.142)		(0.144)
_cut1	-2.672***	-2.676***	-1.925***	-1.773***
	(0.175)	(0.239)	(0.162)	(0.233)
_cut2	-1.014***	-0.980***	0.230	0.432*
	(0.151)	(0.222)	(0.147)	(0.224)
_cut3	0.676***	0.765***	1.872***	2.125***
	(0.149)	(0.221)	(0.159)	(0.233)
N	1,166	1,166	1,166	1,166
Log-likelihood	-1,465.808	-1,443.507	-1,470.776	-1,447.321

Standard errors in parentheses; coefficients reported as log odds

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Other findings

Some of the control variables added to the models provide interesting insights as well.

First, we look at the positivity about ToU tariffs (Model 3 in Table 1, Models 2 and 4 in Table 2, and Model 3 in Table 3). It is strongly predicted by the variables capturing the possibility to actually benefit from ToU tariffs. In particular, people who own more electrical appliances than the median person in the sample (i.e. those who can potentially switch a lot of their usage to cheaper periods) and who think using washing machine overnight is easy or are already doing so (i.e. those who are willing to change their behaviour or have already done so) score higher on positivity. People using the washing machine overnight or perceiving it as easy are also more likely to choose a ToU tariff and the latter are more likely to list both monetary and environmental benefits of ToU tariffs. In contrast, lacking an environmentally friendly attitude is linked with more negative feelings towards ToU tariffs as measured by overall positivity score, but it does not affect the likelihood of choosing a ToU tariff. Perhaps unsurprisingly, this characteristic is also associated with a lower likelihood of listing environmental benefits of ToU tariffs, while being over 60 years old is associated with a higher likelihood of listing monetary benefits. As for choosing a ToU tariff, it is more likely for people who are currently on a day-night tariff as opposed to those a flat tariff, and people holding university degrees. Overall, it looks like the characteristics related to electricity usage and attitudes predict positivity towards ToU tariffs quite strongly.

Understanding (measured by recall, comprehension, and objective tariff choice) seems to be impacted more by socio-demographic characteristics, namely age and university degree (Models 3 and 6 in Table 4, and Models 2 and 4 in Table 5). Having a university degree is associated with better performance, while increasing age leads to decrease in performance. As for other characteristics, people with day-night tariffs perform worse in the vignette task compared to those on flat tariffs and those not knowing their current tariff do worse on the MCQs, possibly suggesting lack of interest in engaging and trying to understand electricity tariffs in general.

CONCLUSION

Our results suggest that the Irish population is broadly positive about ToU tariffs. Households perceive the possibility of making monetary savings as the primary benefit. However, emphasising environmental benefits in the primer made our study participants more likely to mention these in an open text box (not at expense of monetary benefits, but as a complement to them). Furthermore, younger participants became more positive about ToU tariffs when the environmental benefits were emphasised and more inclined to opt for a ToU tariff over other tariffs.

ToU tariffs were the most popular choice in our study in general. Although we only measured hypothetical choices, the findings can still serve as an estimate of potential interest in ToU tariffs in Ireland. Future research should look at whether this potential interest translates into real choices and what the potential barriers in switching tariffs are.

Benchmarking the tariff choices against self-reported electricity usage revealed that a relatively low number of consumers chose the cheapest tariff for their current usage. This result relies on the specific tariff design used in our study and on people's self-reported usage. It may reflect a belief among consumers that choosing a ToU tariff will lead them to make substantial changes to when they use electricity. However, the true extent of behaviour change induced by a ToU tariff may depend on how feedback is supplied to households and characteristics of householders (Di Cosmo and O'Hora, 2017). The ultimate impact on consumer welfare is therefore not straightforward and requires further study.

The experimental method applied in our study had the advantage of enabling us to obtain objective measures of recall, comprehension and ability to match tariffs to usage profiles. These produced some surprising results. It might be thought that describing savings in terms of everyday use of appliances rather than percentage changes in usage would be more salient and familiar for consumers, leading to better recall. We found the opposite.

In general, participants were better at answering questions about understanding of ToU tariffs, rather than recall of specific ToU tariff features. This distinction matters to our investigation of the use of 24h clocks to depict ToU tariffs, which arguably produced the most striking result in this study. Presenting a ToU tariff as a linear clock helped people to recall its features, although a circular clock did the opposite for some participants (those with university degree). However, and more importantly, both of these presentations led to lower comprehension of the ToU tariff compared to tariff information presented in a plain table. This was especially true for younger participants. Clock presentations negatively impacted choice quality as well, making participants less likely to correctly match a tariff to a narrative description of a usage profile. Even if recall of some rates or times is better with a clock presentation, there is likely to be little benefit to this if consumers do not properly understand the key features of the tariff and cannot make the right tariff choice. This result is important, because clocks like those we tested have been designed and promoted in markets where ToU tariffs are already available. Previous research has also indicated that consumers have difficulty processing tariffs presented as clocks (Belton and Lunn, 2020). The implication of this research is that primers for consumers should avoid this type of presentation and instead use simple tables.

This final finding exemplifies the benefits of behaviourally testing interventions through experimental methods. When it comes to consumer decision-making, the intuitions of researchers, policymakers and providers do not always turn out to be accurate. Taking the time and making the effort to pre-test interventions is therefore likely to benefit consumers.

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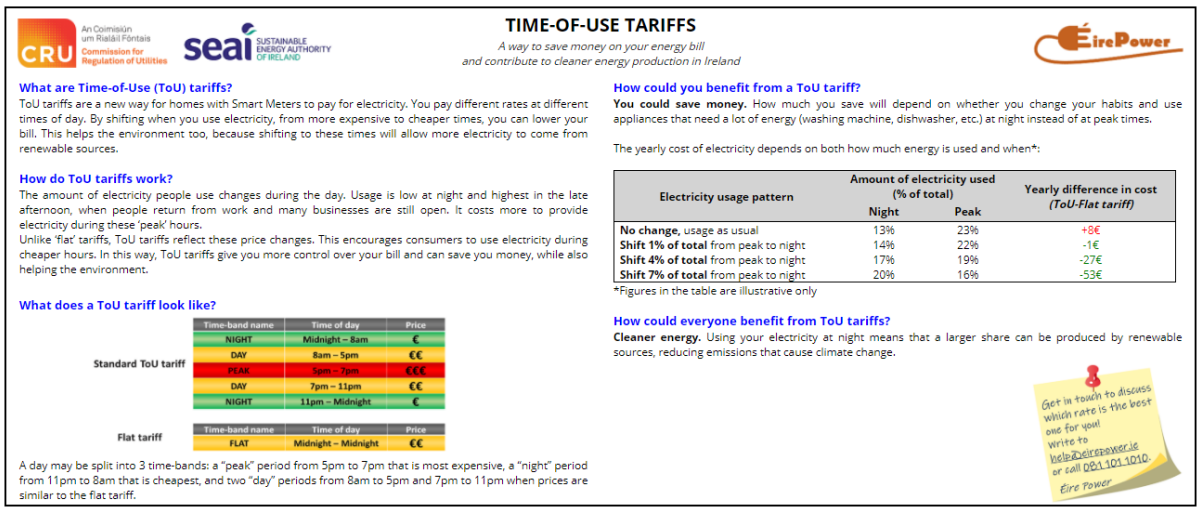
APPENDIX A: MATERIALS

Figure A1. Example ToU primer with (1) monetary framing, (2) FAQ format, (3) benefits based on % shift in usage and (4) coloured table[15].



TIME-OF-USE TARIFFS

A way to save money on your energy bill and contribute to cleaner energy production in Ireland

What are Time-of-Use (ToU) tariffs?

ToU tariffs are a new way for homes with Smart Meters to pay for electricity. You pay different rates at different times of day. By shifting when you use electricity, from more expensive to cheaper times, you can lower your bill. This helps the environment too, because shifting to these times will allow more electricity to come from renewable sources.

How do ToU tariffs work?

The amount of electricity people use changes during the day. Usage is low at night and highest in the late afternoon, when people return from work and many businesses are still open. It costs more to provide electricity during these 'peak' hours.

Unlike 'flat' tariffs, ToU tariffs reflect these price changes. This encourages consumers to use electricity during cheaper hours. In this way, ToU tariffs give you more control over your bill and can save you money, while also helping the environment.

What does a ToU tariff look like?

Standard ToU tariff

Time-band name	Time of day	Price
NIGHT	Midnight – 8am	€
DAY	8am – 5pm	€€
PEAK	5pm – 7pm	€€€
DAY	7pm – 11pm	€€
NIGHT	11pm – Midnight	€

Flat tariff

Time-band name	Time of day	Price
FLAT	Midnight – Midnight	€€

A day may be split into 3 time-bands: a "peak" period from 5pm to 7pm that is most expensive, a "night" period from 11pm to 8am that is cheapest, and two "day" periods from 8am to 5pm and 7pm to 11pm when prices are similar to the flat tariff.

How could you benefit from a ToU tariff?

You could save money. How much you save will depend on whether you change your habits and use appliances that need a lot of energy (washing machine, dishwasher, etc.) at night instead of at peak times.

The yearly cost of electricity depends on both how much energy is used and when*:

Electricity usage pattern	Amount of electricity used (% of total)		Yearly difference in cost *(ToU-Flat tariff)*
	Night	Peak	
No change, usage as usual	13%	23%	+8€
Shift 1% of total from peak to night	14%	22%	-1€
Shift 4% of total from peak to night	17%	19%	-27€
Shift 7% of total from peak to night	20%	16%	-53€

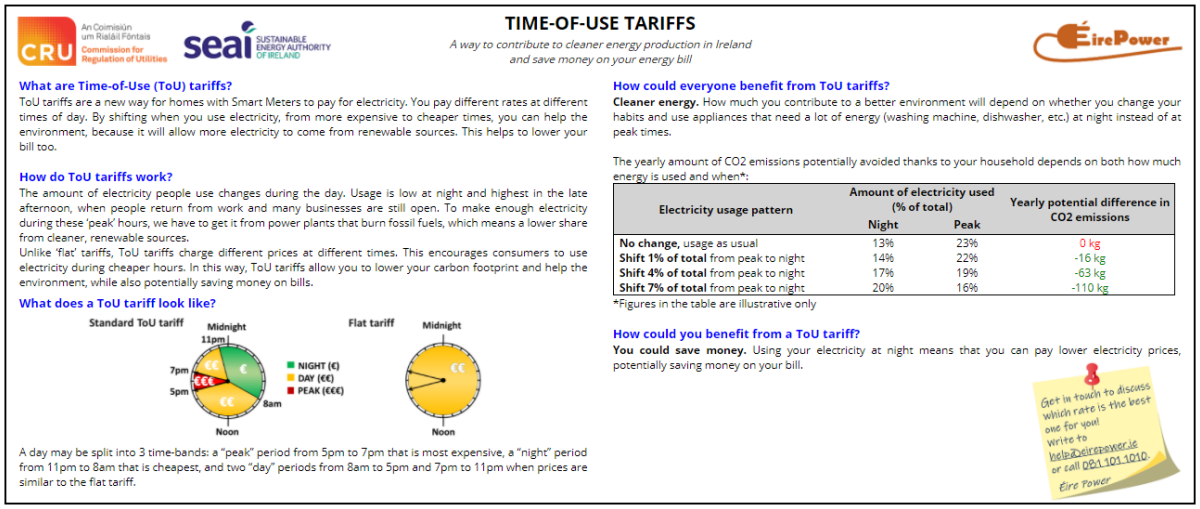
*Figures in the table are illustrative only

How could everyone benefit from ToU tariffs?

Cleaner energy. Using your electricity at night means that a larger share can be produced by renewable sources, reducing emissions that cause climate change.

Get in touch to discuss which rate is the best one for you! Write to help@eirepower.ie or call 0[1] 101 1010. Eire Power

Figure A2. Example ToU primer with (1) environmental framing, (2) FAQ format, (3) benefits based on % shift in usage and (4) circular 24h clock.



TIME-OF-USE TARIFFS

A way to contribute to cleaner energy production in Ireland and save money on your energy bill

What are Time-of-Use (ToU) tariffs?

ToU tariffs are a new way for homes with Smart Meters to pay for electricity. You pay different rates at different times of day. By shifting when you use electricity, from more expensive to cheaper times, you can help the environment, because it will allow more electricity to come from renewable sources. This helps to lower your bill too.

How do ToU tariffs work?

The amount of electricity people use changes during the day. Usage is low at night and highest in the late afternoon, when people return from work and many businesses are still open. To make enough electricity during these 'peak' hours, we have to get it from power plants that burn fossil fuels, which means a lower share from cleaner, renewable sources.

Unlike 'flat' tariffs, ToU tariffs charge different prices at different times. This encourages consumers to use electricity during cheaper hours. In this way, ToU tariffs allow you to lower your carbon footprint and help the environment, while also potentially saving money on bills.

What does a ToU tariff look like?

Standard ToU tariff

Flat tariff

A day may be split into 3 time-bands: a "peak" period from 5pm to 7pm that is most expensive, a "night" period from 11pm to 8am that is cheapest, and two "day" periods from 8am to 5pm and 7pm to 11pm when prices are similar to the flat tariff.

How could everyone benefit from ToU tariffs?

Cleaner energy. How much you contribute to a better environment will depend on whether you change your habits and use appliances that need a lot of energy (washing machine, dishwasher, etc.) at night instead of at peak times.

The yearly amount of CO2 emissions potentially avoided thanks to your household depends on both how much energy is used and when*:

Electricity usage pattern	Amount of electricity used (% of total)		Yearly potential difference in CO2 emissions
	Night	Peak	
No change, usage as usual	13%	23%	0 kg
Shift 1% of total from peak to night	14%	22%	-16 kg
Shift 4% of total from peak to night	17%	19%	-63 kg
Shift 7% of total from peak to night	20%	16%	-110 kg

*Figures in the table are illustrative only

How could you benefit from a ToU tariff?

You could save money. Using your electricity at night means that you can pay lower electricity prices, potentially saving money on your bill.

Get in touch to discuss which rate is the best one for you! Write to help@eirepower.ie or call 0[1] 101 1010. Eire Power

[15] Note that the example tariff presentation was determined randomly and independently from other manipulations, so the primer shown here would contain a 24h circular clock, a 24h linear clock or a plain table instead of the coloured table for some participants. The same holds for all 8 primer versions.

Figure A3. Example ToU primer with (1) monetary framing, (2) graphical format, (3) benefits based on % shift in usage and (4) plain table.

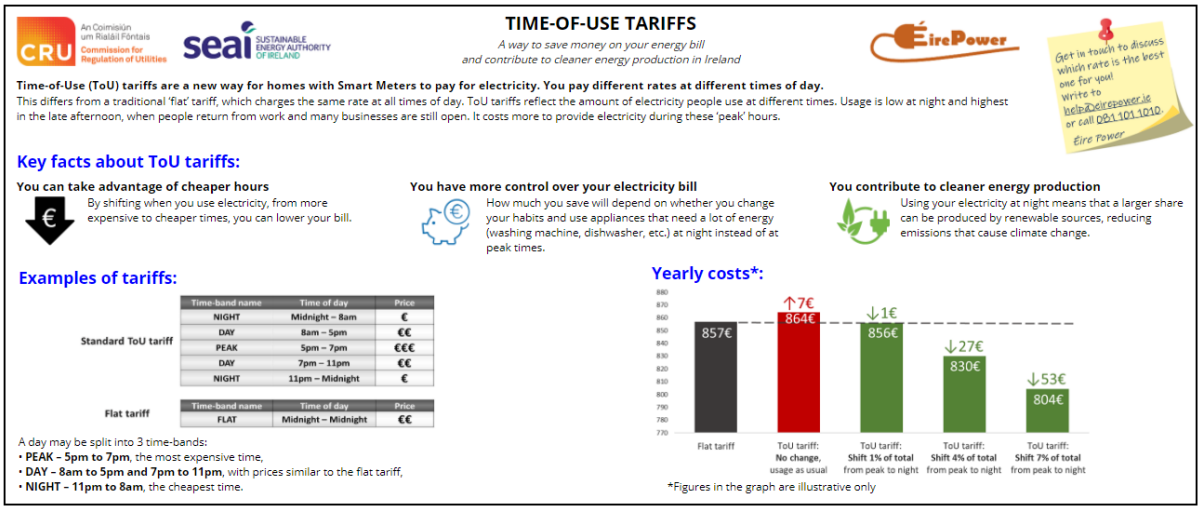


Figure A4. Example ToU primer with (1) environmental framing, (2) graphical format, (3) benefits based on % shift in usage and (4) coloured table.

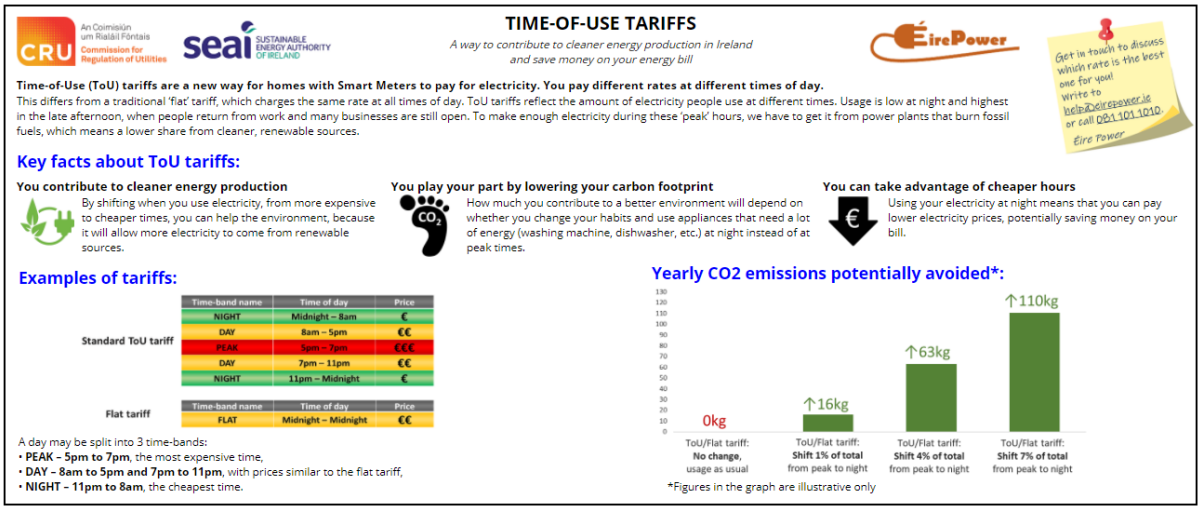
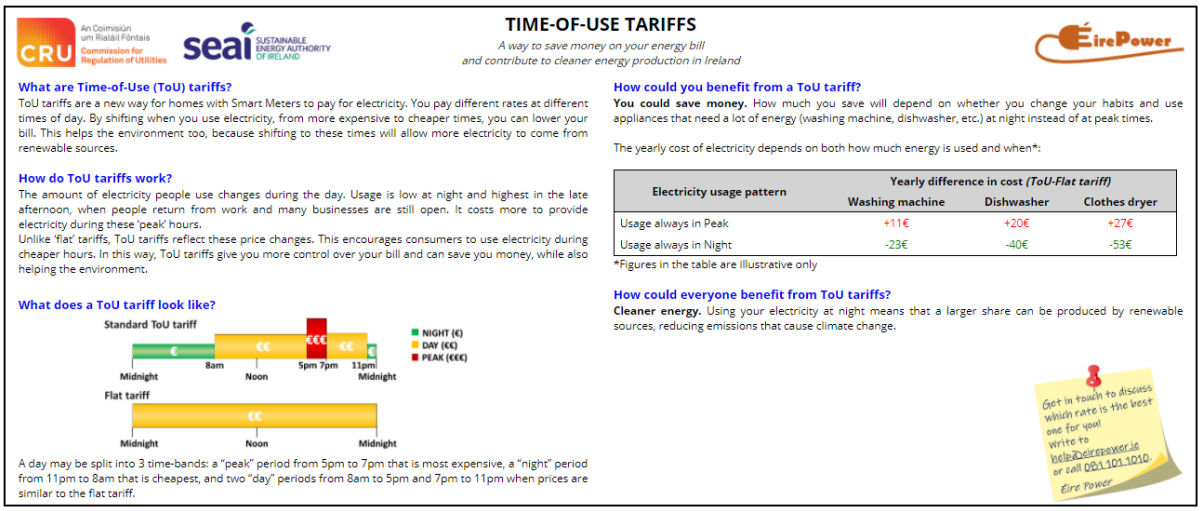


Figure A5. Example ToU primer with (1) monetary framing, (2) FAQ format, (3) benefits based on appliance usage and (4) linear 24h clock.



TIME-OF-USE TARIFFS

A way to save money on your energy bill and contribute to cleaner energy production in Ireland

What are Time-of-Use (ToU) tariffs?

ToU tariffs are a new way for homes with Smart Meters to pay for electricity. You pay different rates at different times of day. By shifting when you use electricity, from more expensive to cheaper times, you can lower your bill. This helps the environment too, because shifting to these times will allow more electricity to come from renewable sources.

How do ToU tariffs work?

The amount of electricity people use changes during the day. Usage is low at night and highest in the late afternoon, when people return from work and many businesses are still open. It costs more to provide electricity during these 'peak' hours.
Unlike 'flat' tariffs, ToU tariffs reflect these price changes. This encourages consumers to use electricity during cheaper hours. In this way, ToU tariffs give you more control over your bill and can save you money, while also helping the environment.

What does a ToU tariff look like?

A day may be split into 3 time-bands: a "peak" period from 5pm to 7pm that is most expensive, a "night" period from 11pm to 8am that is cheapest, and two "day" periods from 8am to 5pm and 7pm to 11pm when prices are similar to the flat tariff.

How could you benefit from a ToU tariff?

You could save money. How much you save will depend on whether you change your habits and use appliances that need a lot of energy (washing machine, dishwasher, etc.) at night instead of at peak times.

The yearly cost of electricity depends on both how much energy is used and when*:

Electricity usage pattern	Yearly difference in cost *(ToU-Flat tariff)*		
	Washing machine	Dishwasher	Clothes dryer
Usage always in Peak	+11€	+20€	+27€
Usage always in Night	-23€	-40€	-53€

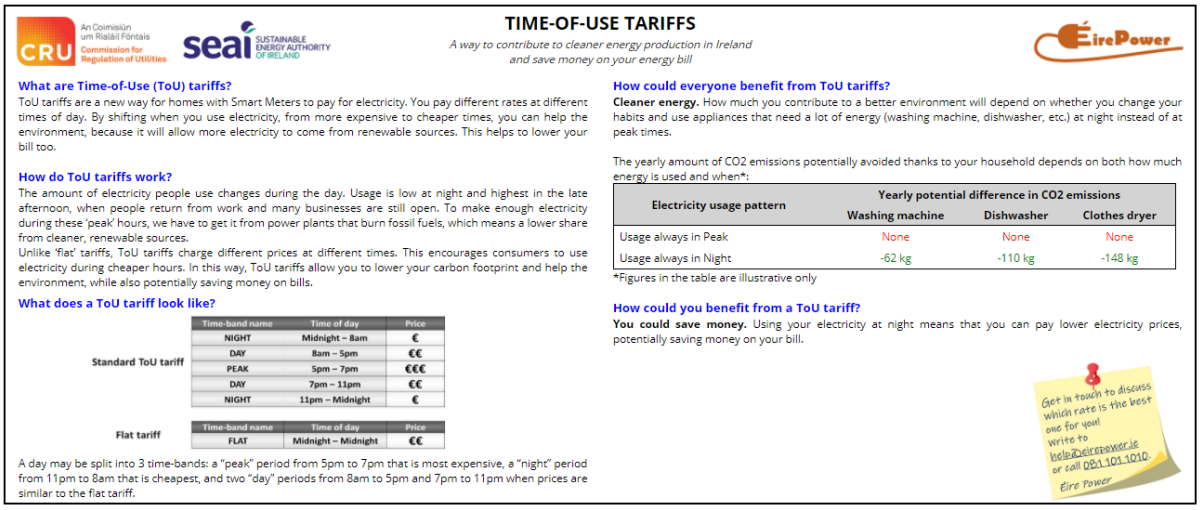
*Figures in the table are illustrative only

How could everyone benefit from ToU tariffs?

Cleaner energy. Using your electricity at night means that a larger share can be produced by renewable sources, reducing emissions that cause climate change.

Get in touch to discuss which rate is the best one for you! Write to help@eirepowir.ie or call 0[1] 101 1010. Eire Power

Figure A6. Example ToU primer with (1) environmental framing, (2) FAQ format, (3) benefits based on appliance usage and (4) plain table.



TIME-OF-USE TARIFFS

A way to contribute to cleaner energy production in Ireland and save money on your energy bill

What are Time-of-Use (ToU) tariffs?

ToU tariffs are a new way for homes with Smart Meters to pay for electricity. You pay different rates at different times of day. By shifting when you use electricity, from more expensive to cheaper times, you can help the environment, because it will allow more electricity to come from renewable sources. This helps to lower your bill too.

How do ToU tariffs work?

The amount of electricity people use changes during the day. Usage is low at night and highest in the late afternoon, when people return from work and many businesses are still open. To make enough electricity during these 'peak' hours, we have to get it from power plants that burn fossil fuels, which means a lower share from cleaner, renewable sources.
Unlike 'flat' tariffs, ToU tariffs charge different prices at different times. This encourages consumers to use electricity during cheaper hours. In this way, ToU tariffs allow you to lower your carbon footprint and help the environment, while also potentially saving money on bills.

What does a ToU tariff look like?

Standard ToU tariff

Time-band name	Time of day	Price
NIGHT	Midnight – 8am	€
DAY	8am – 5pm	€€
PEAK	5pm – 7pm	€€€
DAY	7pm – 11pm	€€
NIGHT	11pm – Midnight	€

Flat tariff

Time-band name	Time of day	Price
FLAT	Midnight – Midnight	€€

A day may be split into 3 time-bands: a "peak" period from 5pm to 7pm that is most expensive, a "night" period from 11pm to 8am that is cheapest, and two "day" periods from 8am to 5pm and 7pm to 11pm when prices are similar to the flat tariff.

How could everyone benefit from ToU tariffs?

Cleaner energy. How much you contribute to a better environment will depend on whether you change your habits and use appliances that need a lot of energy (washing machine, dishwasher, etc.) at night instead of at peak times.

The yearly amount of CO_2 emissions potentially avoided thanks to your household depends on both how much energy is used and when*:

Electricity usage pattern	Yearly potential difference in CO_2 emissions		
	Washing machine	Dishwasher	Clothes dryer
Usage always in Peak	None	None	None
Usage always in Night	-62 kg	-110 kg	-148 kg

*Figures in the table are illustrative only

How could you benefit from a ToU tariff?

You could save money. Using your electricity at night means that you can pay lower electricity prices, potentially saving money on your bill.

Get in touch to discuss which rate is the best one for you! Write to help@eirepowir.ie or call 0[1] 101 1010. Eire Power

Figure A7. Example ToU primer with (1) monetary framing, (2) graphical format, (3) benefits based on appliance usage and (4) plain table.

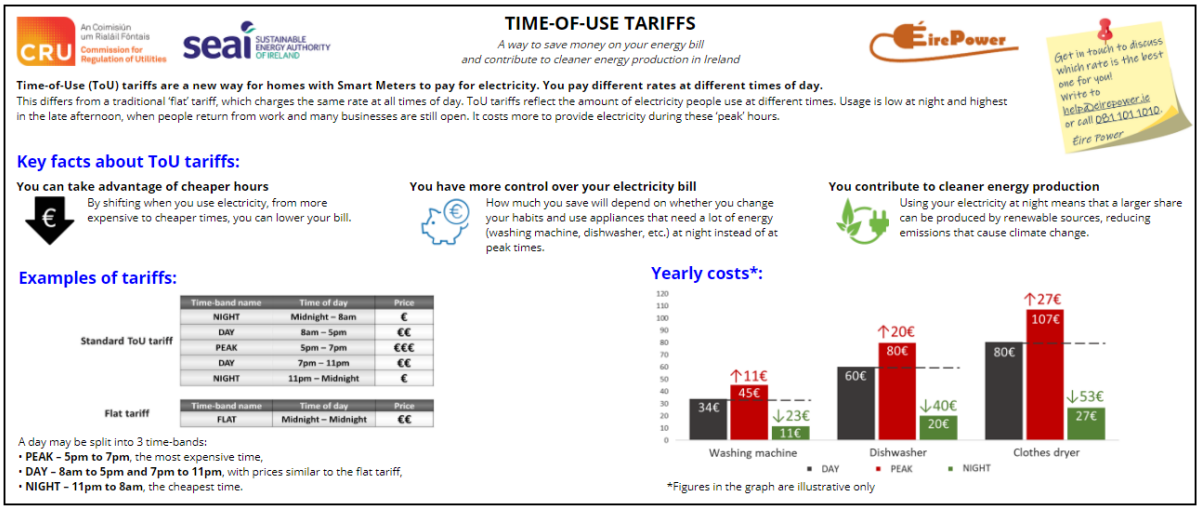
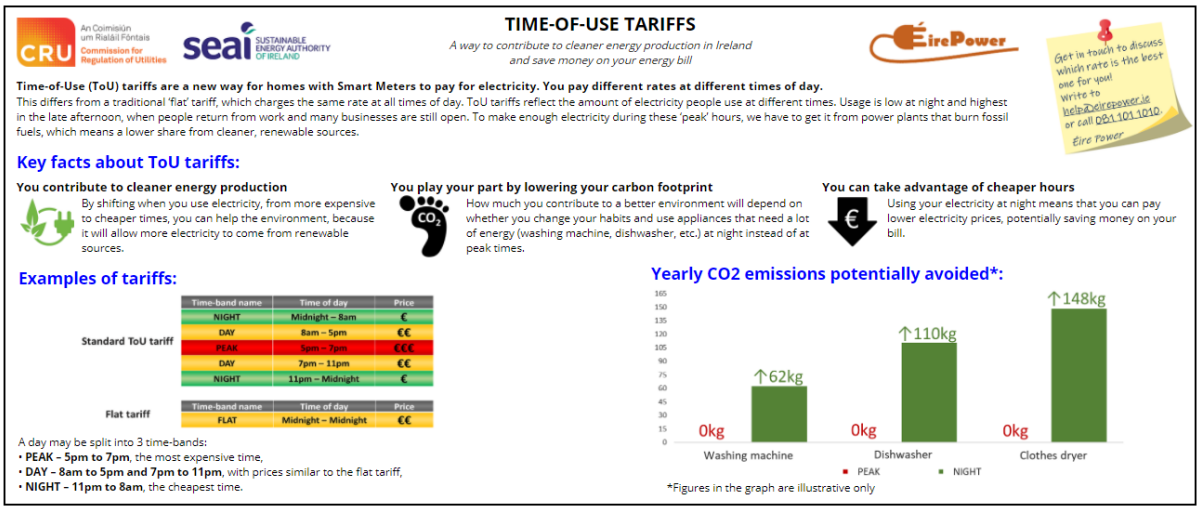


Figure A8. Example ToU primer with (1) environmental framing, (2) graphical format, (3) benefits based on appliance usage and (4) coloured table.



APPENDIX B: RESULTS

Table B1. Summary statistics on subjective measures of positivity towards ToU tariffs.

MEASURE	MEAN	SD	MEDIAN
How well did the information sheet get across the main messages about ToU tariffs? *[Not well at all 1 --- 7 Very well]*	5.8	1.23	6
How interesting did you find the information sheet? *[Not interesting at all 1 --- 7 Very interesting]*	5.6	1.46	6
How confident are you that you now understand the main points about what ToU tariffs are and how they work? *[Not at all confident 1 --- 7 Very confident]*	5.7	1.22	6
What do you think about ToU tariffs in general? *[Very bad idea 1 --- 7 Very good idea]*	5.6	1.48	6
How beneficial do you think a ToU tariff would be for you? *[Not at all beneficial 1 --- 7 Very beneficial]*	5.1	1.72	5
How easy/difficult would it be for you to make savings with a ToU tariff? *[Very easy 1 --- 7 Very difficult]* *	4.1	1.74	4
How likely would you be to search for more information about ToU tariffs? *[Not at all likely 1 --- 7 Very likely]*	5.4	1.73	6
How likely would you be to consider switching to a new ToU tariff? *[Not at all likely 1 ---7 Very likely]*	5.0	1.76	5
How important do you think it is that people in Ireland switch to a ToU tariff? *[Not at all important 1 --- 7 Very important]*	5.2	1.59	5
How fair would it be if everyone was put on a ToU tariff automatically, with an option to opt-out and choose a different tariff if they wanted? *[Very unfair 1 --- 7 Very fair]*	4.5	2.03	5

*Reverse-coded for the analysis

Table B2. Interrater agreement on all open text categories individually.

	LEVEL OF AGREEMENT based on Landis and Koch (1977)	KAPPA STATISTIC	AGREEMENT
Did not answer the question	Almost perfect	0.92	97.8%
More control over electricity use	Almost perfect	0.88	97.8%
Good for environment	Almost perfect	0.88	95.2%
Good idea	Almost perfect	0.87	98.8%
Not sure	Almost perfect	0.84	99.3%
Can't use appliances overnight (risk/noise)	Substantial	0.76	98.3%
Allow to save money	Substantial	0.75	87.9%
Good idea, but…	Substantial	0.75	97.8%
Privacy concern	Substantial	0.75	99.8%
Encourage change in electricity use	Substantial	0.71	97.2%
Distrust, more expensive	Substantial	0.67	97.6%
Good for some, bad for others	Moderate	0.59	95.6%
Make more aware of electricity use	Moderate	0.58	94.4%
Complex	Moderate	0.57	97.6%
Can't see benefits	Moderate	0.57	97.9%
Good for national grid	Moderate	0.57	96.7%
Overnight use hard/inconvenient	Moderate	0.52	94.2%
Depends on specific tariff	Fair	0.25	98.2%

Figure B1. Percentage of participants listing each category when asked about reasons for liking or disliking ToU tariffs.