

Are we getting the best out of Smart Home Technologies? The role of usability.

Energy Systems Catapult on behalf of Users TCP and 4E EDNA



Who are the Energy Systems Catapult?



Mission: Unleash innovation and open new markets to capture the clean growth opportunity

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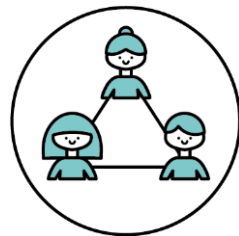
Innovation experts



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Bridge the gap between stakeholders in the sector



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Research



Trials



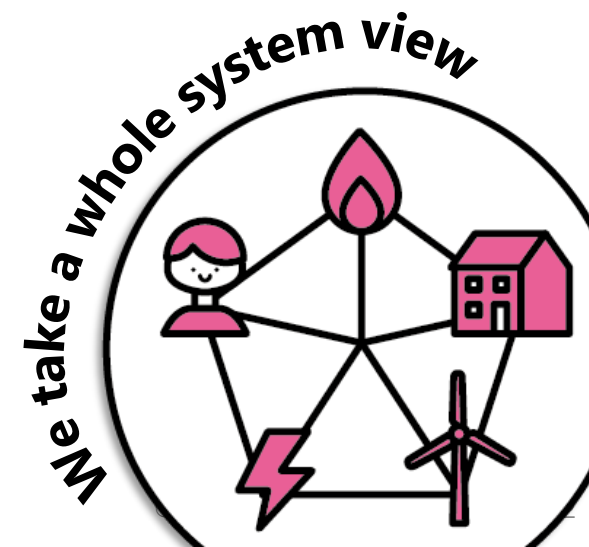
Systems engineering

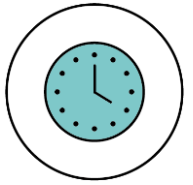


Digital



Modelling and simulation





Overview

Smart Home Technologies are believed to have potential to support reduced carbon emissions. Their contribution can be recognised through promoting efficient operation, demand flexibility and status reporting. **This potential however is not yet being realised, particularly amongst domestic consumers.**

The Energy Systems Catapult were asked to support the Users TCP and 4E EDNA by conducting an evidence review that looks to understand the extent to which poor usability, at set up and operation, is contributing to this issue.

The approach consisted of interviewing a range of industry experts to collate their opinions on the matter, as well as seeking out any relevant evidence publicised on the subject. Finally, look to other sectors for examples of how best to bring emerging technologies to market.





Overview

There are *many* different usability issues that prevent smart devices performing efficiently in the home

In particular, the evidence points to issues with the following

- The benefits of Smart Home Technologies are being poorly or inaccurately communicated. This causes distrust and ultimately means users are reluctant to engage.
- Smart Home Technologies fail to cater to user's complex, diverse and dynamic needs.
- The onboarding experience often fails to prepare users to operate their Smart Home Technologies. Errors made during installation further inhibit the ability to engage, or the accuracy (and therefore value) of the feedback provided.
- Automation holds significant promise, but users don't like to feel like they are not in control. When it is deployed poorly it undermines user trust and they intervene preventing optimal operation.





Overview

However there is a notable lack of understanding available in some important areas

- Uptake of Smart Home Technologies is relatively low at present meaning opportunities to learn are limited. This is exacerbated by private industries unwillingness to publicise errors that have been made when bringing new products to market.
- Experts have suggested that improving usability is *not* an immediate priority for the sector at present. For other sectors, better usability took time to evolve. It can take a while for good usability to emerge in markets
- The climate emergency means the sector cannot afford to wait for better usability to evolve over time. It will have to take steps to route out and address issues as well as ensure the required infrastructure is in place.
- Doing this now will increase the likelihood that Smart Home Technologies will be able to contribute to reducing carbon emissions in a meaningful in time for when ownership has become more widespread.





Approach

We interviewed 12 industry experts, across 10 organisations within 4 different countries

- Flexible energy platform providers
- Network aggregators
- Infrastructure/distribution experts
- Energy suppliers
- Installers (heating and cooling technologies)
- Product/business strategy professionals
- Innovators and start ups
- Consumer/policy groups
- System engineers
- User interface and standards experts

The experts interviewed were based in the UK, USA, Germany and Belgium





Approach

We worked with Users TCP Group and 4E EDNA to define the criteria for evidence sources to be included within the review. The experts interviewed were also asked to indicate any publicly available evidence they knew of.

In addition to being of sufficient quality and relatively recent, the sources had to meet the following conditions to be included.

- **The evidence source must focus on a relevant technology.** This included (but is not limited to):
 - Smart thermostats,
 - Smart appliances
 - Flexible energy services
 - Domestic batteries
 - Demand side response/flexibility
 - Heat pumps
 - Electric vehicle charging
- **The context of the publication must have some focus on the end user experience.** For example, usability reviews, ergonomic reports, consumer trials. Note that studies based on consumer perception (but with no experience of use) are excluded.



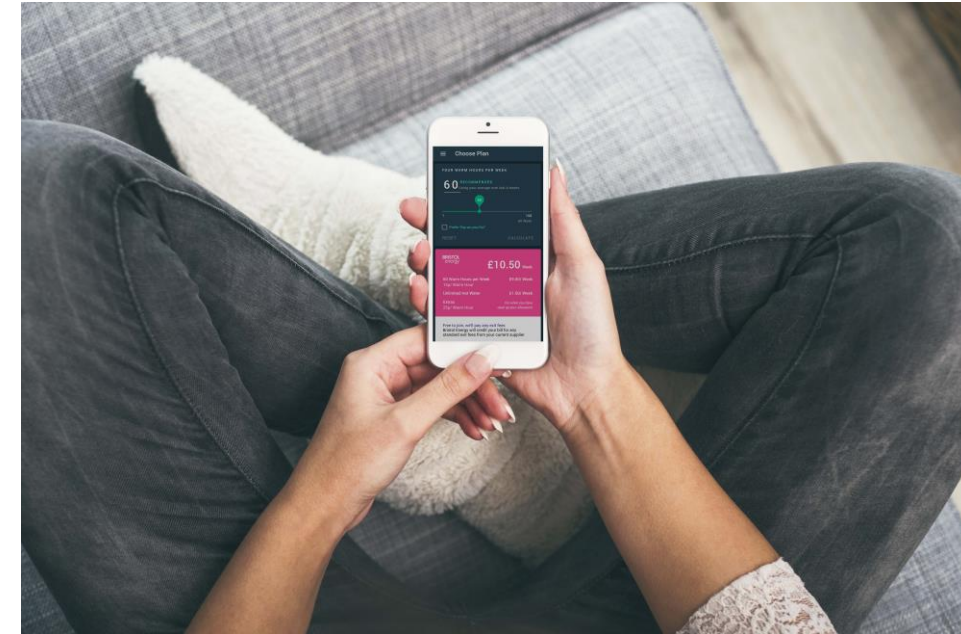


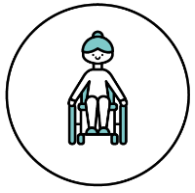
Miscommunicating the benefits

Smart Home Technologies are primarily marketed as a way to help reduce costs

The evidence however suggests the financial benefits are often negligible and only applicable to certain types of user. User suitability however is not established prior to purchase.

- When users realise the technology cannot deliver the benefits promised, they become frustrated.
- Feeling let down, they engage with the technology less often. This means opportunities to optimise based on feedback are lost. Quick and accurate feedback from smart technologies is said to be *crucial* to provoking user action and engagement.
- Furthermore, this poor experience means users are less receptive to participating in related programmes such as flexible energy delivery.



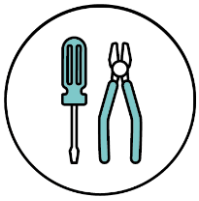


Different users have different needs

User needs are complicated and diverse, but smart systems tend not to account for this

- User age, culture, attitude, climate, lifestyle, interest in technology, routine, gender, homeowner status, economic status, definition of comfort, typical driving range, trust in data sharing, and various psychological factors (e.g. perception, attention and retention) are all said to contribute.
- Furthermore, user needs are dynamic and change over time.
- These factors influence how users engage with smart technologies, the support they require, the outcomes they seek to achieve and ultimately how the success of the smart technology is measured.
- Smart Home Technologies however generally do not seek to cater to different user types by offering different user experiences. This means the needs of users are often not met and the products therefore often fail to meet expectations which can damage engagement and reputation.





Issues with installation

Mis-steps during the installation process can mean users are unable to get the best from their Smart Home Technologies

- Installations are often complicated. This can cause users to feel intimidated and become reluctant to engage once installation is complete.
- Household conditions are variable, but this isn't always considered during product development. Factors such as the thermal efficiency of the building, Wi-Fi range and reliability, and the layout of the property can prevent optimal installation.
- Aesthetical concerns can result in vital components being positioned in suboptimal locations. This can mean that feedback provided to the user is easily missed and/or readings are less reliable.
- In some cases Smart Home Technologies are simply installed poorly. This can include positioning technologies where they are difficult to interact with, or can not easily be seen.





Sub-optimal operation

Often, users are not adequately prepared (or able) to set up their new Smart Home Technologies.

- Poor user interfaces can mean that users feel overwhelmed, or struggle to find the options they want if the process doesn't follow what they perceive to be a logical flow
- As a consequence of feeling overwhelmed by the controls, many users elect to stick to the basic options available and are hesitant to make any changes, in case they cannot easily revert to their previous settings
- The variable needs and preferences of different occupants within the same household can cause issues when choosing how to set up the device in the first instance
- In some cases, poor user understanding can cause them to prevent the system operating optimally e.g. turning the device off completely rather than leaving it in standby mode.





The automation paradox

Users don't like to feel like they're not in control, yet desire technologies to be less demanding of their time

- Automation is expected to play a key role in the efficient operation of Smart Home Technologies. If this is poorly deployed however it can result in a poor experience causing users to reject the technology.
- Perceived lack of control causes users to intervene if they don't understand what the system is doing or why it is doing it. This prevents the system running optimally.
- Some automated actions can be perceived as wasteful or suboptimal causing distrust or for users to override e.g. preheating. Furthermore, some automation *can* be more wasteful e.g. automated lighting may switch off after a period of inactivity, a manual switch can be turned off the moment a room is vacated.
- User behaviour isn't easily rationalised however, automation can only do so much. User preference may also vary based on the circumstances or contradict what is best for efficient operation. This makes it very difficult for automation to make the 'correct' decision.

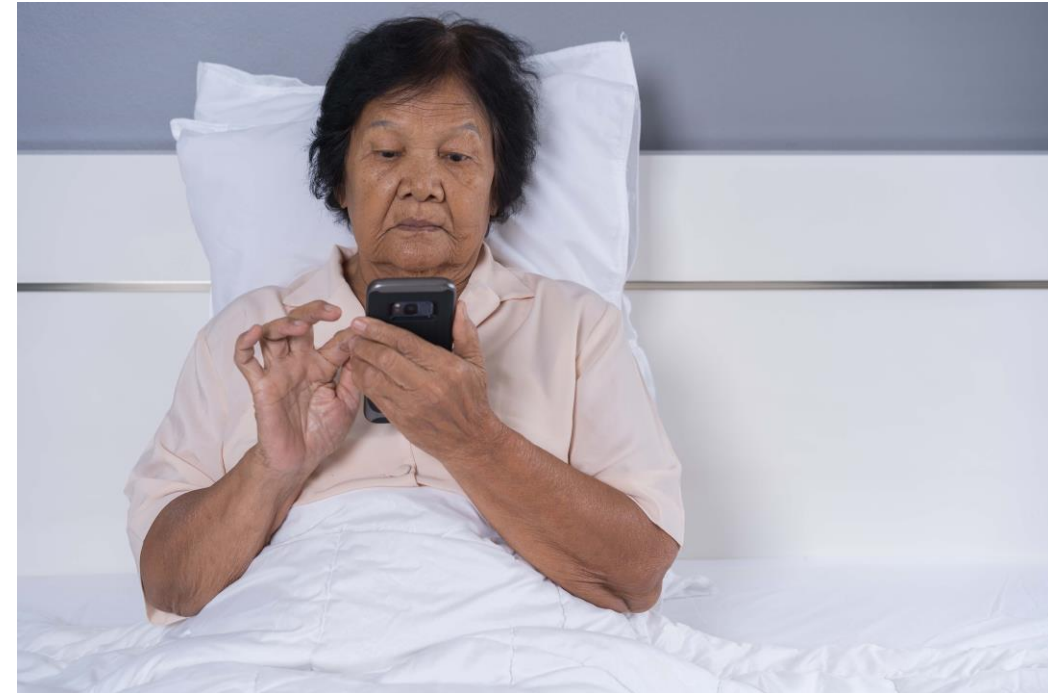




Lessons to learn from

There are many good practices that can be implemented to address the issues that are known

- Be wary of promoting Smart Home Technologies solely as a means to reduce energy bills. Seek to promote a broader range of benefits e.g. greater comfort and convenience.
- Aim to establish if a user is suitable prior to installation. Where they are sub-optimal further support should be offered to help them configure their system and maximise any opportunity to see some benefit.
- Organisations need to be better integrated to ensure consistency and collaboration. Finding a way for commercial rivals to share any lessons learned would also enable improvements to be made faster.





Lessons to learn from

- Products should be intuitive wherever possible. There may be a need for a sector wide discussion to boost consumer awareness of the potential of Smart Home Technologies to help reduce carbon emissions. Business will need to find a way to help users understand how to set up and use their products so they can experience the benefits.
- Seek to reap the benefits of offering a bespoke experience e.g. multiple user profiles. Allowing users to tailor the experience to suit their own diverse and dynamic needs will improve experience and boost engagement.
- Implement standards into user interface design to help support better understanding and operation. Include command prompts, cues and the ability to undo actions to help users with navigation. This will also give users the confidence to experiment with changes
- User interface design should facilitate the adoption of *convenient* behaviours. The advice provided should not be overly demanding of the user. Both cognitive and practical workload should be minimised





Lessons to learn from

Seemingly what concerns users is not that products are automated, but that automation could prevent them from achieving the outcome they desire. The user wants to feel in control and be in control. Automation can still decide how to deliver the outcome they have requested but the user wants the ability to override this action if they disagree.

- Increased automation/more intelligent control *should* be deployed to maximise the energy saved; however, users should retain the option to take control. Automation should seek to augment user engagement with Smart Home Technologies, rather than taking full control
- Seek to understand what users want to retain control of (and when) and what they would prefer the Smart Home Technology controls on their behalf. This will be key to gaining their acceptance of automation.
- System behaviours should be made transparent to the user to build their trust in the technology.
- In some cases, there should be a balance between automation and user control. For example, a flashing light may prompt the user to turn a device off, but if this has not happened after a certain period the system can deactivate itself remotely.



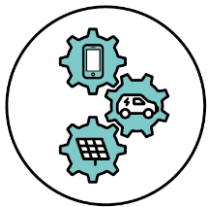


But what about the issues that are not currently known?

In the expert interviews it was identified that improving usability was *not* a priority for the sector at present.

- Experts agree that offering a good user experience is important, but feel there is too much uncertainty to invest at present. They felt there needs to be assurances that certain infrastructure will be in place, and in the longevity of emerging technologies before investing.
- The market rewards are not in place. Current market arrangements don't offer significant reward for those who participate in flexible schemes. It is more sensible to invest in the commercial sector, over the domestic one.
- There is no business case to cooperate and conform. If systems are standardised it becomes more difficult to stand out from competitors. Similarly, supporting interoperability offers risk but no reward.
- Some feel the situation will resolve itself overtime. Those who offer their customers a better experience will naturally win a bigger share of the market. Eventually businesses with largest market shares will agree standards between them, however could take many years to occur.





The issue of interoperability

The issue of interoperability was rarely discussed in the reviewed evidence

- If Smart Home Technologies cannot work seamlessly with one and other, this will mean a poor user experience and suboptimal operation. For this reason offering interoperability is believed to be of critical importance.
- Evidence of issues with interoperability however were rarely discussed in the reviewed evidence. This was because:
 - Academic studies run trials in laboratory settings or install the Smart Home Technology on behalf of their subjects. This means users rarely encounter the issue.
 - Experts from private industry indicate there is no value in promoting the mistakes made by a commercial organisation. This is because it can enable business rivals to benefit or be reputationally damaging – so these learnings are not publicised.
- But uptake of Smart Home Technologies is relatively low at present. This is expected to change in the coming years. As uptake increases, it is likely issues owing to lack of interoperability will become better known





Learning from other sectors

Studies seeking to understand the process of successful diffusion of technology innovations have highlighted the importance of taking a whole system approach

- This includes considering the non-technological (human) parts of the system. This is because changes in one part of the system can impact other parts of the system in complex and dynamic ways.
- Integration of technology into existing systems requires both technical adjustments, as well as organisational and behavioural adjustments. If policymakers and regulators can design and manage a system which support these needs, then the energy sector could see a similar degree of success to other sectors that have taken this approach e.g. telecoms
- Failure to consider all aspects of the system can lead to unexpected consequences across the system and failure of the technology to be accepted and used.





Learning from other sectors

Several factors have been identified as influencing the likelihood of technology acceptance.

- These include cost, social influences, technology self-efficacy, system design features, perceived usefulness and perceived ease of use of the technology.
- Perceived usefulness and perceived ease of use/usability however have been consistently shown across a variety of technologies to be important predictors of eventual technology acceptance and use.
 - Ease of use includes the extent to which the user experiences it as being efficient, effective and satisfying as well as a belief that using the system will be free from effort.
 - Perceived usefulness is a measure of how much the user believes that using the system will help them or improve their outcomes. Many things influence perceived usefulness, including the extent to which it can be integrated into existing technologies and practices





Learning from other sectors

When the first web-enabled and camera phones came to market people were excited.

- Poor usability and lack of interoperability however impeded widescale adoption. This included:
 - Operating systems were hard to navigate
 - Handsets were ugly and cumbersome, making them difficult to control
 - Lack of supporting infrastructure, such as the availability of mobile-friendly websites and supported email clients reduced their usefulness
 - The lack of a critical mass of users, limited the number of others to send emails or photos to, which also reduced their initial usefulness.
- Widescale adoption of web-enabled phones only occurred when both usability and infrastructure issues were resolved. This process also revealed new and unexpected uses as people appropriated the technology into their lives.





Learning from other sectors

This evidence demonstrates the importance of studying and involving users to enable faster innovation.

- In complex systems such as the smart energy system is impossible to understand all use implications before deployment since they emerge as a result of the process of innovation and use.
- Early user research can help discover the emerging requirements and uncover unanticipated value. Identifying and promoting features that offer value to users could be key in increasing early adoption.
- There is a need for the development and uptake of smart energy technologies and services, to make the energy system work more efficiently. Uptake of these technologies and services however is unlikely, if people perceive very little benefit for the associated costs.
- To achieve this not only requires technology innovation to provide solutions to infrastructure and technical problems, but also useful and usable solutions that can add real value to users lives.





What might help?

There are a number of steps the energy sector can take to route out usability issues and ensure the infrastructure is in place to prepare for wide scale adoption.

- **Encourage business to create usable, holistic solutions.** For example, technology-neutral policies can force business to find ways to combine components into simple solutions e.g. ban on sale of petrol/diesel vehicles
- **Develop shared learning infrastructures to help speed up understanding of usability issues in the energy sector.** Given the identified resistance for privately owned organisations to share their knowledge with commercial rivals, this should be publicly funded.
- **Governments should design markets that flow the value of increased flexibility to the right place in the system, including the demand side.** How best to do this could come from the learning environments previously discussed. This makes sure that business models stack up, so innovators can justify the cost of investing in good experiences.





What might help?

There are a number of steps the energy sector can take to route out usability issues and ensure the infrastructure is in place to prepare for wide scale adoption.

- **Allow innovation investments to improve user experiences.** Usability testing can be expensive, and clearly the sector isn't willing to prioritise it at present. Innovation funding has historically helped to de-risk the development of technology components. This could be expanded to help fund improved user experiences
- **Help private industry work together.** In exchange for all this public support, strongly encourage industry to voluntarily specify interoperability standards, with the potential for governments to set them if they fail to do so by a certain point in time. Encourage them to use living labs to define them and prove they can work. Embody in them lessons they learn about how to design and deliver smart products/services consumers will buy so they can deliver the flexibility the system needs.
- **Make sure these innovation work for all sorts of consumers.** Ultimately, taking these steps could help the sector reach a place where it is easy and enjoyable for all sorts of people to set up and operate smart home technologies to get what they want.





Summary

Take steps to address issues we know exist, in particular:

- Consider how Smart Home Technologies are promoted. Promote a range of benefits, and ensure what is promised can be delivered.
- Make sure consumers are supported in the onboarding experience so they know how to operate their new system and can get what they want.
- Enable users to tailor their experience to cater to diverse and dynamic needs
- Deploy automation but ensure the actions are transparent to boost trust and that it works to *support* users, rather than taking full control

Seek to uncover and address predictable issues that are yet to emerge

- Encourage and enable all those in the sector to work together, including industry
- Design markets to flow the value of more flexibility to the right place in the system
- Invest in improving innovation and develop shared learning infrastructures



Thank you

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