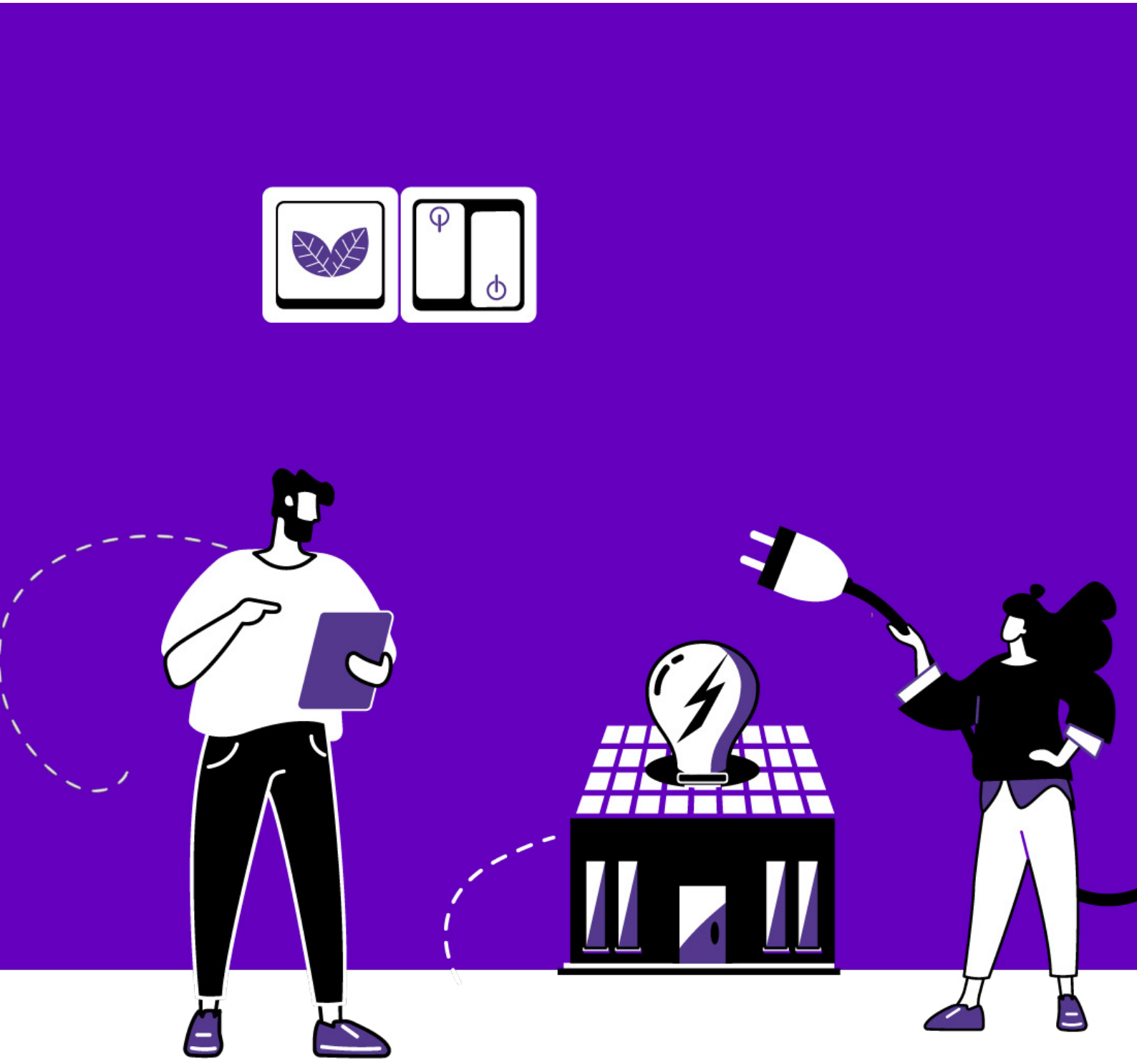
UsersTCP

the behaviouralist

Applying behavioural insights to unlock residential demand flexibility:

Guidebook for practitioners



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by IEA

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About Users TCP
The User-Centred Energy Systems Technology Collaboration Programme (Users TCP) operates under the auspices of the International Energy Agency. The Users TCP's mission is to provide evidence from socio-technical research on the design, social acceptance and usability of clean energy technologies to inform policymaking for clean, efficient and secure energy transitions.

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Executive summary

Countries around the world are transitioning away from fossil fuels to renewable energy sources to meet their Net Zero targets. While beneficial for the environment, this transition brings with it an important challenge: it is not (presently) possible to rapidly increase or decrease the generation of solar, wind and water power to meet existing fluctuations in demand. One solution to this problem is to encourage demand flexibility, which refers to the capability, motivation and willingness of consumers to adapt their energy usage in response to the needs of the grid.

Residential consumers (i.e., households), which are responsible for approximately a fourth of global energy consumption[1], have a large potential for demand flexibility. For example, residents can postpone the use of large appliances such as EV chargers, heat pumps and machine dryers to hours when energy is more abundant. Similarly, domestic batteries can increase flexibility through self-consumption and grid discharge. Unlocking such flexibility behaviours would help speed up the green transition. It could also significantly improve the grid's stability and reduce the need for other (often more costly) solutions, such as building additional energy infrastructure.

This guidebook is primarily intended for policymakers and energy suppliers who are responsible for the development of residential demand-response programmes and initiatives. We present key behavioural challenges associated with residential demand flexibility and show how one can apply behavioural insights to address these challenges, ultimately improving the success of demand-response initiatives.

How was this guidebook developed?

We conducted a systematic review of behavioural evidence, synthesising findings from 124 academic articles and additional grey literature reports and articles. The final content was then reviewed by nine behavioural policy experts from The Users TCP Behavioural Insights Platform.

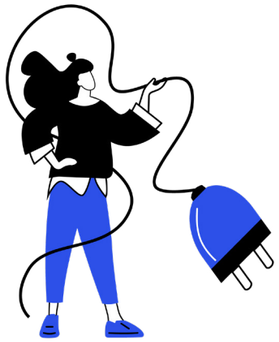
Three behavioural challenges associated with residential demand flexibility

We identify three distinct behavioural challenges that policymakers, energy suppliers and other energy actors must tackle to unlock residential demand flexibility (see below). We also illustrate how these actors can apply insights from behavioural science to address these challenges.

1 Changing energy consumption habits

Changing when and how consumers use energy, like postponing the use of household appliances to off-peak times, is a stepping stone towards attaining demand flexibility. Though less impactful than advanced technologies or demand-response programmes, this approach is cost-effective. Click on “Read more” to learn about behavioural strategies to help residents adopt new energy consumption habits to unlock flexibility.

Read more



2 Encouraging enrolment and participation in demand-response programmes

Enrolment and active participation in demand-response programmes, including time-of-use tariffs and remote control of consumers’ heating and cooling systems, are essential for optimising energy usage during peak times. Click on “Read more” to learn how to enhance enrolment rates and ensure sustained engagement in these programmes.

Read more

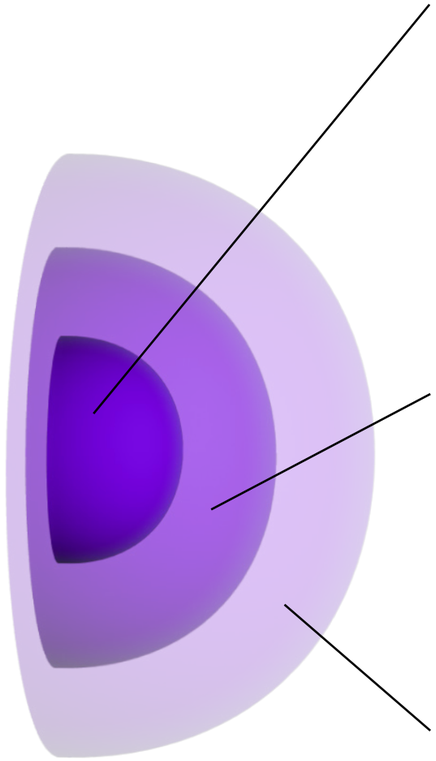
3 Increasing adoption of demand-response technologies

Technologies such as smart thermostats, behind-the-meter batteries and solar panels play a crucial role in alleviating strain on the energy grid when they are installed at scale and set up correctly. Click on “Read more” to learn about strategies to enhance the adoption of these technologies for maximum impact and effectiveness.

Read more

The System-Design-Communication framework (SDC) for applying behavioural insights to residential demand flexibility

Consumers’ ability and willingness to engage in demand response are affected by a multitude of factors, from energy market regulations to the interface design of smart thermostats and consumers’ beliefs about renewable energy. Correspondingly, we propose that behavioural insights can be applied at different levels, which we refer to as system, design and communication.



System level

Applying behavioural insights on the system level involves changing how energy market actors interact with each other, which ultimately changes consumer behaviour. For example, regulators can mandate a phase-out of energy inefficient appliances to restrict consumer choices, technology manufacturers can improve green technology options by agreeing on common interoperability standards, and municipalities can establish new social norms by making environmental commitments.

Design level

On the design level, behavioural insights can be applied to change environments where consumers make choices to encourage more flexible consumption. This type of solutions is also referred to as choice architecture. It includes examples such as simplifying programme sign-up forms, making the green options default choices and improving the visual attractiveness of smart meter interfaces.

Communication level

Finally, applying behavioural insights on the communication level refers to engaging with customers through content that is understandable, persuasive and appealing to a given target group. Examples include highlighting that many other consumers have taken the desired action, simplifying the communicated message and actively debunking misinformation.

In the remainder of this guidebook we describe how behavioural insights can be applied on the system, design and communication levels to foster adoption of new energy consumption habits, increase consumer uptake of demand-response technologies, and increase enrolment and participation in demand-response programmes. The provided strategies are meant to serve as starting points. They should always be piloted on a small sample of customers first, and ideally supplemented with additional research before being fully implemented.

Introduction

High-emission countries are transitioning from coal and gas to renewable energy. In 2020, the UK generated the most energy from renewables for the first time in history,[2] with a similar course being taken by the EU, Canada, the US, India and China.[3,4,5,6,7] The International Energy Agency projects that about 90% of the generated electricity globally will come from renewables.[8] In addition, the overall demand for electricity will grow. In 2022, the share of electricity in total energy consumption was 20%. This is projected to rise to 50% by 2050.[9] Correspondingly, many countries are taking substantial policy actions to increase energy efficiency.[10]

Though the transition to renewables is essential to achieve Net Zero targets, it presents a new challenge. The dependence on the sun, wind and ocean makes the global energy supply less predictable. The lack of predictability puts more strain on energy network operators and increases the risk of blackouts. An unstable energy grid can further lead to security, health and safety challenges.

What is demand flexibility?

One solution to improve grid stability is demand flexibility. It refers to the capability and motivation of consumers to shift electricity consumption across times of day. Households and businesses that are flexible in their energy use can respond to the needs of the grid, helping to keep the supply stable. This response can take many forms, ranging from households purposefully charging their electric vehicle overnight or preheating their boilers at times when the energy supply is high. It can also involve businesses turning off non-essential appliances at times when the grid is under the highest load.

The guidebook specifically focuses on demand flexibility in the residential sector. Households consume approximately one-quarter of all energy that is produced, which presents significant potential for balancing the grid.[11] This potential further increases with photovoltaic panels, behind-the-meter batteries and other technologies that are increasingly used by households to generate, store and trade surplus energy. Through smart use and automation of these technologies, households can deliver considerable flexibility to the electrical network.

However, unlocking residential demand flexibility requires addressing several challenges, many of which are behavioural. Drawing on previous research,[12,13] we propose that the main behavioural challenges are (1) developing homeowners' ability and willingness to change their energy consumption habits, (2) increasing installations of demand-response technologies and (3) promoting consumers' enrolment and participation in demand-response programmes.

How can behavioural insights help?

Civil servants and energy suppliers can apply insights from behavioural science to help consumers adopt new habits and technologies, and engage with demand-response programmes. Applications of behavioural insights to demand flexibility can take various forms, ranging from human-centred technology interfaces to behaviourally informed communication campaigns. We propose the **System-Design-Communication (SDC) framework** to discern three main levels on which behavioural insights can be applied to unlock residential demand flexibility.

Applying behavioural insights on the system level

We use the term 'system' in line with the systems thinking approach, which posits that the behaviour of one group (e.g., consumers) is affected by other actors (e.g., energy suppliers, regulators, technology manufacturers and energy communities) that operate in response to each other.[14] The key is to understand how the components of a system interact, identify potential levers and trigger a tipping point to achieve the desired behaviour.[15] Behaviour change can impact other components of the system through positive feedback loops, producing a scalable change across the system.

For example, a government that mandates real estate agents to disclose the smart building rating[16] of the properties they sell can influence the purchasing behaviour of consumers. Customer preference for smart buildings can, in turn, put a pressure on technology manufactures, real estate agents, and energy suppliers to provide more market options and advice to customers who want to invest in smart demand-response technologies.

Behavioural science can help policymakers identify potential levers (i.e., where to intervene in the system) and implement evidence-based solutions to change the behaviour and interaction between energy actors. System-level behavioural interventions can involve increasing visibility of particular information to motivate behaviour change. It can also involve instilling new social norms through public commitments of organisations and public institutions. These interventions can, albeit often indirectly, provide consumers with stronger capability, opportunity and willingness to engage in demand response.

Applying behavioural insights on the design level

We use the term ‘design’ in a broad sense. It can encompass the look of digital interfaces (e.g., what is presented on a smart thermostat display), functionalities of appliances (e.g., a functionality that enables delaying the start of a washing machine), and the design of processes and services (e.g., a sign-up process that customers need to go through to enrol on a time-of-use tariff).

The design of demand-response programmes and technologies can dramatically influence user engagement. For example, a sign-up form into a demand-response programme that is lengthy and requires customers to enter information that might not be readily available (e.g., smart meter customer ID) tends to result in less customers signing up than a short form or no form at all (i.e., in the case of automatic enrolment). Similarly, the choice of information being presented can impact customer engagement. A smart meter that displays how much money was saved due to demand response might be more successful than a smart meter displaying the same information in kilowatt hours, which are harder to understand.

Behavioural insights can be applied to the design of demand-response initiatives and technologies to make them more appealing and easy to use for consumers. This includes simplifying sign up processes, making presented information more relevant, providing the right kind of incentives and designing environments in a way that nudges people towards the desired behaviour (e.g., through smart default options).

Applying behavioural insights on the communication level

The third level refers to information about demand response that energy actors communicate to consumers. It can involve social media campaigns, emails, leaflets, newsletters, and TV ads that aim to persuade people to change their energy consumption habits, enrol into a demand-response programme, or invest in a technology such as a behind-the-meter battery, heat pump, or a smart thermostat.

Some consumers might have pre-existing knowledge and beliefs about demand-response technologies and programmes, whereas others might lack understanding of demand response completely. Certain people might have already formed misconceptions and contribute to its spread on social media. Communicating with all such segments is essential to address misinformation, promote development of positive attitudes and foster public acceptance of demand-response initiatives and technologies.

Here behavioural insights can be applied to consumer-facing communications to make them more appealing and persuasive. Behavioural science also provides evidence-based strategies to combat misinformation and prevent its spread, ultimately strengthening social acceptance of demand flexibility.

How do I use this guidebook?

This resource is primarily aimed to assist civil servants, energy suppliers and energy operators who develop and implement demand-response initiatives targeted at households. It is meant to provide advice on how to apply behavioural insights to these initiatives and make them more likely to succeed.

The following chapters are structured into three key behavioural challenges: (1) promoting uptake of new habits, (2) increasing adoption of demand-response technology, and (3) promoting enrolment and participation in demand-response programmes. For each challenge, we provide a set of behavioural strategies that you can implement to unlock greater flexibility. The strategies are grouped into system-, design-, and communication-level strategies.

The guidebook is not meant to be read from start to finish. Instead, we encourage you to browse the behavioural challenges and strategies that are the most applicable to your work. Further, the presented strategies are meant to serve as starting points. The barriers we refer to might not apply in all contexts, and the solutions we propose may not be sufficient in tackling a specific barrier if other barriers are also present. Thus, while the recommendations contained in this guidebook are likely to improve the efficacy of your demand flexibility initiative, we also encourage you to examine your specific context (e.g. through surveys, focus groups, and interviews) and to test your solution (e.g. through randomised controlled trials) to increase the changes of generating positive change.

How were the strategies developed?

The presented strategies are the result of a systematic review of existing behavioural evidence that we conducted between May and July 2023. Using three search terms* and the Web of Science database, we identified 652 studies that were related to applying behavioural insights to unlock residential demand flexibility. Out of those studies, we manually screened 287 articles and selected 96 papers for a full review. We then extracted the recommendations and synthesised them into a list of behavioural strategies that we present in this guidebook. The strategies were further reviewed by 10 behavioural experts who are members of The IEA Users TCP Behavioural Insights Platform. Most of the evidence that was available to us comes from Western countries, and therefore there may be limits to the generalisability of our solutions.

The search terms contained combinations of the following topics and keywords: TS=(behavioural OR behavioral OR psychological OR social); TS=(drivers OR enablers OR barriers OR motivators OR factors); TS=(adopt OR uptake OR purchas* OR install*) AND (“battery storage” OR “energy storage” OR “home batteries” OR “solar panels” OR “photovoltaics” OR “smart thermostats” OR “smart meters” OR “heat pumps” OR “electric vehicles”); TS=(participation OR engagement); TS=(“demand side management” OR “load shedding” OR “peak shaving” OR “demand response” OR “demand flexibility”); TS=(intervention OR programme OR program OR campaign OR treatment); TS=(change OR shift); TS=(household OR Residential OR Domestic OR Personal OR Consumer OR home); TS=(“energy consumption” OR “energy usage” OR “appliance use” OR “energy saving”); TS=(habit OR pattern).

1 Changing energy consumption habits

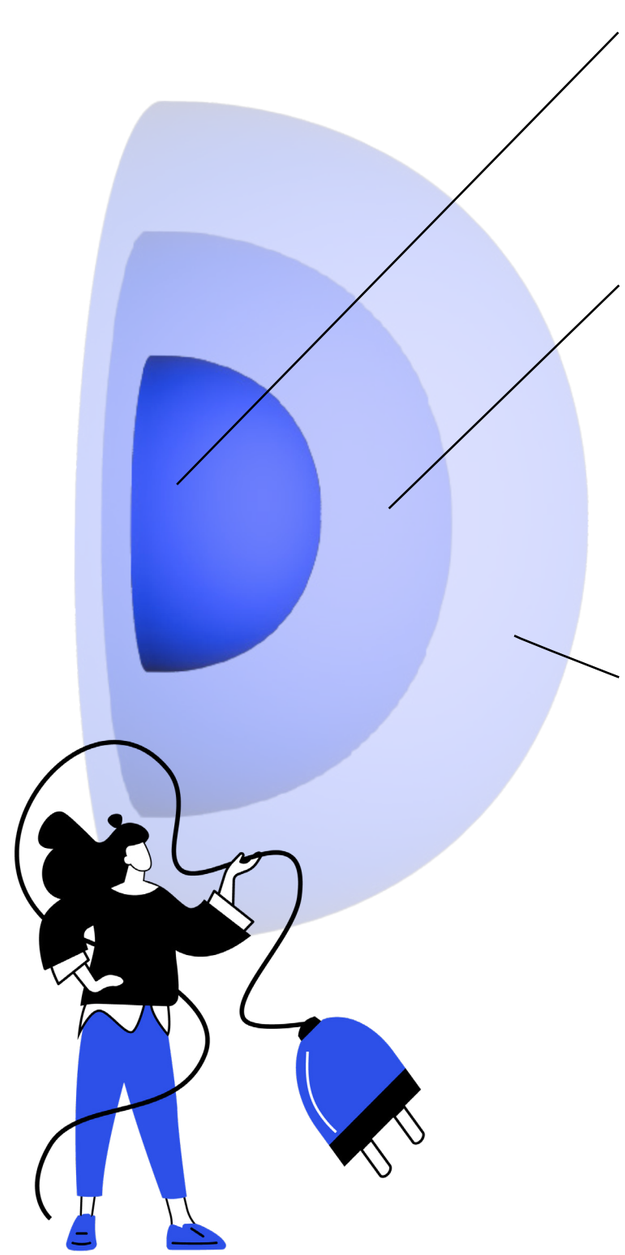
Households can start consuming energy more flexibly and boost energy efficiency by changing their current energy consumption habits. This approach is widely accessible, as it doesn't require additional investments in sophisticated demand-response technologies such as solar panels and heat pumps, or participation in demand flexibility programmes.

Although changing behaviours is challenging and may have a limited impact on energy consumption – especially without access to programmes or technologies – this approach can serve as the foundation for introducing demand flexibility to households. When programmes and demand-response technologies are not readily accessible, changing consumption habits may represent the only feasible approach. It can also lay the groundwork for a comprehensive strategy that later encourages households to participate in demand-response programmes and install technologies, working together to further reduce energy consumption.

Key behavioural changes that households can adopt in their day-to-day life include:

1. **Delaying Usage of Electrical Appliances During Off-Peak Times:** This includes activities such as operating washing machines, dishwashers, and cooking appliances powered by electricity during periods of lower demand.
2. **Adjusting Home Heating or Cooling Temperature:** Households can reduce electricity consumption by modifying heating or cooling settings in the home.
3. **Adopting Energy-Saving Habits:** Simple actions like turning off appliances in standby mode and switching off lights when not in use contribute to overall energy savings.

While these energy-saving behaviours may seem straightforward, they are often deep-seated habits that are challenging to change. The next section explores system-level, design-level and communication-level strategies to foster the adoption of energy-saving habits.



System level

1.1 Use regulations to make energy-saving habits easier to perform

Design level

1.2 Leverage moments of change

1.3 Reward consumers that adopt new energy-saving habits

1.4 Make energy-saving habits easier to adopt

Communication level

1.5 Help consumers identify the most impactful energy-saving actions

1.6 Reward consumers that adopt new energy-saving habits

1.7 Use reminders

1.1 Use regulations to make energy-saving habits easier to perform

To facilitate the adoption of new energy-saving habits, it is important to make them more accessible and easier to perform and to discourage energy-intensive behaviours. This can be achieved by implementing regulations that support demand flexibility behaviours, such as incorporating user-friendly features in electrical appliances or banning certain appliances that are energy-intensive.

What you can do:

- **Embed demand flexibility functions in appliances:** Mandate manufacturers of household appliances to embed demand flexibility functions into their appliances. For example, appliances such as smart thermostats, or washing machines could prompt users to schedule their heating or washing during off-peak times.
- **Mandate appliance energy rating:** Require technology manufacturers to use energy labels to nudge consumers towards energy-efficient appliances.
- **Public disclosure of emissions:** Require businesses to disclose their carbon emissions and publicly state their strategies for improving demand response in self-reported assessments.
- **Incentivise demand flexibility:** Offer incentives, such as tax breaks or subsidies, for homeowners who actively replace energy-inefficient appliances or upgrade to more energy-saving options.
- **Provide real-time feedback:** Collaborate with energy providers to provide real-time feedback on energy usage, making homeowners aware of the energy consumed by their existing habits and encouraging behaviour change. Alongside feedback on energy usage, consumers could also receive actionable tips to help them adopt energy-saving actions in their day-to-day lives.

Tips

- Help build public support for the policy by clearly communicating the reasons behind regulations and incentives to homeowners, emphasising the benefits of adopting new energy-saving habits.
- Provide resources and guidance on energy-saving alternatives and options that homeowners can adopt to replace their old habits.

Contents > Changing energy consumption habits > System level

Example

Requiring carbon emission self-reporting to increase compliance

A 1999 study identified that requiring firms to self-report pollution levels led to higher levels of compliance with pollution-related policies, even when the consequences of non-compliance were relatively minimal.[17] Making the undesirable behaviour publicly visible can lead to fewer instances of non-compliance.

1.2 Leverage moments of change

Important life events, such as moving house, making energy-efficiency improvements at home, or installing new demand-response technologies, provide opportunities for individuals to develop new habits. During these moments of change, people are more receptive to adopting new behaviours, offering an opportunity to encourage them to adopt new energy-saving habits during peak times.[18,19] Capitalise on these natural opportunities by delivering timely and personalised messages and behavioural change interventions to encourage households to embrace new energy-saving practices.

What you can do:

- **Leverage moments of change for energy savings:** Provide personalised messaging and offers during significant life events, such as moving house, making energy-efficiency improvements at home, or purchasing new appliances, to promote the adoption of energy-saving habits. For instance, consumers could receive letters or emails with tips on how and when to engage in energy saving behaviours that are relevant to the specific event they are experiencing (e.g., how to use a heat pump flexibly).
- **Use energy-efficiency messengers:** Collaborate with energy-efficiency improvement contractors to educate homeowners about the benefits of energy-saving habits during key moments. These industry professionals can play a crucial role in influencing homeowners' decisions and behaviours.
- **Provide advice through installation service:** For example, share energy-saving tips with homeowners when a smart meter is installed or when they enroll on a new tariff or sign up for service.

Tips

Utilise existing data about your target audience to identify key metrics that reflect significant changes in people's lives (e.g., changes in primary address, planned smart meter installations, property renovations). Use these metrics for delivering personalised and timely communications that encourage individuals to adopt energy-saving habits.

Contents > Changing energy consumption habits > Design level

Example

Using moments of disruption to encourage the adoption of new habits

Commuting habits are much more easily disrupted when someone has just moved houses or started a new job. This was demonstrated in a trial by The Behavioural Insights Team that investigated adoption of a cycle share scheme in Portland, Oregon, USA.[20]

Promotional leaflets were distributed, and although uptake was low across the board (highlighting that information provision is often a weak intervention), uptake was nearly four times higher among those who had just moved to the area.

1.3 Reward consumers that adopt new energy-saving habits

Demand flexibility behaviours, like delaying appliance use to off-peak times, often require extra effort, and the benefits may not be immediately evident. For example, for some consumers the benefits,such as savings on their next energy bill,may only become evident over time, or not be apparent at all, for those on fixed energy tariffs.

To overcome this challenge, it is important to offer rewards promptly after individuals engage in the desired behaviour. Providing immediate feedback can also help reinforce energy-saving actions over time. Rewards can take various forms, including monetary, social, and symbolic incentives, all contributing to driving behaviour change. For instance, a study demonstrated that a simple letter recognising homeowners are part of a “energy-efficient neighbours” group effectively maintained motivation to reduce energy consumption over time.[21]

What you can do:

- **Reward flexible consumption:** Implement rewards programmes that offer financial incentives, such as discounts on energy bills or cashback rewards, for homeowners who actively engage in energy-saving behaviours. Consumers could receive information about rewards through notifications on their smart meter. These financial rewards provide a tangible benefit for adopting and maintaining energy-saving habits.
- **Celebrate energy savers:** Foster a sense of social recognition and belonging by acknowledging and highlighting the efforts of homeowners who have successfully adopted energy-saving habits. Publicly acknowledging their achievements, via, for example, a community newsletter or in consumers energy bills, can create a positive social norm and encourage others to follow suit.

Tips

Keep in mind that that if you only focus on offering money as a reward, you might unintentionally push away some people who are naturally motivated to save energy for other reasons.offering only economic incentives may unintentionally alienate some audience segments that are intrinsically motivated to save energy. To prevent this, it’s important to recognise and validate their energy-saving efforts in addition to providing incentives.

Example

Using financial incentives to reduce energy consumption during peak times

Octopus Energy, in partnership with the UK’s National Grid Electricity System Operator (ESO), conducted a large-scale trial that aimed to encourage customers to reduce their energy usage using small incentives.[22] Customers who were interested in participating were sent an email notification a day prior that informed them the two-hour window they needed to reduce their usage. Those who opted in and successfully reduced their consumption were rewarded with free electricity for the two-hour period.

The trial successfully recruited tens of thousands of customers. On average, participants reduced their consumption by 18% during the evening peak window, with two-thirds of households reducing their usage by at least 30% in one or more demand-response events.

Image credit: Octopus Energy

1.4 Make energy-saving habits easier to adopt

Changing energy consumption patterns can be effortful, which often discourages homeowners who prioritise comfort and convenience.[23] To overcome this barrier, it is important to make energy-saving habits easy to adopt by making relevant tools and programmes more accessible. Another effective approach is integrating automated features into electric devices that streamline the adoption of energy-saving actions without requiring users to actively remember or engage in these behaviours. For instance, electric vehicles (EVs) can be programmed to charge during periods when energy is cleaner and more affordable. By automating such processes, consumers can effortlessly incorporate energy-saving habits into their daily routines.

What you can do:

- **Provide guidance:** Simplify the process of adopting energy-saving habits by providing easy-to-follow instructions and step-by-step guides that break-down actions into manageable steps. For example, consumers could be provided with tips on how to set their thermostat in accordance with programmes that heat their home during off-peak times.
- **Make demand-response appliances more accessible:** Increase the availability and affordability of energy-saving tools and technologies, such as light switches, heating controls, and programmable thermostats. Making these tools readily available and easy to obtain encourages homeowners to incorporate them into their daily routines.[24]
- **Offer in-built demand-flexibility features:** Collaborate with home appliance manufacturers to integrate energy-saving features into their products, making it effortless for homeowners to save energy. By incorporating energy-saving technologies directly into appliances, homeowners can adopt energy-saving habits without additional effort. For example, Apple introduced a function that allows users to set their devices to charge during periods of cleaner energy production.[25]
- **Set demand flexibility defaults:** Mandate electrical appliance manufacturers to preset devices to energy-saving or demand flexibility modes by default. For instance, default settings on smart thermostats can be configured to reduce heat during peak hours. Ensure, however, that users have the flexibility to override and customise these settings to avoid any potential backlash related to perceived loss of control or independence

Tips

Individuals who purchase green technologies, such as smart meters, solar panels, and heat pumps are also more likely to embrace energy-efficient practices and change their behaviours during peak times.[26] As such, leveraging the occasions when individuals acquire green technologies, present opportunities to deliver tailored communications or support that encourage the adoption of further demand flexibility habits.

Example

Making renewable energy the default option to increase uptake

A study of 200,000 homes and 8,000 businesses in Switzerland assessed the impact of energy suppliers making renewable energy the default option.[27]

The results showed that 80% of customers accepted the renewable energy option, a pattern that continued over the course of the following year. These findings suggest that defaults can be a useful tool for increasing the uptake of green energy.

1.5 Help consumers identify the most impactful energy-saving actions

People often lack knowledge of how much energy various daily behaviours, like turning on lights, using appliances, or charging devices[28] consume. As a result, they tend to overestimate the impact of low-impact activities, underestimate the high-energy ones and therefore often prioritise less impactful actions. Limited feedback and information on specific energy consumption and a lack of understanding of varying energy prices during on- and off-peak times, contribute to this knowledge gap.

To encourage more flexible energy consumption, you should help households understand which actions yield the most significant energy savings and when to perform them during the day to achieve the most benefits.

What you can do:

- **Facilitate knowledge sharing:** Encourage energy-saving during peak times by organising Q&A sessions, webinars, or community meet-ups where individuals can share insights. Designate “energy champions” within the community to guide and inspire others in implementing simple energy-saving measures. These champions serve as valuable resources, fostering a shared commitment to sustainability.
- **Provide feedback on consumers’ energy consumption:** Educate people on energy consumption associated with various activities during peak times, such as operating appliances or using lighting. Highlight the potential energy savings achievable by modifying their behaviour, emphasising actions with the greatest impact. Keep communications concise and straightforward, prioritising the most energy-efficient behaviours for clarity.
- **Provide how-to guides:** Inform people about how they can shift their use of electrical appliances to other times of the day. This might include explaining how to practically change the settings of their appliances, for example, by setting a timer function on washing machines and dishwashers. Providing visual guides and images might be particularly helpful here.[29]
- **Start with small changes:** Begin by focusing on simple energy-saving actions that require minimal effort, such as turning off lights when leaving a room or unplugging electronics when not in use. Once people get used to these simple changes, they are likely to be more inclined to embrace more demanding energy-saving practices.

Contents > Changing energy consumption habits > Communication level

Tips

Couples and single individuals residing in homes are likely more capable of curbing energy usage during peak times compared to larger families who tend to have more established set routines. Consequently, for a more impactful and targeted approach, efforts could be initially concentrated on identifying and engaging with couples and single occupants to encourage and support their energy-efficient practices.

Example

Providing key information online to help households conserve energy

In collaboration with local authorities from Kent and Medway and the NHS, The Behaviouralist co-designed a behavioural intervention to help households learn about the most effective energy-saving actions through an online platform called Share the Warmth.[30]

While measuring the effect of the intervention on energy consumption was beyond the scope of the trial, it was found that sharing energy-saving tips significantly improved participants’ energy-saving knowledge. The treatment group scored, on average, 39% higher than the control group in the knowledge assessment. Interestingly, while most participants only spent a short amount of time reading the tips, it was sufficient to improve their energy-saving knowledge considerably.

These findings suggest that online information provision can help improve households’ knowledge about energy-saving actions and increase their demand flexibility.

1.6 Appeal to different motives to shift energy consumption habits new energy-saving habits

While adopting new energy-saving habits may disrupt one's way of life, feel effortful or prove costly, there are various reasons that might motivate someone to make changes regardless of the burden. Some are motivated by cost savings, others by a desire to reduce environmental impact, and some seek social acknowledgment or aspire to improve their health.

To effectively promote behaviour change, communicators should analyse the motivations that resonate most with distinct consumer segments. This understanding is crucial for designing compelling campaigns tailored to the right drivers that encourage specific types of households to embrace new energy-saving habits. The motivation may vary based on the specific energy-saving behaviour targeted, the expected duration of the behaviour change, and the characteristics of the household being addressed.

What you can do:

- **Appeal to social motives:** Leverage social motivation by highlighting demand flexibility achievements of consumers, such as that of neighbours or the community, through consumers' energy bills, local media or app leaderboards. This fosters social comparison, establishes new norms, and attributes value to demand flexibility within the community, encouraging broader participation.
- **Appeal to environmental motives:** Emphasise environmental benefits to promote demand flexibility behaviours, like reducing CO2 emissions during peak times. Offer real-time information on CO2 savings and celebrate achievements. Recognise varying priorities and appeal to a broader audience by combining environmental benefits with cost savings.
- **Make demand flexibility behaviours engaging:** Frame demand flexibility as a collective challenge. Incorporate gamification elements, such as levels, points, and leaderboards to add a competitive and rewarding element. Offer feedback on consumers' achievements, and celebrate milestones and reductions in energy consumption.
- **Provide small one-off financial incentives:** Use small financial incentives to encourage households to change their energy consumption habits for short-term, or one-off events, such as during peak times.[31]
- **Provide tailored communications:** Customise your strategy based on the specific habit targeted. For low-effort behaviours, like turning off appliances, appeal to self-interest through highlighting the financial and energy-saving benefits. For more demanding behaviours like off-peak laundry, emphasise altruism by highlighting environmental benefits.[32]

Contents > Changing energy consumption habits > Communication level

Tips

Conduct market research to identify the main motives driving your target audience's energy consumption choices. Consider conducting interviews or delivering short surveys to elicit their motivations for different energy-saving behaviours.

Example

Understanding different factors that motivate energy-saving behaviour change

Equitable Novel Flexibility Exchange (EQUINOX) is an innovation project that is testing new commercial and technical arrangements to reward households with heat pumps for temporarily altering their heating choices The project's first trial ran from December 2022 to March 2023, with 2-hour events scheduled up to 3 times a week (when participants either allowed suppliers to control their heat pumps remotely or were asked to turn off or down the heat pumps on their own).[33]

A survey administered toward the end of the trial revealed that while environmental reasons were the most important motivator for participation, there were more nuances. In addition to environmental and financial reasons, participants commonly cited other drivers, including understanding heat pump performance, contributing to research, and helping manage the grid.

1.7 Use reminders

Habits are deeply ingrained behaviours that people perform regularly without giving too much thought to them. While people may shift their behaviours at first, it is easy for them to revert back to their old habits. They might forget about them or fail to see the impact or benefits over time.

For this reason, it is important to use regular prompts or cues to remind people about the behaviours we want them to adopt. These can be, for example, reminder letters, notifications, or signage.

What you can do:

- **Send timely notifications:** Send timely notifications via an app that reminds people to run their devices during off-peak times (e.g., charging their electric vehicle). Consider leveraging location-based triggers to send reminders when users are at home, facilitating engagement in demand flexibility behaviours.
- **Allow users to set in-app reminders:** Empower users by providing the option to set personalised in-app reminders for energy-saving actions. These reminders should be customisable to align with personal preferences and may include prompts to participate in demand-response programmes or engage in energy-saving activities during peak hours.
- **Make off-peak times visually accessible:** Empower users of demand flexibility apps with enhanced visualisation tools, such as graphs or infographics, displaying off-peak times throughout the day. This visual representation enables users to make informed decisions and strategically engage in energy-saving behaviours during these periods.

Tips

When sending reminders, it is beneficial to also offer consumers feedback on their energy-saving efforts and provide encouragement. This feedback can serve as additional support.

Contents > Changing energy consumption habits > Communication level

Example

Sending reminders to help households achieve flexible energy consumption

Centre for Net Zero ran a field experiment in March 2023 in collaboration with Octopus Energy to assess whether households can provide demand flexibility with short notice.[34] In the trial, the control group was given 6-hour advance notice, while the treatment groups received an additional 24-hour advance notification email or an additional SMS notifying them about the extra incentives provided.

While customer participation rates were higher in the treatment groups, as many as 40% control households who only received a six-hour notice participated in the demand-response event. Survey results also revealed that 75% of the participants would like at least 4-hour notice before a demand-response event, and about 20% of participants reported that they could respond with 1- to 4-hour notice, especially if they were notified by SMS/push notification as opposed to email.

These findings suggest that providing reminders about demand-response events, even at short notice, can help households reduce or shift their consumption during peak times. To further increase household demand flexibility, reminders can be provided with longer advance notice or through more direct channels (e.g., push notifications).

Image credit: Octopus Energy

2.1 Encouraging enrolment in demand-response programmes

By enrolling consumers into demand-response programmes, energy providers can send signals to consumers to adjust their electricity consumption at specific times to improve grid stability. Consumers who positively respond to these signals obtain lower electricity prices or other incentives. Though demand-response programmes can be effective in unlocking flexibility, their uptake among households remains low.

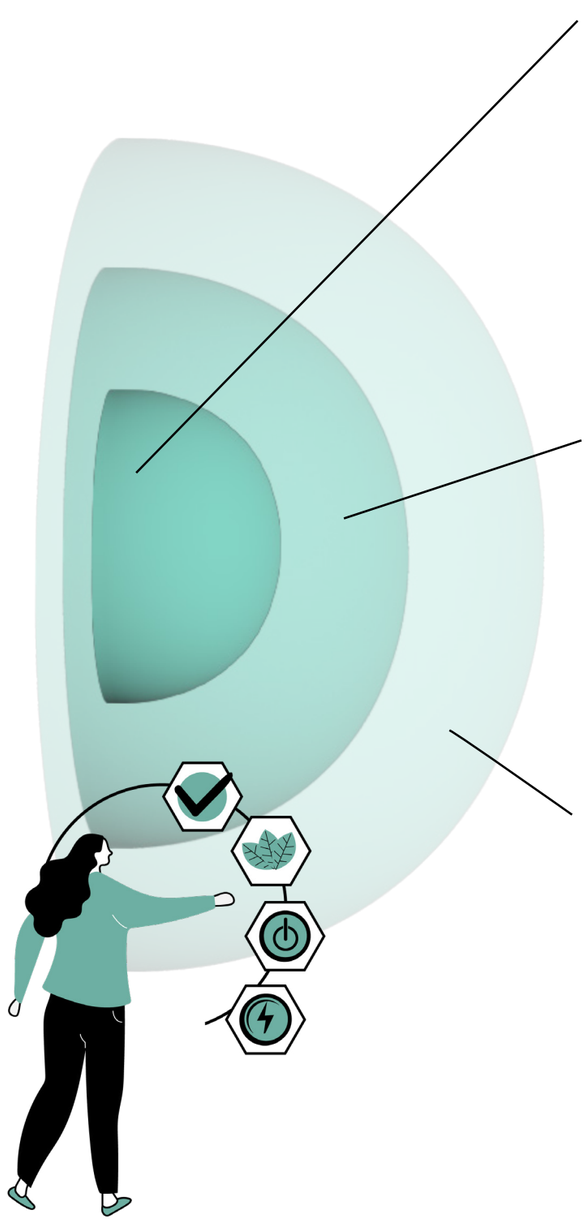
Demand-response programmes typically fall into one of three categories:

1. **Manual response programmes -** Consumers are notified by their energy provider about a peak event in advance (e.g. through an email or a text message a day ahead of the event) and asked to manually adjust their consumption during the event.
2. **Automated response programmes -** Energy supplier remotely controls consumers' heat pumps, EV chargers, smart thermostats or other smart devices for a certain period (usually 1-3 hours) to reduce energy load when the supply is low.
3. **Time-of-use tariffs -** Consumers who sign up for the tariff pay lower electricity rates in off-peak times (i.e., when the overall energy demand is low and the supply is high) and higher rates during peak times (i.e., when there is a high demand).

Existing research suggests that demand-response programmes can reduce peak energy demand. For example, a meta-analysis of more than 60 studies involving 337 treatments found that households who opted into time-of-use tariffs decreased their energy usage during peak times.[35] Further, a recent trial by the UK's Energy System Operator showed that simply inviting people to take part in a manual demand-response programme reduced their consumption by 10%, regardless of whether they signed up or not. Households that opted into the programme and participated in the events reduced their peak consumption by 40% on average.[36]

Despite the effectiveness of demand-response programmes, historical evidence shows that only a minority of people enrol in them.[37] This is often due to behavioural frictions: People might not enrol if they feel that the programme is hard to understand, not user-friendly or difficult to sign up into. Some people hold misconceptions, such as that programmes enable energy providers to collect additional personal data and use them for profiteering purposes.

In this section, we illustrate how behavioural insights can be applied on the system, design and communication level to increase the uptake of residential demand-response programmes.



System level

- 2.1.1 Build local endorsement for demand-response programmes
- 2.1.2 Foster collaboration between demand-response stakeholders
- 2.1.3 Promote common interoperability standards

Design level

- 2.1.4 Use the right incentives to promote programme uptake
- 2.1.5 Simplify the enrolment process
- 2.1.6 Simplify the programme and tariff structures

Communication level

- 2.1.7 Correct misinformation about demand-response programmes
- 2.1.8 Help consumers understand how demand-response programmes work

2.1.1 Build local endorsement for demand-response programmes

Demand response can challenge people's understanding of how energy is generated and consumed. Instead of viewing energy as unlimited and always available, consumers in demand response programmes must engage in more deliberate planning and active decision-making.

Consumers are more likely to embrace this change when it is endorsed by their peers,[38,39] local community leaders,[40] and energy technicians who install appliances in people's homes.[41] Effective endorsements can also come from municipalities and local businesses.[42] You should explore ways to unlock these endorsements and trigger positive feedback loops across the system.

What you can do:

- **Showcase positive actions that other consumers are taking:** For example, UK-based utility Octopus Energy has launched a campaign that involved its customers showcasing on social media that it is normal to pre-charge devices in off-peak times, shift cooking times, and engage in other types of flexible consumption.[43]
- **Engage with early adopters and help them spark peer conversations:** Often you will find a group of engaged citizens who, if provided with good resources, can engage in conversations with their friends and family and promote demand flexibility programmes. For example, online forums can serve as a channel to reach early adopters.
- **Provide communication training to local energy servicemen and experts:** Servicemen who install energy appliances are often seen as the authority in energy advice by households. Training these workers to be able to explain and promote demand flexibility programmes during their visits can boost programme uptake.
- **Make firm environmental commitments to gain community trust:** Past research found that utilities and municipalities with legitimate emission-reduction pledges are associated with stronger customer interest in demand-response programmes.[44]

Tips

Evidence suggests that it only takes about 20% to 30% of group members to change social conventions.[45,46] As opposed to trying to convince the whole community, it might be sufficient to bring one-third of the community on board and then benefit from the knock-on effect.

Example

Partnering with trusted local organisations to enrol hard-to-reach households

UK's Energywise explored how low-income households who struggle to pay energy bills can better manage their household energy usage and how Distribution Network Operators (DNOs) can support fuel poor customers through energy-saving and demand-response programmes.[47] During the recruitment and installation phase of a trial, it was recognised that customer field officers played a key role to book installation appointments, deliver energy saving devices and facilitate access to participants' properties when required.

Importantly, most of the field officers employed by the project's recruitment partner–local community charity Bromley by Bow Centre–lived in the local area and had good knowledge of local languages and cultures. Partnering with respected local organisations ensured inclusive recruitment and facilitated access to customers' homes for the installation appointment.

2.1.2 Foster collaboration between demand-response stakeholders

Energy providers, appliance manufacturers, DSOs and policy actors may face inertia and uncertainties, hindering demand-response programme development.[48,49] For instance, energy providers may lack agreement on remuneration for demand response participation and discussions might exclude representatives from local energy communities, leaving their needs unheard.[50,51] Insufficient communication among energy stakeholders often results in programmes that are unattractive to consumers and are ultimately not successful.

Initiate conversations among stakeholders to understand their needs, align all actors, and address uncertainties hindering demand-response programme deployment.

What you can do:

- **Organise joint pilot studies in collaboration with different energy actors:** For example, the Demand Flexibility Service pilot in the UK[52] helped stimulate knowledge exchange between energy regulators, the country's electricity system operator and several energy providers, leading to an improved range of flexibility-related services offered to customers in the UK.
- **Help establish common standards for demand flexibility services:** These might include guidance on how consumer flexibility should be rewarded, and mandating interoperability capabilities for technologies used in demand-response programmes such as smart thermostats.
- **Mandate reporting on the implementation of demand-response services from utilities:** This can help utility managers overcome their reluctance and provide feedback on obstacles that prevent the utility from implementing the programmes.
- **Lead by example:** Signal your commitment by enrolling your facilities in demand-response programmes and installing demand-response technologies.
- **Showcase other leading energy actors:** Showcasing utilities, municipalities and associations that are investing resources in demand flexibility can provide assurances and motivation to the organisations that are lagging behind.

Contents > Encouraging programme enrolment > System level

Example

Collaborating with energy stakeholders to implement demand-response programmes

ESO, the electricity system operator for the UK, collaborated with energy providers to launch The Demand Flexibility Service (DFS). The service ran from November 2022 to March 2023 and was designed to incentivise households and businesses to reduce or shift their electricity use from peak times.[53]

In total, 31 energy providers signed up and implemented their own incentive schemes for their customers (e.g., using points, cash back, or prize draws). Through the collaboration, the DFS successfully enrolled 1.6 million households and businesses, delivering a total of 3,300MWh in electricity reduction at key times (roughly the amount of electricity that 9.9 million households would use at peak times across a single hour).

2.1.3 Promote common interoperability standards

People might be ineligible to participate in automated demand-response programmes because their heat pump, smart thermostat or other technologies are not compatible with the programme. Consumers who own the wrong type of equipment often face *the sunk cost effect:* reluctance to purchase a compatible device because they feel already invested in another solution.[54]

To increase engagement in demand-response programmes, appeal to policymakers, manufacturers and energy providers to develop (and adhere to) common interoperability standards for appliances such as heat pumps, smart thermostats and EV chargers.

What you can do:

- **Organise consultations:** Engage with technology manufacturers and energy providers to understand opportunities for developing common interoperability standards in your country.
- **Mandate interoperability standards:** If common standards have already been developed, require energy stakeholders to adhere to these standards to ensure that a maximum number of consumers are eligible to participate.
- **Invest in research and development of smart interconnected technologies:** Investigate technologies that enable consumers to connect their existing smart devices to demand-response programmes. The research should also focus on understanding under which conditions consumers are willing to share additional data and in exchange for what benefits.

Example

Improving interoperability to increase household demand flexibility

HeatFlex UK, a pilot project conducted by Nesta and the Centre for Net Zero, investigated heat pump flexibility, consumer preferences and how consumers with heat pumps are affected by third-party automation and pre-heating.[55]

The pilot uncovered several interoperability issues that produced challenges throughout the recruitment and implementation phases. Specifically, different types of heat pumps were found to not function properly with the smart thermostat that was used to remotely control the heat pumps.

The HeatFlex team listed interoperability as one of the key elements affecting the programme's success. Ensuring that different heat pumps and smart thermostats are compatible increases the number of households that could benefit from offering their heat pump as a flexibility asset, and also increases the flexibility potential in households with complex heating or energy systems.

2.1.4 Use the right incentives to promote programme uptake

People might not sign up for a demand-response programme because they do not find it appealing. Different people are motivated by different factors; some may join if the programme reduces their energy bills, while others may be driven by environmental concerns or attracted by a fun-to-use app connected to the demand-response programme.

While many programmes emphasise financial benefits like bill reductions, credits and discounts, these may only attract specific customer groups. There is a much broader range of factors that can motivate programme enrolment, including hedonistic, gain and normative motivators.[56] You should explore what motives drive the main interest in the programme among your customer segments and then leverage these findings in the programme design.

What you can do:

- **Understand what drives your programme uptake:** Conduct interviews, focus groups, or customer surveys to explore the role of gain, normative and hedonistic motivators.
  - *Gain motivators* refer to protecting and increasing a household's resources (e.g., saving money, reducing one's bills, obtaining access to a new technology, improving one's understanding of energy consumption, improving control of appliances, obtaining health-related advice and increasing property value)
  - *Normative motivators* refer to meeting the expectations of others (e.g., being among energy-efficient neighbours, being part of an innovative community that shapes a new demand-response programme, and feeling like "doing the right thing" for environmental reasons)
  - *Hedonistic motivators* refer to enjoyment here and now (e.g. having fun when completing energy-saving challenges and using a gamified app in connection to the programme)
- **Design the programme so that it adequately responds to customer needs:** Based on research findings, this can mean changing the information that is communicated to households, developing new functionalities of the programme, or removing less relevant programme components.

Tips

- High-usage, high-income households tend to be less attracted by the prospect of reduced energy bills and are more driven by normative motives (e.g., being an energy-efficient and environmentally conscious neighbour).[57]
- Similarly, people who are new to the concept of demand flexibility tend to be more sensitive to what other people say about the programme. To get these people on board, think about how you can expose them to positive programme reviews and community champions who are enthusiastic about the programme.
- Many customers own smart home devices. Explore how you can enable customers to connect their smart devices to the demand-response programme to obtain a richer experience, such as gaining deeper energy-related insights.

Example

Using philanthropical elements to increase willingness to participate

A study in Japan examined different factors that influence households' willingness to participate in demand-response programmes.[58] It found that altruism can serve as a key driver to promote programme enrolment. Specifically, households were more likely to participate in a demand response programme when it allowed the households to donate money they saved through demand response to reduce the electricity bill of low-income households.

2.1.5 Simplify the enrolment process

People might not sign up for a demand-response programme (or drop out halfway) if the sign-up process requires a significant amount of time and effort. Lengthy forms, requests to call customer support lines and requirements to enter customer account information all constitute friction that reduces customers' motivation to complete their enrolment.[59,60] When designing the demand-response programme, focus on creating as automated and frictionless a process as possible.

What you can do:

- **Leverage auto-enrolment where possible:** Consider automating the sign-up process to programmes such as critical peak alerts so that people do not need to exert additional effort. Make it easy to opt-out, such as through a link in email or text notifications.
- **Consider pairing demand-response programmes with retrofit incentive 'programmes:** If a home has been recently equipped with better insulation, the occupants are less likely to notice that their heating or cooling systems have been turned up or down, so are more likely to stay enrolled.
- **Make the programme sign-up form prominent across multiple channels:** A visible call to action on customer bills, a prominently displayed banner on a website and interactive social media ads tend to work better than relying on consumers to do the hard work themselves.
- **Partner with local leaders to explain the programme to the community:** A local community leader or energy champion can act as a trusted source of information about the programme and can help community members with the sign-up process.
- **Shorten the sign-up form:** Eliminate unnecessary fields to reduce strain on consumers and increase completion rates.
- **Pre-fill customer data to the form:** In most cases, customers need to log in to a secure portal as a first step. This allows for pre-loading customer data from their existing account so that they do not need to type in all information manually.

Tips

Automating the sign-up process can boost the number of registrations. However, automated enrolment will also sign up those who are less motivated and, as a result, less likely to commit to the programme. You might need to deploy additional strategies (some of which are described in the next section of this resource) to ensure these users continuously engage.

Contents > Encouraging programme enrolment > Design level

Example

Using opt-out to increase participation rates

The Solent Achieving Value from Efficiency (SAVE) project investigated how price signals can impact household peak demand.[61] In 2018, approximately 2,000 households took part in a 'peak banded pricing' randomised trial for 12 weeks and were asked to set consumption targets with rewards for meeting these targets.

Participants were split into opt-in (offered the opportunity to participate and asked to enrol) and opt-out (automatically enrolled and could choose to drop out) groups. The trial found that a lot more households in the opt-out group participated (98%), compared to the opt-in group (38%). While the peak savings were more consistent and predictable in the opt-in group, the opt-out group achieved higher overall peak savings as their participation rate was far higher. The opt-out method might, however, require additional safeguarding to protect vulnerable consumers.

2.1.6 Simplify the programme and tariff structures

People tend to prefer programmes and tariffs that are easy to understand, even when they provide less benefits than more complex programmes.

Previous experiments found that customers favour intuitive programmes such as automated direct load control with the possibility of manual override. In contrast, dynamic tariff pricing with multiple pricing tiers is among the most challenging to comprehend and also the least preferred by consumers.[62,63,64] As complexity increases, people perceive demand-response services as riskier and less trustworthy.[65]

You should invest resources in developing programmes and tariffs that require minimal customer knowledge, offer pre-programmed default settings, and provide straightforward steps for setting preferences.

What you can do:

- **Reduce the number of pricing tiers in tiered tariffs:** Two pricing tiers (i.e., off-peak and peak pricing) set for the same time each day are the easiest for customers to understand. Avoid additional pricing tiers and dynamic pricing, particularly when introducing a demand-response programme or tariff for the first time.
- **Make pricing information easily accessible:** Ensure that consumers know how they can access information on the current electricity price and that accessing the information is simple, such as through a mobile app, in-home display, or a website.
- **Help consumers develop rules of thumb for electricity prices:** Establish straightforward guidelines for consumers to decide when and how to best manage their energy usage. For instance, inform customers that peak demand typically occurs in the mornings and afternoons on weekdays when people leave for (and return from) work.
- **Maintain a consistent communication schedule with customers:** If your programme involves sending messages and price signals to consumers, it is good practice to stick to the same schedule (e.g., the evening before the event). This regularity helps customers anticipate when they will receive these notifications.
- **Guarantee the same or lower bills than customers' old tariffs:** Consider adding a risk-free period in the initial months that will guarantee that consumers do not pay more than they would have on their old tariff. This can increase consumers' confidence in signing up.

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Tips

As people get more familiar with a new programme or tariff, they become more open to experimenting with more complex offerings, such as dynamic pricing or multiple pricing tiers that enable more flexibility. Start with simple offerings and add complexity as customers' knowledge grows.

Example

Helping consumers understand their tariff structure through customer support

Powerloop, one of the UK's key demonstrator projects for Vehicle-to-Grid (V2G) electric vehicle charging, aimed to demonstrate the technical, commercial and practical viability of V2G technology at a domestic level, through a trial of V2G-enabled vehicles and chargers.[66]

The project found that many participating customers experienced system issues and struggled to understand the V2G tariff and the associated mobile app. The project had a strong support team in place that assisted customers and ensured the programme's success. Overall, the demonstration showed the importance of simple and easy-to-understand tariff structures and digital environments.

2.1.7 Correct misinformation about demand-response programmes

Consumers might not enrol in demand-response programmes thinking that the programmes do more harm than good. For example, people might fear that demand-response programmes often involve hidden costs.[67,68] Another concern is that participation might allow for additional data collection, leading to privacy loss.[69,70] Some people also believe that the additional data will be used by energy providers for profiteering purposes.[71] This (mostly false) information can spread through social networks, discouraging homeowners from enroling in demand-response programmes. To avoid this, you should actively monitor and "pre-bunk" emerging misinformation about your programme.

What you can do:

- **Apply pre-bunking:** Bring people's attention to the common misconceptions about your demand-response programme and explain why they are false. This technique prevents spreading misinformation more effectively than debunking (i.e., waiting for the misinformation to emerge from another source and then attempting to address it).[72]
- **Be transparent about data use:** When introducing a demand-response programme, provide clear information about (i) what and when consumer data are collected, (ii) with whom the data are shared and (iii) what purposes the data are used for.
- **Be transparent about benefits for the programme provider:** For example, communicate that demand response makes it cheaper for the energy provider to generate electricity during peak times and that it reduces the need to invest in additional energy infrastructure. This transparency can increase consumer trust.
- **Be transparent about costs:** Explain when and how consumers are charged. Provide indicative comparisons between homeowners' current payments and the payments incurred by homeowners who participate in the demand-response programme.

Tips

Customer trust is one of the key factors affecting susceptibility to misinformation.[73] If the trust in the programme provider is high, people will be more inclined to sign up, and potential myths will be less of an issue. If the overall trust is poor, the programme provider might first need to invest in improving the trust in existing services before offering a demand-response programme.

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Example

Highlighting how demand-response services can benefit households without decreasing comfort levels

A Norwegian smart home pilot, Flekshome, was conducted in 2019 to 2022 and featured smart home devices that allowed for direct load control.[74] Participants received access to an app in which they could customise their own set-ups and add other smart house equipment.

The pilot actively targeted homeowners' concerns about loss of comfort. In-app messaging highlighted that users can distribute electricity consumption throughout the day without compromising their needs, as seen in the following excerpt:

"It may sound difficult to move your normal power consumption from one time of day to another, but it does not have to go beyond your comfort [...] the home will adapt to your routines and needs. If you use the oven in the afternoon, the electric car can be switched off and started later or the water heater can turn off for an hour."

2.1.8 Help consumers understand how demand-response programmes work

Many homeowners are unwilling to sign up for demand-response programmes because they have a limited understanding of how these programmes work, including how to enrol and what benefits there are.[75,76,77] Past research showed that the more confident people are in their knowledge of demand-response technologies and programmes, the more likely they are to engage with them. [78,79] A substantial part of your efforts should therefore focus on explaining how the service works and what benefits it can bring to consumers.

What you can do:

- **Use metaphors that people can relate to:** For example, some initiatives describe demand-response programmes as an Airbnb for energy or approximate it to a rideshare app.[80,81]
- **Use visual information whenever possible:** People tend to be more attracted by images and videos than lengthy paragraphs.
- **Highlight the benefits early on:** Learning that demand response can, for example, reduce energy bills in the first place can make homeowners more willing to sign up.
- **Highlight the ease of participation:** Homeowners are more likely to give demand response a try when they know it is simple to sign up, will not incur extra costs and can easily be reverted if needed.

Tips

Demand-response programmes are particularly hard to grasp for households with lower numeracy, graphical literacy and digital literacy.[82] Ensure that your communication strategy is tailored to population segments with varied digital experiences and abilities.

Example

Providing consumers with risk-free trials

The Advantage Power Pricing (APP) Pilot, conducted in North America from 2015 to 2019, studied residential customers' response to dynamic price signals by allowing them to choose a plan that fits their lifestyle and try it out risk-free.[83] While customers remained subject to status quo pricing, they were sent shadow bills that tracked what their bill would have been under APP rate. They received the difference as a rebate if their bill was lower under APP rate, and there was no penalty otherwise. It was found that, on average, participants reduced winter commodity costs by 9-27% and summer commodity costs by 0-10%. While participants were primarily motivated by bill savings, nearly 80% of participants reported that the risk-free aspect of the programme was very important in their decision to enrol.

2.2 Encouraging continuous participation in demand-response programmes

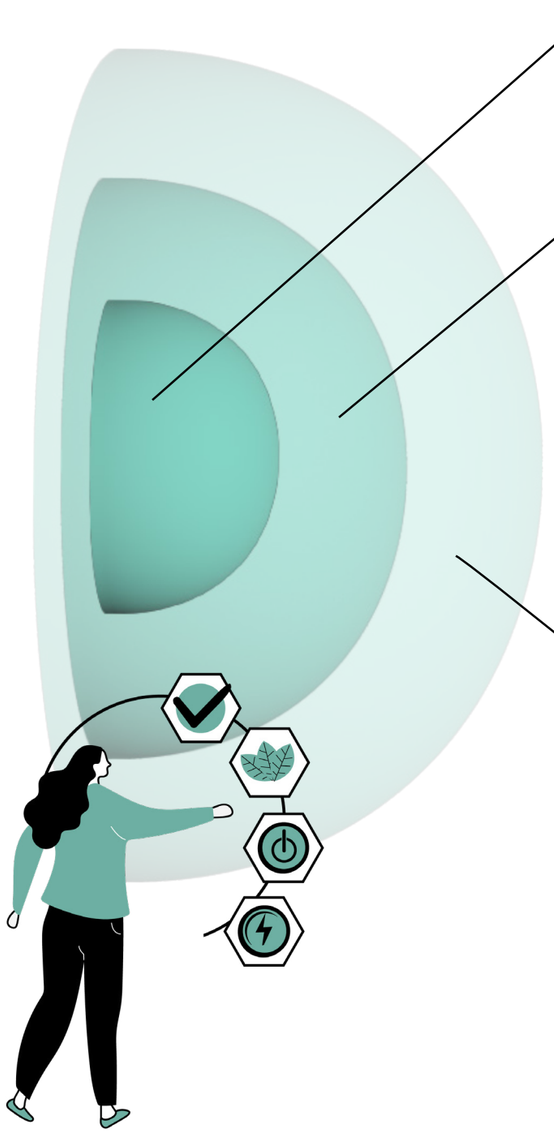
After consumers successfully enrol in a demand-response programme, energy providers also need to ensure that the consumers actually participate in the programme. That is, consumers adjust their consumption in response to the signals they receive from their energy provider.

In winter 2022/23, Octopus Energy launched its demand-response programme called *Saving Sessions*. Approximately 700,000 Octopus consumers who opted into the programme received signals (i.e., emails and text messages) a day before a planned peak event. The messages asked customers to reduce their consumption during the event and to confirm their participation. Thirteen events took place in total over the winter. Out of the enroled households, only 42-69% confirmed their intention to participate and the proportion of households who *actually* reduced their consumption was even lower.[84]

As the Octopus Energy case illustrates, not every household that enrols in a demand-response programme actually adjusts their consumption when requested. To maximise the number of participating households, energy providers need to ensure that their customers feel capable and motivated to respond to demand-response signals over time.

The lack of participation might seem less of an issue in automated response programmes where suppliers control customers' appliances remotely. However, automated programmes also face challenges. For example, one trial showed that some consumers interfere with automated controls, such as by readjusting their automated smart thermostats and carrying them around the house, reducing the overall effectiveness of the programme.[85]

In this section, we illustrate how behavioural insights can be applied to strengthen homeowners' motivation to participate in demand-response programmes over time. This includes ensuring that customers optimally respond to the signals and do not interfere with automated demand response systems.



System level

2.2.1 Provide community involvement and co-ownership

Design level

2.2.2 Make demand-response programmes intuitive and easy to use

2.2.3 Make demand-response services immediately rewarding

2.2.4 Provide people with options to control their participation

Communication level

2.2.5 Help people understand how and when to reduce their usage

2.2.6 Provide feedback on participation in demand-response programmes

2.2.1 Promote community involvement and co-ownership

People are less inclined to participate in a demand-response programme if it is implemented by a large provider or an authority with low public trust. Past research showed that consumers tend to question the motives behind the programme, have concerns about hidden costs, or fear that the new programme might collect additional data that will enable the utilities to see the homeowners' behavioural patterns, losing their privacy and enabling profiteering of the utility company.[86, 87, 88]

You should work together with local communities to shape the programme, boost its transparency and increase community ownership to alleviate trust-related challenges.

What you can do:

- **Organise Q&A sessions for citizens:** Bring the community together to talk about energy issues, communicate the benefits that each party receives from demand-response programmes and explain the bigger picture to consumers (e.g., that demand flexibility can increase the stability and affordability of energy) to increase public trust.
- **Foster the development of local technology champions:** Train early adopters in sparking conversations about demand flexibility in the local community. Peer conversations have been shown to boost positive attitudes and increase people's confidence in demand-response technologies and programmes.[89,90] Local champions can also provide peer support to citizens who struggle to enrol and engage with the programme.
- **Collaborate with local energy communities:** People who feel that a demand-response programme responds to local community goals are particularly supportive of the programme.[91] Similarly, involving the community in the programme design and piloting increases participation rates and raises awareness about demand response among less-engaged community members.[92]
- **Communicate and show your commitment to the energy transition:** Environmental commitments and the corresponding actions taken were previously shown to increase local communities' trust in demand-response initiatives.[93]

Tips

Tech-savvy citizens and early adopters can be particularly helpful when sourcing feedback and local support for the programme.

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Example

Leveraging community engagement to boost programme participation

A recent systematic review of demand-response pilot programmes found that many projects leveraged community engagement to increase programme participation, which included strategies such as emphasising the local impacts of the projects and involving local stakeholders in programme design and implementation.[94]

As many customers liked the idea of engaging with their community, framing demand response as a local effort made the projects more appealing to customers. The involvement of local stakeholders in the recruitment and support of customers also increased the credibility of demand-response programmes in the eyes of customers and improved customer engagement. It was found that customers tend to trust local stakeholders (e.g., regional authorities, community members, businesses and local media) who can act as intermediaries between customers and service providers.

2.2.2 Make demand-response programmes intuitive and easy to use

Users might disengage from demand-response programmes if they find them confusing or difficult to participate in. For example, if a programme requires the use of devices such as smart thermostats, people might disengage if the devices are too cumbersome to use. Customers should be able to easily access information about the programme and learn how and when to respond to peak events. If such information is hard to access, difficult to understand or not communicated well in advance, customers might not participate.

You should analyse all touchpoints between the customers and your programme and ensure these are optimised for effortless navigation as well as for providing relevant and timely information to the customer.

What you can do:

- **Automate:** By connecting your programme to automated technologies such as smart thermostats, heat pumps and EV chargers, you can make participation in the programme almost effortless for consumers, and thus maximise engagement.
- **Make the information relevant:** Design programme interfaces to highlight information that people understand and care about. For example, kWh consumed is harder to understand (and for most people less interesting) than money saved through the programme.
- **Use smart pre-programmed defaults:** Demand-response programmes and devices might require initial set-up. By setting the optimal settings as defaults (while allowing the user to change them), you will lower the chance that the programme will perform poorly or produce extra discomfort for consumers.
- **Communicate consistently and through relevant channels:** Mobile notifications, text messages and in-home displays tend to work better for most consumers than emails and websites, which typically require more effort to access. If your programme sends signals or notifications to customers, send these at the same time and sufficiently in advance (a day before the event tends to work best)[95] to help consumers adapt and know what to expect.

Tips

Creating a user journey map can help you identify different pain points throughout the programme that need to be addressed to make it more user-friendly and intuitive. Design Kit by IDEO offers free guidance on how a journey map can be created.[96]

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Example

Making information about energy consumption intuitive

Research conducted in 2014 by the Customer-Led Network Revolution (CLNR) Project in the UK found that making energy consumption information easy to interpret can help improve user engagement.[97] Customers reacted positively to the use of a simple "traffic light" system on in-home displays (IHDs) where current energy consumption level or price was indicated by colour. The system was seen as intuitive and easy to understand and little information was needed for people to know that 'green' is a positive level of consumption and 'red' is a warning about high electricity use or costs. The system was the most widely used feature of the IHDs and was not perceived as difficult to engage with by any of the participants, including those in demographic groups that might typically be less likely to engage with IHDs and other smart devices.

2.2.3 Make demand-response programmes immediately rewarding

People might drop out from demand-response programmes if they feel the programme does not offer good benefits to them.

While extra bill credits and vouchers might appeal to some, others might find the incentive too low to justify their involvement.[98, 99] The timing of the benefits matters too. Most people are present-biassed, overvaluing immediate rewards and undervaluing rewards in the future.[100]

You should identify the types of benefits and motivators most relevant to your programme's target audience and provide the benefits immediately after a successful participation in a demand-response event.

What you can do:

- **Design your programme so that it increases customers' sense of control and understanding:** Offer enhanced insights into energy consumption, personalised recommendations for reducing energy usage and information on the amount of money saved in the past month.
- **Identify the benefits that resonate most with your consumer base:** Collect data from programme participants through surveys and focus groups to explore a variety of benefits and emphasise those most relevant to your target audience, including environmental and social benefits, insights into energy consumption and financial incentives.
- **Provide immediate rewards to programme participants:** Previous studies suggest that rewards given right after a person successfully participates in a demand-response event are more effective in maintaining engagement than delayed rewards.

Tips

High- and low-usage households might be receptive to different types of benefits. A large field experiment suggested that low-usage households tend to respond better to financial incentives whereas high-usage households were more responsive to social motives (e.g., becoming more energy efficient to meet social expectations).[101]

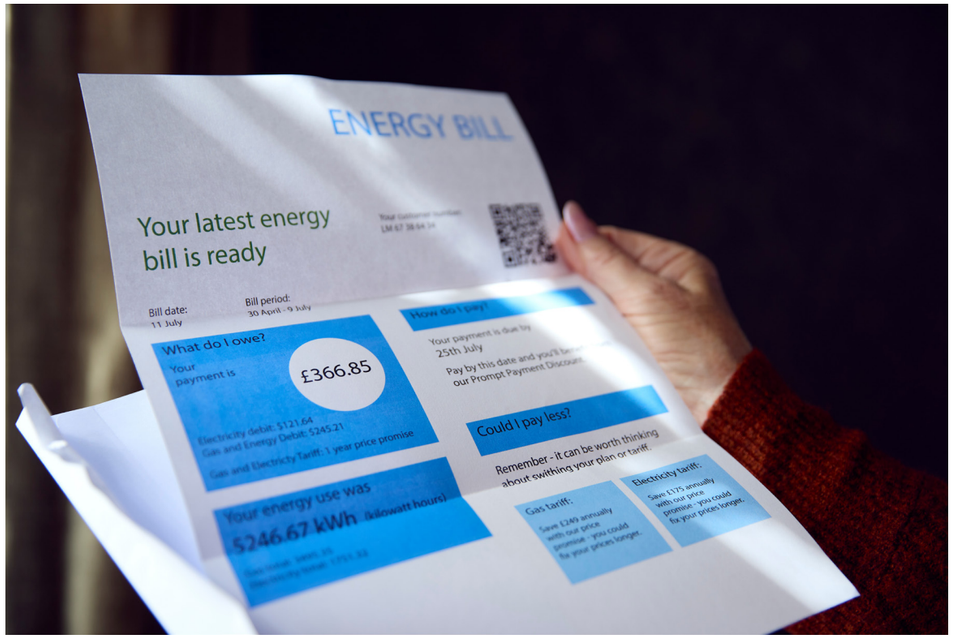
Contents > Encouraging programme participation > Design level

Example

Providing rewards immediately after programme participation

Equitable Novel Flexibility Exchange (EQUINOX) is an innovation project that is testing new commercial and technical arrangements to reward households with heat pumps for temporarily altering their heating choices. The project's first trial ran from December 2022 to March 2023, with 2-hour events scheduled up to 3 times a week (when participants either allowed suppliers to control their heat pumps remotely or were asked to turn off or down their own heat pumps).[102]

The trial tested two payment types: 'pay monthly' (where participants were paid four fixed £25 monthly instalments in advance of their participation in that month's events) and 'pay per event' (where participants were paid up to £6 after each event for their participation). It was found that participants in the 'pay per event' group found the trial easier to navigate and were less likely to opt out of trial events. These findings suggest that the cost of non-participation in the 'pay per event' group incentivised participation and that rewarding participants immediately after their participation is an effective way of increasing engagement.



2.2.4 Provide people with options to control their participation

A growing number of demand-response programmes are automated (i.e., allowing energy providers to remotely control people's heating systems, EV chargers and other appliances). While automated programmes tend to deliver more flexibility than manual response programmes,[103] taking the control away from individuals can generate negative responses.

Some households were shown to perceive direct load control as intrusive and for some consumers automation elements can generate a strong signal to avoid such a programme.[104,105] If the programme is fully automated, people might resist by unplugging the technology. [106, 107]

You should help consumers develop a sense of control, personalise automated settings, and offer a straightforward method to override automation whenever necessary. This not only requires developing manual override functionality but also effectively communicating it to consumers.

What you can do:

- **Use metaphors that people can relate to:** For example, some initiatives describe demand-response programmes as an Airbnb for energy or approximate it to a rideshare app.
- **Use visual information whenever possible:** People tend to be more attracted by images and videos than lengthy paragraphs.
- **Highlight the benefits early on:** Learning that demand response can, for example, reduce energy bills in the first place can make homeowners more willing to sign up.
- **Highlight the ease of participation:** Homeowners are more likely to give demand response a try when they know it is simple to sign up, will not incur extra costs and can easily be reverted if needed.

Tips

- Previous research found that homeowners rarely override the automated control. What is key is that homeowners perceive they could override the programme if they wanted to.[108]
- Past research also suggested that people's aversion to remote control particularly applies to heating.[109] As such, automated demand-response programmes that lower customers' thermostat temperature might require more effort to promote.
- Some automated control events can lead to more manual overrides than others. For example, a heat pump pilot by Nesta found that participants overrode devices more in morning events than in afternoon events.[110]

Example

Striking a balance between automation and control

To optimise the integration of heat pumps into the electricity system, ViFlex tested how aggregated heat pumps can contribute to a stable transmission system by reducing or shifting heat pump demand when system demand is high.[111] Single heat flow tariff was offered to consumers from the ViShare tariff plan options and customers received €120 flexibility bonus during sign-up, with a further discount of up to €0.10/kWh if they signed up to have their heat pumps controlled remotely.

While automation was encouraged in ViFlex via monetary incentives, customers retained control by having the options to define eligible blocking times for remote control, varying from no restrictions to certain hours a day when automation was not allowed. In addition, there was an emphasis on data privacy and customer data being kept anonymous throughout the project. These important features help strike a balance between automation and control, ensuring that customers always have the ultimate control of their appliances.

2.2.5 Help people understand how and when to reduce their usage

When people sign up for a programme, they may not be aware of the steps they should take to reduce their energy usage, or they might simply forget to follow through.

Previous research has indicated that most individuals lack knowledge on how to effectively reduce their energy consumption and tend to underestimate their potential energy savings.[112, 113, 114] In the context of automated demand-response programmes, people might unintentionally interfere with the automated settings on their appliances, thereby diminishing the programme's effectiveness. For instance, in one pilot study, individuals were found to be moving their smart thermostats around the house, which had a negative impact on the programme's effectiveness.[115]

You should put effort into explaining the specific actions consumers need to take to reduce their energy consumption and to optimally participate in the programme.

What you can do:

- **Share the top 3-5 energy saving actions to take before and during peak events:** Communicate what actions a customer can engage in (and which actions they should avoid) to optimally participate in the programme. Keep the advice limited to a few most impactful behaviours that people can easily adopt.
- **Help customers understand the benefits of appliance scheduling:** Explain how customers can use delayed start on their appliances such as EV chargers, dishwashers and washing machines to reduce their load (and save money) during peak hours.
- **Help customers understand how automated programmes work:** In direct load control programmes, communicate with customers what they can do (e.g., closing doors to unused rooms and eliminating air drafts) to make the automated solutions work optimally while ensuring comfort.
- **Remind people about peak events in advance:** This particularly applies to manual response programmes. Whereas different past pilots notified customers about peak events from 15 minutes to one day in advance, a large-scale trial found that the reminders work best when sent a day in advance of the event.[116]

Tips

Monitor how people interact with your programme throughout. Post-event customer surveys and interviews can help identify what consumers are finding difficult or unsure about, especially in the early days when a new programme is being rolled out.

Contents > Encouraging programme participation > Communication level

Example

Sending reminders one day in advance

A recent study evaluated the Demand Flexibility Service, the UK's largest ever demand-response programme, to measure its impact on energy demand and economic welfare.[117] A natural field experiment was conducted in collaboration with Octopus Energy to assess different advance notice periods and incentives provided to customers for their participation in a demand-response event.

The study found that being invited to participate in demand-response events led to a 10% reduction in energy demand, with active participation resulting in a 40% reduction. Interestingly, it was found that customers who received a shorter advance notice (i.e., receiving it on the day of the event itself) reduced their demand less than those who received the notice on the day prior to the event by about 25%. It was also found that participation rates in demand-response events were higher when customers have longer notice.

Image credit: Octopus Energy

2.2.6 Provide feedback on participation in demand-response programmes

People might stop taking part in demand-response programmes if they believe their actions do not produce any results. Feedback is essential in conveying impact and, consequently, in sustaining people's involvement.[118, 119]

You should regularly communicate with consumers about the impact of their participation. This communication should extend beyond reduced bills to encompass positive environmental effects and the contribution to a community of homeowners dedicated to reducing peak consumption. [120, 121]

What you can do:

- **Show consumers how much money they saved:** You can use existing communications such as monthly energy bills to inform your consumers about the change in their bills since they started participating in demand-response events.
- **Emphasise the growing number of programme participants:** Programmes that showcase customers their neighbours' efforts to reduce peak energy consumption create a sense of collective effort, leading to greater success.
- **Help consumers realise their positive environmental and social impact:** Explain in your communications how people's participation helped the utility to cut back on fossil fuels and improve the stability of the energy grid.
- **Provide feedback that is easy to understand:** A past study found that the most relied-upon feature of the feedback system was an in-home display with a simple traffic-light colour system signalling whether a household's current energy consumption is low, medium or high.[122]

Tips

Some programme participants might want to "set and forget" as opposed to receiving frequent feedback. Ask people if they would like to be informed about the positive impact of their participation during the sign-up process. Limiting communications to a minimum might be the most effective way for certain customers to maintain their engagement.

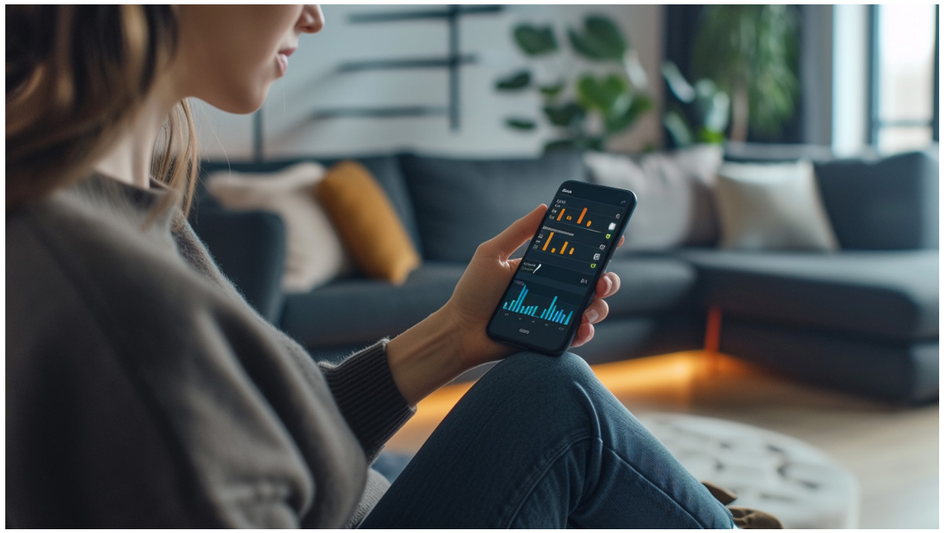
Contents > Encouraging programme participation > Communication level

Example

Understanding the type of feedback participants are interested in receiving

Equitable Novel Flexibility Exchange (EQUINOX) is an innovation project that is testing new commercial and technical arrangements to reward households with heat pumps for temporarily altering their heating choices. The project's first trial ran from December 2022 to March 2023, with 2-hour events scheduled up to 3 times a week (when participants either allowed suppliers to control their heat pumps remotely or were asked to turn off or down their own heat pumps).[123]

Interviews and focus group discussions conducted with customers revealed a general desire for more updates and feedback as participants progressed through the trial. More specifically, participants were interested in learning more about what the trial is studying, the impact of their participation (e.g., feedback on their carbon saving) and the research findings.



3 Increasing adoption of demand-response technologies

Promoting widespread adoption of demand-response technologies is crucial for achieving demand flexibility. These technologies empower individuals to use energy more efficiently and flexibly, thereby alleviating pressure on the electricity grid's supply. Key demand-response technologies include:

1. **Smart Thermostats and Smart Meters:** These enable users to programme energy consumption reduction during peak times. Additionally, these devices serve as interfaces for utilities to directly communicate peak times and demand flexibility measures to their customers.

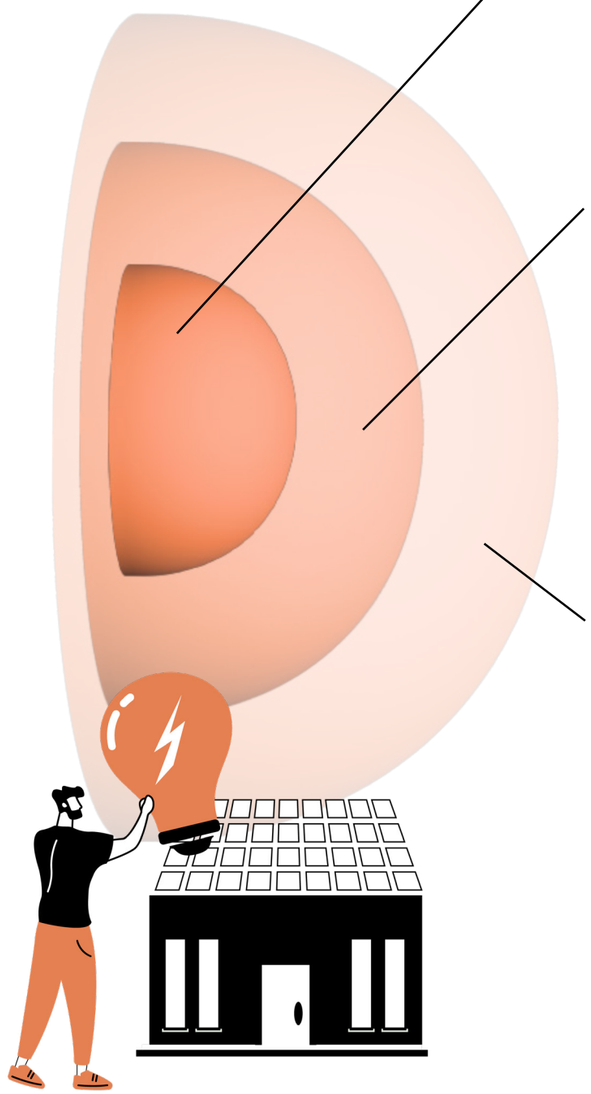
2. **Solar Panels and Behind-the-Meter Batteries:** Offering users the capability to generate their electricity, solar panels provide a degree of autonomy from the grid. While their functionality is weather-dependent, users can enhance their effectiveness by coupling solar panels with battery packs. This enables energy storage during non-consumption periods, allowing users to draw upon stored energy during evenings and nights without imposing additional strain on the grid.

3. **Heat Pumps:** Despite relying on electricity, heat pumps operate at lower temperatures and for more extended periods compared to traditional gas boilers. They contribute to maintaining a consistent temperature in homes while minimising energy consumption during peak times. Integrating them with solar panels and battery storages offers a fully autonomous heating system, independent of the grid.

Encouraging the widespread adoption of demand-response technologies is crucial because these technologies do not only provide users with autonomy over their energy production,– such as in the case of solar panels,– but they also automate the behaviours required for more flexible energy consumption. This, in turn, alleviates the burden of achieving demand flexibility from end-users, rendering the goal more feasible and effective.

However, despite these benefits, the adoption of demand-response technologies remains low. Various factors contribute to this; many of these technologies require an upfront investment, while the benefits, such as energy savings,are often realised only later in time. Additionally, misconceptions such as concerns about the maturity of these technologies and potential privacy infringements act as further barriers.

The application of behavioural insights can help address these challenges. Understanding how to encourage individuals to adopt these technologies involves addressing barriers and concerns, as well as providing effective motivators. The next section explores system-level, design-level and communication-level solutions to increase the adoption of demand-response technologies.



System level

- 3.1 Build local support for demand-response technologies
- 3.2 Lead by example through public policies and regulations

Design level

- 3.3 Simplify the user experience of digital interfaces
- 3.4 Ensure that the use of demand-response technologies is publicly visible
- 3.5 Make the use of demand-response technologies rewarding

Communication level

- 3.6 Address misconceptions about demand-response technologies
- 3.7 Help people understand how demand-response technologies work
- 3.8 Highlight the benefits of demand-response technologies

3.1 Build local support for demand-response technologies

Adopting new demand-response technologies often requires a shift in people's behaviours, which may seem unfamiliar or unusual, thereby becoming a potential barrier to many individuals. For instance, electric vehicles take longer to charge and it might take longer to heat up a room using heat pumps.

While there may be future advancements that make the transition to these new technologies smoother, like faster charging stations for electric vehicles, in the short term individuals will likely need to plan their energy needs more deliberately, which can be effortful. However, people are more inclined to make this effort if they see others endorsing energy flexibility, and adapting or planning their energy usage.

It is therefore important to build local endorsement for demand flexibility and foster a supportive social network that provides homeowners with guidance, tips and advice during this transition.[124]

What you can do:

- **Facilitate conversations among homeowners:** Facilitate conversations between homeowners and their neighbours or close friends who have already adopted demand-response technologies though platforms, webinars, associations or community events. These personal interactions can increase individuals' intentions to adopt these technologies as they see the positive experiences of others first-hand.
- **Collaborate with installers and professionals:** Work closely with installers and professionals who have direct interactions with homeowners during the installation process.[125] Provide them with information and resources to effectively communicate the benefits and value of demand-response technologies, thereby influencing homeowners' perceptions and decisions.
- **Secure endorsement from local authorities:** Get local authorities and policymakers to endorse and support demand-response technologies. Their position and influence can significantly impact homeowners' perception of these technologies and encourage their wider adoption.

Tips

When aiming to foster local support for demand flexibility, keep in mind that people are more likely to follow advice from individuals they are socially close to, like community leaders and friends, rather than information coming from their energy providers. Emphasising advice from these influential connections can enhance the effectiveness of your communication efforts.

Contents > Increasing adoption of demand-response technologies > System level

Example

Increasing awareness and knowledge of local electricity grids through middle actors

In Norway, researchers study how the influx of electric vehicles enabled new forms of engagement with the electricity grid in urban residential communities.[126]

Middle actors (i.e., electricians) who have traditionally been seen as external to the local community were identified as a central element of smart EV charging. They played a vital role in translating material constraints and local capacity problems into tangible community concerns (e.g., equity and fairness), which resonated well with the local communities. They also helped ensure the engagement of the local communities in managing the electricity loads flowing through the strained grids and in turn contributed to the expansion of the Norwegian EV transition more broadly.

3.2 Lead by example through public policies and regulations

The slow acceptance and adoption of demand flexibility technologies in society can be attributed, in part, to a perceived lack of commitment from governments and influential institutions. Without clear signals from the government, individuals may be reluctant to see these technologies as an aspect of the future.

To overcome this challenge, governments should take proactive steps to establish robust regulations, incentive programmes and public commitments in support of demand flexibility. Equally crucial is making these initiatives visible and conspicuous to raise awareness and demonstrate leadership. Through the implementation of these measures, governments can effectively convey their commitment, reshape societal norms and promote widespread acceptance of demand flexibility as an essential aspect of the future.

What you can do:

- **Public Commitments:** Governments and organisations should publicly commit to achieving demand flexibility goals, installing demand-response technologies in public spaces. This signals a commitment to sustainability, setting a positive example for wider societal participation.
- **Highlight proactive measures:** Promote awareness among the general public regarding governments' or organisations' proactive measures concerning demand flexibility technology, sending a clear signal to the market.
- **Encourage peer influence and social proof:** Share success stories and positive experiences of homeowners who have already adopted demand-response technologies. Highlighting the positive outcomes and benefits they have experienced can influence others to follow suit.

Tips

When designing technology adoption campaigns, it is important to avoid using motivational factors that could alienate certain audience segments. Instead, opt for universally accepted motives. For instance, appealing to environmental motives may not resonate with some segments of the population. On the other hand, reducing energy bills may appeal to a broader audience.

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Example

Using regulations to expedite the transition to clean energy[127]

Having relied historically on natural gas, The Netherlands has committed to going completely gas-free by 2050 and halting domestic production by 2030.

Through the introduction of stringent climate legislation at the national and local levels, the Netherlands is undergoing a rapid transition to clean energy. Initial progress has been promising; for example, by the end of 2018, the Dutch subsidiary of supermarket chain Lidl had disconnected all 410 of its stores from the gas grid and adopted heat pumps powered by electricity from renewables. This example illustrates that with stringent climate regulations and ambitious targets, it is feasible to rapidly scale up low-carbon alternatives to gas.

3.3 Simplify the user experience of digital interfaces

Demand response technologies often include digital interfaces that allow consumers to configure and manage them independently, such as apps for monitoring the amount of energy produced from solar panels or smart meter displays. However, these platforms can seem complex to navigate, deterring their adoption, especially among those less tech-savvy or with limited time and attention. Boosting adoption requires streamlining the user experience, simplifying applications and ensuring these interfaces are user-friendly.

What you can do:

- **Make interfaces user-friendly:** Prioritise ease of use when designing digital interfaces for demand-response technologies. Streamline the user journey, use simple language and visual cues, chunk down device set-up processes and ensure that homeowners can easily access and use the features and functionalities.
- **Gamify the interfaces:** Incorporate elements of challenge, reward and interactivity into the interfaces to make the user experience more enjoyable and engaging.[128] Introduce progress trackers, badges, or virtual rewards to motivate homeowners to adopt the technologies and actively participate in energy-saving activities. For example, some hybrid cars have gamified their experience by offering features in their dashboards that challenge drivers to drive in all-electric mode.[129]
- **Provide relevant information:** Ensure that digital interfaces for demand response technologies provide consumers with behaviourally relevant information. This entails offering insights into their energy consumption in a clear, actionable and straightforward manner, motivating them to take proactive measures.

Tips

- Conduct usability testing with homeowners: Involve homeowners in the design and testing process to identify pain points, usability issues, and areas for improvement in the digital interfaces. Incorporate their feedback and iterate on the design to ensure that it aligns with their needs and preferences.
- Consider designing for underrepresented user types to ensure that digital interfaces are inclusive. Make sure to follow accessibility guidelines.

Example

Using a user-centred design for smart meter interfaces

To help households consume energy more efficiently, a research team illustrated how a user-centred design of an energy-use information system can be developed based on user interviews.[130]

The envisioned smart meter system automatically computes the monetary savings from replacing an appliance or changing the operational behaviour of an appliance. The information provided is then personalised with respect to appliance use and includes additional data from external databases.

Key design principles highlighted by the researchers include:
- Collect continuous data at the appliance level through electrical outlet sensors.
- Provide information on appliances states (e.g., on or off) and settings (e.g., wash program) through automatic post-processing of data.
- Provide energy-use information in comprehensible units (e.g., in the form of monetary savings), both in the short and the long term.

3.4 Ensure that the use of demand-response technologies is publicly visible

People are less likely to adopt demand-response technologies if they believe only a few others have done so. The visibility and public acknowledgment of demand-response technologies play a crucial role in encouraging wider adoption.[131] Enhancing the conspicuousness of demand-response technologies enables adopters to signal higher social status and commitment to demand flexibility, facilitating broader acceptance. For instance, research has shown that installing solar panels and purchasing electric vehicles can be socially desirable[132], thereby promoting their adoption.

However, most technologies, such as batteries, smart thermostats and meters, often lack visibility. Therefore, exploring ways to increase the visibility of demand-response technologies is essential to fostering broader awareness and adoption, particularly among non- or late adopters.

What you can do:

- **Establish a demand flexibility labelling system:** A labelling system can make the adoption of demand-response technologies more visible. This can contribute to building collective awareness and enhancing the perceived value of these technologies and also about the properties that are equipped with them.
- **Monitor and communicate adoption trends:** Encourage building management agents, homeowner associations, or building committees to monitor the adoption of demand flexibility technologies among residents in building blocks and communicate this data back to the residents. Sharing these annual adoption trends can help foster awareness and encourage further adoption.
- **Foster peer-to-peer communication and support networks:** Create platforms, events or forums where homeowners can connect with and learn from each other. Encourage the sharing of success stories, energy-saving tips and best practices to foster a sense of community and support among homeowners.
- **Encourage homeowners to share their energy-saving achievements on social media or other public platforms:** Create social media campaigns that allow homeowners to showcase their energy-saving efforts and inspire others. Engage with homeowners on social media to amplify their stories and experiences.

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Example

Using ratings to increase the visibility of demand flexibility

The Smart Building Rating (SBR), as proposed by the Center for Net Zero, is a measure of demand flexibility capacity which helps increase the visibility of demand flexibility.[133] The SBR can help increase the demand for smart technologies enabling flexibility in different ways, including by increasing consumer awareness of demand flexibility and signalling the increased value of a property (due to the potential for bill savings, greater comfort and as a future-proofing measure).

As long as the ratings are publicly accessible, the SBR can help increase the visibility of demand flexibility as households are better aware of the capacity of their property as well as of their neighbours' for demand flexibility. By making the use of demand-response technologies visible and enabling easy comparison, households' intention to adopt such technologies can be increased through social signalling.

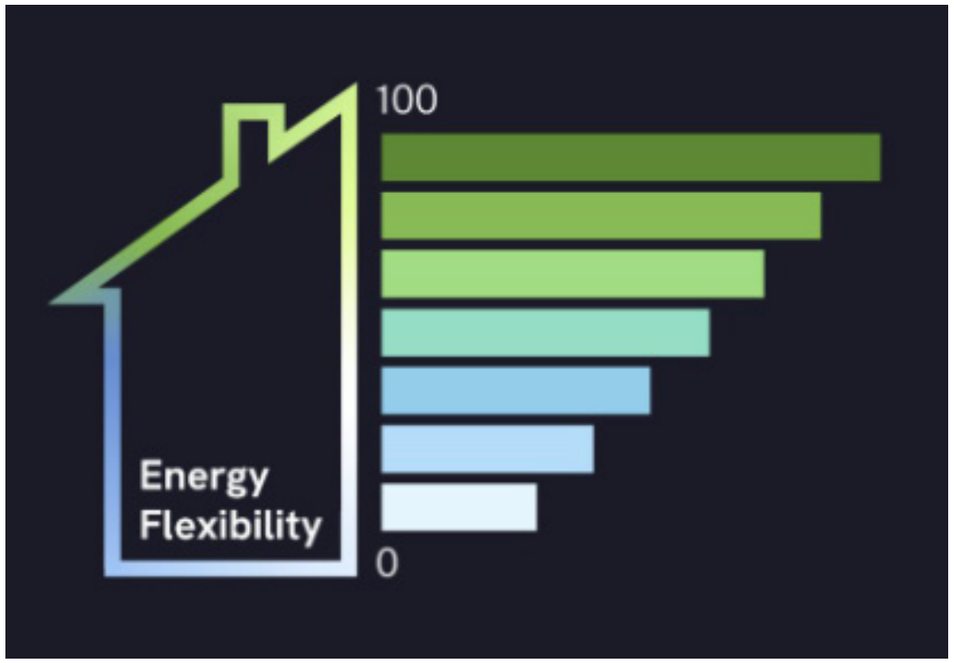

Image credit: Center for Net Zero

3.5 Make the use of demand-response technologies rewarding

The benefits of installing demand-response technologies are typically realised gradually over time, such as energy cost savings and reduced carbon emissions. However, people tend to place greater importance on upfront costs over future gains, which can lead to a lack of recognition of the direct benefits of adopting these technologies in the present.

Providing tangible rewards can enhance homeowners' motivation to adopt these technologies. These can, for example, include financial incentives, in-kind rewards or symbolic rewards (e.g., a certificate, a social acknowledgement).

What you can do:

- **Offer financial rewards or discounts on energy bills:** Provide homeowners with financial incentives for actively using demand-response technologies and achieving energy-saving goals. These can include tiered pricing structures or rebates based on energy savings. Installers can also offer packages where consumers can earn additional bonuses when they enroll their new technology in a demand response programme.
- **Provide exclusive access to special services or programmes:** Offer homeowners who actively participate in demand-response programmes access to additional benefits or perks. These can include priority customer service, energy-saving tips and resources, or exclusive offers from partner organisations.
- **Gamify the use of demand-response technologies:** Introduce elements of challenge, competition and reward to make the experience more engaging and enjoyable for homeowners. These can include setting energy-saving goals, tracking progress and unlocking virtual rewards or badges for achieving milestones.
- **Leverage the scarcity effect:** Design time-limited offers to make rewards more attractive and engage homeowners. Introducing limited-time promotions or exclusive rewards for specific periods can create a sense of urgency, motivating homeowners to actively participate in demand-response technologies.

Tips

Although financial incentives and gamification may spark initial interest, relying solely on extrinsic rewards can lead to short-lived engagement. Participants may lose interest when rewards are discontinued. To foster sustained engagement, appeal to intrinsic motivators like energy efficiency, autonomy, or social acknowledgment. A balanced approach, incorporating both extrinsic and intrinsic elements, ensures a comprehensive strategy that resonates with diverse homeowner motivations.

Example

Using Time-Limited Incentives to Boost Solar Panel Purchases

Governments in many countries offer grants to boost purchases of renewable energy sources (RES), such as solar panels. In Germany, the amount of money a grant applicant can receive changes with time, as regulated by The Renewable Energy Sources Act.

A 2017 study found that investments in RES increased immediately before an announced reduction of the remuneration.[134] This highlights that favourable, time-limited offers can help citizens overcome procrastination when applying for renewable energy grants and subsidies.

3.6 Address misconceptions about demand-response technologies

Misconceptions about demand-response technologies can hinder their adoption[135]. Some people believe that demand-response technologies such as heat pumps and electric vehicles are not fully developed yet, are unreliable and unsafe.[136] Additionally, concerns about suitability for their homes and affordability further deter potential adopters. For example, many people incorrectly assume that installing heat pumps will be particularly hard in rural areas, especially in detached, traditionally-built houses which lie off the gas grid.[137]

Communicators should identify and address these misconceptions by providing accurate information to homeowners, which in turn will encourage their acceptance and adoption of these technologies.

What you can do:

- **Debunk false information:** Launch educational campaigns that debunk common misconceptions about demand-response technologies. Address specific concerns or objections that homeowners may have about demand-response technologies and provide clear and evidence-based explanations to alleviate their worries. This approach has been effective at addressing falsehoods about EVs specifically[138] and could be effectively applied to other new technologies.
- **Preemptively address potential misconceptions:** Get ahead of potential misunderstandings by giving people tools to spot false information and warn them before they come across it.[139] This approach is commonly referred to as “pre-bunking”. First, figure out the misleading ideas or stories that could cause the most problems. Then, use a “sandwich technique”: start with facts, bring in the mistaken belief and its reasoning, and finish with more facts. This avoids accidentally making the misconception more widespread.
- **Collaborate with trusted sources,** such as industry experts, community leaders or consumer advocacy groups, to disseminate accurate and reliable information about demand-response technologies.

Tips

- Make communications more credible by providing balanced information that is fact-based, easily understandable and jargon-free.
- Spread the message that an increasing number of individuals are embracing the new technology and highlighting their positive experiences to persuade sceptics.

Example

Understanding inaccurate beliefs about heat pumps

Funded by the Department for Business, Energy and Industrial Strategy (BEIS), the Electrification of Heat project studied the technical and practical feasibility of a large-scale rollout of heat pumps and how to overcome current barriers.[140] The recruitment and installation phase of the project ran from July 2020 to October 2021, and 742 heat pumps were installed into a variety of housing types and socio-economic groups.

While many households who were interested in the project mistakenly thought their homes would not be suited to heat pumps due to age, layout and/or energy efficiency, it was found that heat pumps were installable across all housing types in the UK. In fact, only 8% of 8,800 applicants lacked outdoor space for the heat pump, and only 2% lacked indoor space for the thermal store.

3.7 Help people understand how demand-response technologies work

Many demand-response technologies are relatively new, and their features and capabilities, which provide users with enhanced demand flexibility, are not widely known. For instance, electric vehicles can store energy for home use during peak times, heat pumps can be remotely controlled to preheat a house before peak hours and batteries can charge during off-peak times and provide energy during peak hours. However, limited information and awareness of these capabilities, can discourage households from considering these technologies.[141]

Research indicates that the more people feel they know about a technology, the more likely they are to adopt it.[142] Therefore, providing clear explanations and helping homeowners develop a solid understanding of how these technologies work is crucial to increase their acceptance and adoption.

What you can do:

- **Leverage local technology enthusiasts:** Collaborate with local technology enthusiasts to organise community events focused on demand flexibility. Leveraging local influencers, such as friends and neighbours, for these events can be an effective communication channel. Support these enthusiasts with resources and training to enhance peer engagement. This grassroots approach builds an informed network and fosters broader adoption of demand flexibility.
- **Offer user-friendly instructions: O**ffer user-friendly instructions and step-by-step guides for installing and using energy-demand technologies. Consider using simple and concise language and imagery. Additionally, consider following up with relevant information to individuals who have recently installed demand response technology.
- **Collaborate with local organisations** to offer personalised consultations or home visits that provide homeowners with a practical understanding of how demand-response technologies can be integrated into their daily lives.

Tips

When informing people about the demand flexibility capabilities of technologies, make sure that the information that is presented is accessible and easy to understand. Break down complex technical concepts into easily digestible information. Provide visual aids, such as images or infographics (e.g., of how a heat pump works or outlining property requirements for heat pump installation) to enhance understanding and retention of information.

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Example

Using interactive diagrams and short videos to explain how a programme works

The OVO Vehicle-to-Grid (V2G) Trial sought to use bidirectional charging to balance the grid and improve energy efficiency in the UK by harnessing the potential of EVs to act as stores and sources of energy.[143]

Results from the trial,which ran from 2020 to 2022,showed that participants saved up to £725 per year. One of the key features that contributed to the success of the trial was the use of interactive diagrams and short videos to explain how the setup works, in addition to the Kaluza app, an intelligent energy platform that controls the V2G charger.[144]

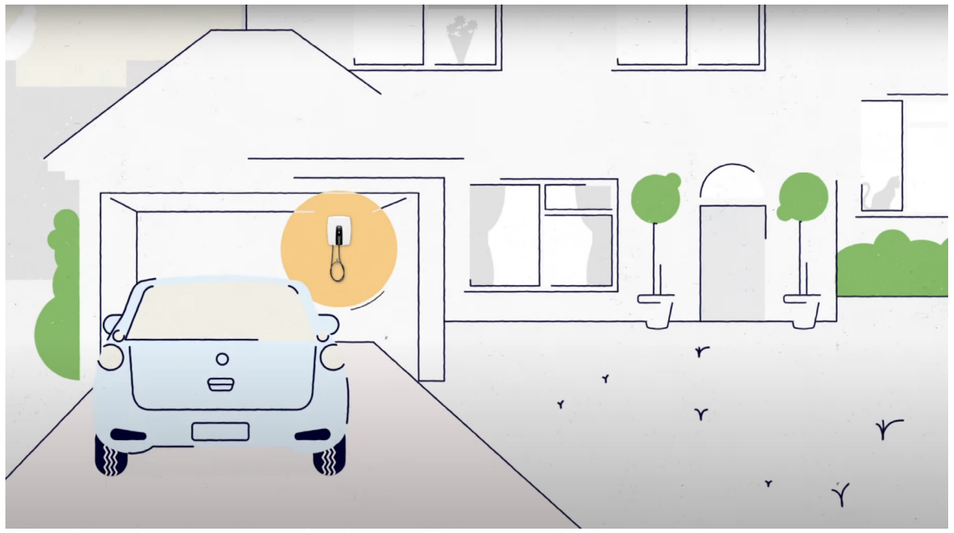

Image credit: OVO Energy

3.8 Highlight the right benefits

Demand-response technologies can offer consumers a wide range of benefits beyond just cost-savings and environmental impact, which are often not communicated to households, impacting their motivation to adopt these technologies. These include a sense of self-sufficiency[145], future-proofing one's property and increasing its value[146], acquiring a 'green identity'[147], and improved health benefits[148]. It is crucial to identify the relevant benefits associated with demand-response technologies and to highlight them in communications to encourage homeowners to adopt them.

What you can do:

- **Showcase the health benefits of demand-response technologies:** Highlight how these technologies can improve indoor air quality, reduce exposure to harmful pollutants and create a healthier living environment for homeowners and their families.
- **Emphasise the potential increase in property value:** Demonstrate how the installation and use of demand-response technologies can enhance the value of homes and future-proof them, making them more attractive to potential buyers or renters.
- **Highlight the sense of autarky and autonomy:** Showcase how demand-response technologies can empower homeowners by providing them with greater control over their energy usage, allowing them to become more self-sufficient in meeting their energy needs.

Tips

- To effectively tailor your communications, conduct research to identify the most relevant benefits for your target audience. A useful approach is to distribute surveys, asking people to rank their motivations for adopting the specific technology. Additionally, capture measurable indicators that can enable you to deliver personalised messages.
- Share success stories and experiences of homeowners who have already adopted demand-response technologies. These stories can help potential adopters understand the specific benefits and positive outcomes they can expect from integrating these technologies into their homes.

Contents > Increasing adoption of demand-response technologies > Communication level

Example

Highlighting different benefits to different consumer groups

EcoGrid EU was a large demonstration project involving private customers in the use of market mechanisms and smart control of electricity to balance the energy system.[149] Ran from 2011 to 2015 in Bornholm, Denmark, the project tested real-time market and home-automation technologies to enable consumers to control and move their electricity consumption to the exact hours when the price was low.

One of the key findings from the project was that motivations can greatly differ by consumer groups. The most enthusiastic consumers were found to be more motivated by environmental and community-related benefits, while those who had no particular interest in technology, energy, or environment were found to be primarily motivated by financial gain (or the prospect of loss if they do not act). This finding suggests that the benefits of demand-response technologies should be marketed differently so that they resonate with different populations.

References

[1] IEA (2021). Key World Energy Statistics 2021 - Final Consumption.
[2] UK National Grid (2022). How much of the UK's energy is renewable?
[3] The EU Comission (2023). Renewable energy targets.
[4] Natural Resources Canada (2017). About renewable energy.
[5] The United States Environmental Protection Agency (2023). Summary of Inflation Reduction Act provisions related to renewable energy.
[6] Ministry of New and Renewable Energy (2022). Renewable Energy in India.
[7] Global Energy Monitor (2023). A Race to the Top: China 2023.
[8] IEA (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector.
[9] IEA (2023). Electricity.
[10] IEA (2023). Energy Efficiency 2023.
[11] IEA (2021). Key World Energy Statistics 2021 - Final Consumption.
[12] Sloot, D., Lehmann, N., Ardone, A., & Fichtner, W. (2023). A Behavioral Science Perspective on Consumers' Engagement With Demand Response Programs. Energy Research Letters, 4(1).
[13] Schuitema, G., Ryan, L., & Aravena, C. (2017). The consumer's role in flexible energy systems: An interdisciplinary approach to changing consumers' behavior. IEEE Power and Energy Magazine, 15(1), 53-60.
[14] Meadows, D. H. (2008). Thinking in systems: A primer. Chelsea Green Publishing.
[15] Hallsworth, M. (2023). A manifesto for applying behavioural science. Nature Human Behaviour, 7(3), 310-322.
[16] Centre For Net Zero (2023). Smart Building Rating.
[17] Livernois, J., & McKenna, C. J. (1999). Truth or consequences. Journal of Public Economics, 71(3), 415–440.
[18] Verplanken, B., & Roy, D. (2016). Empowering interventions to promote sustainable lifestyles: Testing the habit discontinuity hypothesis in a field experiment. Journal of Environmental Psychology, 45, 127-134..
[19] Niamir, L., Ivanova, O., Filatova, T., Voinov, A., & Bressers, H. (2020). Demand-side solutions for climate mitigation: Bottom-up drivers of household energy behavior change in the Netherlands and Spain. Energy Research & Social Science, 62, 101356.
[20] The Behavioural Insights Team (2021). Applying Behavioural Insights to Reduce Commuting Emissions.
[21] Allcott, H. (2011). Social norms and energy conservation. Journal of public Economics, 95(9-10), 1082-1095.
[22] McHugh, S. (2022). We paid customers to use less power at peak times. here's what happened. Octopus Energy.
[23] Spandagos, C., Yarime, M., Baark, E., & Ng, T. L. (2020). "Triple Target" policy framework to influence household energy behavior: Satisfy, strengthen, include. Applied Energy, 269, 115117.
[24] Kowalska-Pyzalska, A. (2018). What makes consumers adopt to innovative energy services in the energy market? A review of incentives and barriers. Renewable and Sustainable Energy Reviews, 82, 3570-3581.
[25] Apple (2023). Use Clean Energy Charging on your iPhone.
[26] National Grid ESO (2023). Household engagement with the Demand Flexibility Service 2022/23.
[27] Liebe, U., Gewinner, J., & Diekmann, A. (2021). Large and persistent effects of green energy defaults in the household and business sectors. Nature Human Behaviour, 5(5), 576–585.
[28] The Policy Institute (2019). Misperceptions about climate change and the natural environment.
[29] Testa, F., Pretner, G., Iovino, R., Bianchi, G., Tessitore, S., & Iraldo, F. (2021). Drivers to green consumption: A systematic review. Environment, development and sustainability, 23, 4826-4880.
[30] The Behaviouralist (2023). Share the warmth: Applying behavioural insights to help manage energy consumption at home.
[31] McHugh, S. (2022). We paid customers to use less power at peak times. here's what happened. Octopus Energy.
[32] Moore, H. E., & Boldero, J. (2017). Designing interventions that last: a classification of environmental behaviors in relation to the activities, costs, and effort involved for adoption and maintenance. Frontiers in psychology, 8, 1874.
[33] National Grid (2023). EQUINOX Trial One Customer Experience.
[34] Centre for Net Zero (2023). Insights from the UK's largest consumer energy flexibility trial.
[35] Faruqui, A., Sergici, S., & Warner, C. (2017). Arcturus 2.0: A meta-analysis of time-varying rates for electricity. The Electricity Journal, 30(10), 64-72.
[36] Centre for Net Zero (2023). The impact of demand response on energy consumption and economic welfare.
[37] 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.
[38] Palm, A. (2017). Peer effects in residential solar photovoltaics adoption—A mixed methods study of Swedish users. Energy Research & Social Science, 26, 1-10.
[39] Selvakkumaran, S., & Ahlgren, E. O. (2019). Determining the factors of household energy transitions: A multi-domain study. Technology in Society, 57, 54-75.
[40] Ellabban, O., & Abu-Rub, H. (2016). Smart grid customers' acceptance and engagement: An overview. Renewable and Sustainable Energy Reviews, 65, 1285-1298.
[41] Simó-Solsona, M., Palumbo, M., Bosch, M., & Fernandez, A. I. (2021). Why it's so hard? Exploring social barriers for the deployment of thermal energy storage in Spanish buildings. Energy research & social science, 76, 102057.
[42] Iliopoulos, N., Onuki, M., & Esteban, M. (2021). Shedding light on the factors that influence residential demand response in Japan. Energies, 14(10), 2795.
[43] Octopus Energy (2022). Believe it or watt: Octopus Energy customers provide 108MW of grid flexibility in first 'Saving Session' - equivalent of a gas power station.
[44] Iliopoulos, N., Onuki, M., & Esteban, M. (2021). Shedding light on the factors that influence residential demand response in Japan. Energies, 14(10), 2795.
[45] Centola, D., Becker, J., Brackbill, D., & Baronchelli, A. (2018). Experimental evidence for tipping points in social convention. Science, 360(6393), 1116-1119.
[46] Rogers, E. M., Singhal, A., & Quinlan, M. M. (2014). Diffusion of innovations. In An integrated approach to communication theory and research (pp. 432-448). Routledge.
[47] UK Power Networks (2018). Energywise (also known as vulnerable customers and energy efficiency).
[48] Testa, F., Pretner, G., Iovino, R., Bianchi, G., Tessitore, S., & Iraldo, F. (2021). Drivers to green consumption: A systematic review. Environment, development and sustainability, 23, 4826-4880.
[49] Cardoso, C. A., Torriti, J., & Lorincz, M. (2020). Making demand side response happen: A review of barriers in commercial and public organisations. Energy Research & Social Science, 64, 101443.
[50] Lazdins, R., Mutule, A., & Zalostiba, D. (2021). PV energy communities—Challenges and barriers from a consumer perspective: A literature review. Energies, 14(16), 4873.
[51] Norouzi, F., Hoppe, T., Elizondo, L. R., & Bauer, P. (2022). A review of socio-technical barriers to Smart Microgrid development. Renewable and Sustainable Energy Reviews, 167, 112674.
[52] National Grid ESO (2023). Demand Flexibility Service (DFS).
[53] National Grid ESO (2023). Household engagement with the Demand Flexibility Service 2022/23
[54] Arkes, H. R., & Blumer, C. (1985). The psychology of sunk cost. Organizational behavior and human decision processes, 35(1), 124-140.
[55] Nesta & Centre for the Net Zero (2023). Automating heat pump flexibility: Results from a pilot.
[56] Lindenberg, S., & Steg, L. (2007). Normative, gain and hedonic goal frames guiding environmental behavior. Journal of Social issues, 63(1), 117-137.
[57] List, J. A., Metcalfe, R. D., Price, M. K., & Rundhammer, F. (2017). Harnessing policy complementarities to conserve energy: Evidence from a natural field experiment (No. w23355). National Bureau of Economic Research.
[58] Iliopoulos, N., Onuki, M., & Esteban, M. (2021). Shedding light on the factors that influence residential demand response in Japan. Energies, 14(10), 2795. https://doi.org/10.3390/en14102795
[59] Kessels, K., Kraan, C., Karg, L., Maggiore, S., Valkering, P., & Laes, E. (2016). Fostering residential demand response through dynamic pricing schemes: A behavioural review of smart grid pilots in Europe. Sustainability, 8(9), 929.
[60] Ellabban, O., & Abu-Rub, H. (2016). Smart grid customers' acceptance and engagement: An overview. Renewable and Sustainable Energy Reviews, 65, 1285-1298.

[61] Scottish and Southern Electricity Networks. SAVE Project.
[62] Ellabban, O., & Abu-Rub, H. (2016). Smart grid customers' acceptance and engagement: An overview. Renewable and Sustainable Energy Reviews, 65, 1285-1298.
[63] Kessels, K., Kraan, C., Karg, L., Maggiore, S., Valkering, P., & Laes, E. (2016). Fostering residential demand response through dynamic pricing schemes: A behavioural review of smart grid pilots in Europe. Sustainability, 8(9), 929.
[64] Sintov, N. D., & Schultz, P. W. (2017). Adjustable green defaults can help make smart homes more sustainable. Sustainability, 9(4), 622.
[65] 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, 111221.
[66] Energy Savings Trust (2022). Powerloop Vehicle-to-Grid trial: Customer insights and best practice guide.
[67] Siitonen, P., Honkapuro, S., Annala, S., & Wolff, A. (2023). Customer perspectives on demand response in Europe: a systematic review and thematic synthesis. Sustainability: Science, Practice and Policy, 19(1), 2154986.
[68] Sintov, N. D., & Schultz, P. W. (2015). Unlocking the potential of smart grid technologies with behavioral science. Frontiers in psychology, 6, 410.
[69] Ellabban, O., & Abu-Rub, H. (2016). Smart grid customers' acceptance and engagement: An overview. Renewable and Sustainable Energy Reviews, 65, 1285-1298.
[70] Kowalska-Pyzalska, A. (2018). What makes consumers adopt to innovative energy services in the energy market? A review of incentives and barriers. Renewable and Sustainable Energy Reviews, 82, 3570-3581.
[71] Iliopoulos, N., Esteban, M., & Kudo, S. (2020). Assessing the willingness of residential electricity consumers to adopt demand side management and distributed energy resources: A case study on the Japanese market. Energy Policy, 137, 111169.
[72] Harjani, T., Roozenbeek, J., Biddlestone, M., van der Linden, S., Stuart, A., Iwahara, M., Piri, B., Xu, R., Goldberg, B., & Graham, M. (2022). A Practical Guide to Prebunking Misinformation.
[73] Siitonen, P., Honkapuro, S., Annala, S., & Wolff, A. (2023). Customer perspectives on demand response in Europe: asystematic review and thematic synthesis. Sustainability: Science, Practice and Policy, 19 (1), 2154986.
[74] Users TCP Social License to automate (2021). Emerging Approaches to Demand Side Management.
[75] Ellabban, O., & Abu-Rub, H. (2016). Smart grid customers' acceptance and engagement: An overview. Renewable and Sustainable Energy Reviews, 65, 1285-1298.
[76] Iliopoulos, N., Esteban, M., & Kudo, S. (2020). Assessing the willingness of residential electricity consumers to adopt demand side management and distributed energy resources: A case study on the Japanese market. Energy Policy, 137, 111169.
[77] 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, 111221.
[78] Parkins, J. R., Rollins, C., Anders, S., & Comeau, L. (2018). Predicting intention to adopt solar technology in Canada: The role of knowledge, public engagement, and visibility. Energy Policy, 114, 114-122.
[79] Barth, M., Jugert, P., & Fritsche, I. (2016). Still underdetected–Social norms and collective efficacy predict the acceptance of electric vehicles in Germany. Transportation research part F: traffic psychology and behaviour, 37, 64-77.
[80] Enel X (2017). What is Demand Response? 5 Easy-to-Understand Answers.
[81] Flow Power. A Guide to Demand Response.
[82] Reis, I. F., Lopes, M. A., & Antunes, C. H. (2021). Energy literacy: an overlooked concept to end users' adoption of time-differentiated tariffs. Energy Efficiency, 14(4), 39.
[83] Tantalus (2020). Advantage power pricing.
[84] Centre for Net Zero (2023). The impact of demand response on energy consumption and economic welfare.
[85] Nesta & Centre for the Net Zero (2023). Automating heat pump flexibility: Results from a pilot.
[86] Sintov, N. D., & Schultz, P. W. (2015). Unlocking the potential of smart grid technologies with behavioral science. Frontiers in psychology, 6, 410.
[87] Ellabban, O., & Abu-Rub, H. (2016). Smart grid customers' acceptance and engagement: An overview. Renewable and Sustainable Energy Reviews, 65, 1285-1298.
[88] Kowalska-Pyzalska, A. (2018). What makes consumers adopt to innovative energy services in the energy market? A review of incentives and barriers. Renewable and Sustainable Energy Reviews, 82, 3570-3581.
[89] Palm, A. (2017). Peer effects in residential solar photovoltaics adoption—A mixed methods study of Swedish users. Energy Research & Social Science, 26, 1-10.
[90] Selvakkumaran, S., & Ahlgren, E. O. (2019). Determining the factors of household energy transitions: A multi-domain study. Technology in Society, 57, 54-75.
[91] Siitonen, P., Honkapuro, S., Annala, S., & Wolff, A. (2023). Customer perspectives on demand response in Europe: a systematic review and thematic synthesis. Sustainability: Science, Practice and Policy, 19(1), 2154986.
[92] Von Wirth, T., Gislason, L., & Seidl, R. (2018). Distributed energy systems on a neighborhood scale: Reviewing drivers of and barriers to social acceptance. Renewable and Sustainable Energy Reviews, 82, 2618-2628.
[93] Bax, V., van de Lageweg, W. I., van den Berg, B., Hoosemans, R., & Terpstra, T. (2022). Will it float? Exploring the social feasibility of floating solar energy infrastructure in the Netherlands. Energy Research & Social Science, 89, 102569.
[94] Siitonen, P., Honkapuro, S., Annala, S., & Wolff, A. (2022). Customer Perspectives on Demand Response in Europe: A systematic review and thematic synthesis. Sustainability: Science, Practice and Policy, 19(1).
[95] Centre for Net Zero (2023). The Impact of Demand Response on Energy Consumption and Economic Welfare.
[96] Design Kit by IDEO.org. Journey Map.
[97] Customer-led network revolution (2014). Social Science Report.
[98] de Leon Barido, D. P., Suffian, S., Kammen, D. M., & Callaway, D. (2018). Opportunities for behavioral energy efficiency and flexible demand in data-limited low-carbon resource constrained environments. Applied energy, 228, 512-523.
[99] Iliopoulos, N., Onuki, M., & Esteban, M. (2021). Shedding light on the factors that influence residential demand response in Japan. Energies, 14(10), 2795.
[100] O'Donoghue, T., & Rabin, M. (2015). Present bias: Lessons learned and to be learned. American Economic Review, 105(5), 273-279.
[101] List, J. A., Metcalfe, R. D., Price, M. K., & Rundhammer, F. (2017). Harnessing policy complementarities to conserve energy: Evidence from a natural field experiment (No. w23355). National Bureau of Economic Research.
[102] National Grid (2023). EQUINOX Trial One Customer Experience.
[103] Crawley, J., Johnson, C., Calver, P., & Fell, M. (2021). Demand response beyond the numbers: A critical reappraisal of flexibility in two United Kingdom field trials. Energy Research & Social Science, 75, 102032.
[104] Iliopoulos, N., Onuki, M., & Esteban, M. (2021). Shedding light on the factors that influence residential demand response in Japan. Energies, 14(10), 2795.
[105] Siitonen, P., Honkapuro, S., Annala, S., & Wolff, A. (2023). Customer perspectives on demand response in Europe: a systematic review and thematic synthesis. Sustainability: Science, Practice and Policy, 19(1), 2154986.
[106] Ellabban, O., & Abu-Rub, H. (2016). Smart grid customers' acceptance and engagement: An overview. Renewable and Sustainable Energy Reviews, 65, 1285-1298.
[107] Sintov, N. D., & Schultz, P. W. (2015). Unlocking the potential of smart grid technologies with behavioral science. Frontiers in psychology, 6, 410.
[108] EcoGrid EU (2016). A Prototype for European Smart Grids, Deliverable D6.7.
[109] Apesteguía, M., Virto, I., Orcaray, L., Bescansa, P., Enrique, A., Imaz, M. J., & Karlen, D. L. (2017). Tillage effects on soil quality after three years of irrigation in northern Spain. Sustainability, 9(8), 1476.
[110] Nesta & Centre for the Net Zero (2023). Automating heat pump flexibility: Results from a pilot.
[111] Hughes, J. (2023, August 3). Integrating heat pumps into the electricity system: Tennet and viessmann on the leading edge. LCP Delta.
[112] Lazowski, B., Parker, P., & Rowlands, I. H. (2018). Towards a smart and sustainable residential energy culture: Assessing participant feedback from a long-term smart grid pilot project. Energy, Sustainability and Society, 8(1), 1-21.
[113] The Policy Institute (2019). Misperceptions about climate change and the natural environment.

[114] Attari, S. Z., DeKay, M. L., Davidson, C. I., & Bruine de Bruin, W. (2010). Public perceptions of energy consumption and savings. Proceedings of the National Academy of sciences, 107(37), 16054-16059.
[115] Nesta & Centre for the Net Zero (2023). Automating heat pump flexibility: Results from a pilot.
[116] Centre for Net Zero (2023). The Impact of Demand Response on Energy Consumption and Economic Welfare.
[117] Centre for Net Zero (2023). The Impact of Demand Response on Energy Consumption and Economic Welfare.
[118] Bastida, L., Cohen, J. J., Kollmann, A., Moya, A., & Reichl, J. (2019). Exploring the role of ICT on household behavioural energy efficiency to mitigate global warming. Renewable and Sustainable Energy Reviews, 103, 455-462.
[119] Ozarisoy, B., & Altan, H. (2017). Adoption of energy design strategies for retrofitting mass housing estates in Northern Cyprus. Sustainability, 9(8), 1477.
[120] 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, 111221.
[121] Maréchal, K., & Holzemer, L. (2015). Getting a (sustainable) grip on energy consumption: The importance of household dynamics and 'habitual practices'. Energy research & social science, 10, 228-239.
[122] Customer-led network revolution (2014). Progress Report 7.
[123] National Grid (2023). EQUINOX Trial One Customer Experience.
[124] Palm, A. (2017). Peer effects in residential solar photovoltaics adoption—A mixed methods study of Swedish users. Energy Research & Social Science, 26, 1-10.
[125] Bach, L., Hopkins, D., & Stephenson, J. (2020). Solar electricity cultures: Household adoption dynamics and energy policy in Switzerland. Energy Research & Social Science, 63, 101395.
[126] Skjølsvold, T. M., Henriksen, I. M., & Ryghaug, M. (2022). Beyond the car: How electric vehicles may enable new forms of material politics at the intersection of the Smart Grid and Smart City. Urban Geography, 1–18.
[127] Rapid Transition Alliance (2021). The dash away from gas: How the Netherlands kicked a big fossil fuel habit.
[128] Gumz, J., & Fettermann, D. C. (2022). What improves smart meters' implementation? A statistical meta-analysis on smart meters' acceptance. Smart and Sustainable Built Environment, 11(4), 1116-1136.
[129] Axsen, J., & Sovacool, B. K. (2019). The roles of users in electric, shared and automated mobility transitions. Transportation Research Part D: Transport and Environment, 71, 1-21.
[130] Dalén, A., & Krämer, J. (2017). Towards a user-centered feedback design for smart meter interfaces to support efficient energy-use choices. Business & Information Systems Engineering, 59(5), 361–373.
[131] Singh, V., Singh, V., & Vaibhav, S. (2020). A review and simple meta-analysis of factors influencing adoption of electric vehicles. Transportation Research Part D: Transport and Environment, 86, 102436.
[132] Bach, L., Hopkins, D., & Stephenson, J. (2020). Solar electricity cultures: Household adoption dynamics and energy policy in Switzerland. Energy Research & Social Science, 63, 101395.
[133] Centre for Net Zero (2023). The Smart Building Rating: A Digital Tool to scale demand flexibility.
[134] Klein, M., & Deissenroth, M. (2017). When do households invest in solar photovoltaics? an application of prospect theory. Energy Policy, 109, 270–278.
[135] Wang, S., Wang, J., Li, J., Wang, J., & Liang, L. (2018). Policy implications for promoting the adoption of electric vehicles: Do consumer's knowledge, perceived risk and financial incentive policy matter?. Transportation Research Part A: Policy and Practice, 117, 58-69.
[136] Singh, V., Singh, V., & Vaibhav, S. (2020). A review and simple meta-analysis of factors influencing adoption of electric vehicles. Transportation Research Part D: Transport and Environment, 86, 102436.
[137] Sissons, A. (2023). Do heat pumps work in rural areas? Nesta.
[138] Corradi, C., Sica, E., & Morone, P. (2023). What drives electric vehicle adoption? Insights from a systematic review on European transport actors and behaviours. Energy Research & Social Science, 95, 102908.
[139] Van der Linden, S., Roozenbeek, J., Maertens, R., Basol, M., Kácha, O., Rathje, S., & Traberg, C. S. (2021). How can psychological science help counter the spread of fake news?. The Spanish Journal of Psychology, 24, e25.
[140] Energy Systems Catapult. Electrification of heat UK demonstration project.
[141] Peñaloza, D., Mata, É., Fransson, N., Fridén, H., Samperio, Á., Quijano, A., & Cuneo, A. (2022). Social and market acceptance of photovoltaic panels and heat pumps in Europe: A literature review and survey. Renewable and Sustainable Energy Reviews, 155, 111867.
[142] Wang, S., Wang, J., Li, J., Wang, J., & Liang, L. (2018). Policy implications for promoting the adoption of electric vehicles: Do consumer's knowledge, perceived risk and financial incentive policy matter?. Transportation Research Part A: Policy and Practice, 117, 58-69.
[143] OVO Energy. OVO vehicle-to-grid trial: Building a better grid for everyone.
[144] OVO Energy | Vehicle-to-grid. (2019). YouTube.
[145] Alipour, M., Salim, H., Stewart, R. A., & Sahin, O. (2020). Predictors, taxonomy of predictors, and correlations of predictors with the decision behaviour of residential solar photovoltaics adoption: A review. Renewable and Sustainable Energy Reviews, 123, 109749.
[146] Peñaloza, D., Mata, É., Fransson, N., Fridén, H., Samperio, Á., Quijano, A., & Cuneo, A. (2022). Social and market acceptance of photovoltaic panels and heat pumps in Europe: A literature review and survey. Renewable and Sustainable Energy Reviews, 155, 111867.
[147] Climate Assembly UK (2020). The path to net zero.
[148] Selvakkumaran, S., & Ahlgren, E. O. (2019). Determining the factors of household energy transitions: A multi-domain study. Technology in Society, 57, 54-75.
[149] EcoGrid EU.