Report

Energy Village - Technology adoption and Consumer Behaviour

Published: April 2025

Project: Energy Village - Technology adoption and Consumer Behaviour

Project Partners: National Energy Action, Newcastle University, NGN, Energy Innovation Centre

Funder: Ofgem Network Innovation Allowance / Network Innovation Allowance (NIA)

Report

Energy Village –
Technology adoption and Consumer Behaviour

This work forms part of the Energy Village – Technology Adoption and Consumer Behaviour project. The project has been delivered through collaboration between National Energy Action, Newcastle University, NGN, and the Energy Innovation Centre, with funding provided by Northern Gas Networks.

Newcastle upon Tyne, April 2025

This project is funded by Ofgem Network Innovation Allowance / Network Innovation Allowance (NIA). This document is the report: “Energy Village - Technology adoption and Consumer Behaviour”, published by National Energy Action (NEA), Newcastle University, Northern Gas Networks and Northern Powergrid.

Contents

Executive Summary

To achieve net-zero targets by 2050, energy efficiency has to be seen as a cornerstone of any transition to a decarbonised energy system. Efficiency measures support the drive to lower costs of transition by minimising the amount of energy required, reducing stress on the network, minimising customer bills and supporting more rapid adoption across the country. It is also necessary to support the UK in reducing energy consumption across its existing housing stock and to decarbonise networks.

Technologies that can help to improve the energy efficiency of a home or reduce the amount of gas or electricity that is necessary for daily activities can play an important role in achieving this goal. This depends on a greater understanding of future patterns of energy consumption that will be affected by the advent of new energy related technologies and the degree of their assimilation into new and existing UK housing stock. This large collaborative research project aimed to assess how innovative technologies performed in a range of different house types and how they were received by members of the public.

During the first stage of the project, a purpose-built test-site of nine demonstrator houses was constructed at the heart of the NGN Net Zero Research Village (NeRV) at Low Thornley in the northeast of England. This is the UK's first combined whole-systems research, development, and demonstration facility that integrates gas, electricity, and water systems. There are five types of property, each built to original building standards and employing materials commonly used at that time, to fully reflect the building fabric and challenges that exist with buildings of each era. The property styles have been designed to be representative of UK housing stock from 1910 through to the modern day. Each house was equipped with sensors to monitor metrics such as temperature, humidity, gas, water, and electricity consumption, with approximately 500 sensors across the nine houses sending data back to a platform that can be accessed by the project partners.

Stage 2 involved the commission and installation of a set of diverse energy-efficiency related technologies. The EIC "Energy Efficiency Challenge" invited vendors to showcase new and innovative ideas for inclusion within the project. Applications were shortlisted and then selected by members of the research team at National Energy Action (NEA) and Newcastle University, before their installation on site.

During this stage the energy efficiency solutions were evaluated in different housing types through a structured process based on controlled experimental conditions and subsequent data analysis. Assessment measured energy consumption, temperature and humidity, air tightness and thermal efficiency changes before and after installation of the technology under consideration, with data collected over set periods of time. Historical weather data was taken into account and cost calculations were performed using standard electricity and gas rates at the time of the study. Tests on three out of the seven technologies produced conclusive results (Appendices 1a, 1b, 1c). Tests for the other technologies were inconclusive for different reasons and the results could not be published. The challenges faced (e.g. limited testing and evaluation time due to construction delays and data integrity; or the absence of real-world occupancy factors in the houses (e.g., moisture, ventilation)) still offered valuable insights for future testing and experimentation.

Stage 3 featured two projects focused on the appeal of the technologies to end-users and potential factors that affect adoption, while two pieces of supplementary work extended this by considering user engagement with new technologies.

More specifically, the first project (Appendix 2) made use of the Futures Close site, inviting members of the public to experience the technologies that had been installed and spend time discussing their personal circumstances and feedback with the research team. The sample included people that can be considered vulnerable and non-vulnerable in an energy context. The research indicated that participants were initially concerned with practical considerations such as cost, return on investment and disruption, but that perceptions of the look and feel of the products had a greater bearing on appeal once the participants had experienced them in situ. Underpinning both sets of factors, however, uncertainty about new, unfamiliar and untested products remained a concern throughout the sessions, accentuating the challenges associated with risk, cost and disruption and, for most people, overriding the positive impact of the engagement process. The influence of the latter set of factors was more pronounced in the context of smart technologies. Participants categorised as vulnerable emphasised affordability, practical solutions for heat retention, and the importance of trust in products and companies, highlighting their heightened financial- and health-related concerns. Those categorised as non-vulnerable, though still conscious of costs and efficiency, placed greater weight on aesthetics and the longer-term convenience. A follow-up survey indicated increased awareness of new technology and a greater interest in ways to improve energy efficiency but any actions following the site visit were modest compared to the range of technologies on show at Futures Close.

The second project (Appendix 3) built upon this work by conducting a large-scale survey to test the relevance of the adoption factors identified in the exploratory work on site. It also considered smart technologies more broadly, assessing perceptions of their ability to perform various tasks in the home and the implications this has for autonomy, life satisfaction, and technology satisfaction. Both areas were further analysed to consider the relevance of financial, knowledge- and skill-related, and health-related constraints. The results indicated that intention to adopt depends on several factors: the perception that the technology provides sustainability benefits, the belief that it is worth the investment, the ability to observe its use by others, the minimal effort required for operation, its usefulness in optimising energy consumption, and its convenience. However, durability was not found to be a significant predictor. In addition, perceptions of smart technology fit to a task increase when home dwellers view the technology as a sustainable solution, a worthwhile investment, durable, useful for home-related tasks, beneficial to health, convenient, and easy to use. Further analysis indicated that vulnerabilities related to finance, knowledge and skills and health had varying impacts on the appeal and assessment of technologies.

The third piece of work (Appendix 4) focused on consumer experience and how users respond to and act upon energy consumption feedback. Through a qualitative study with 21 university students in the northeast of England, the study focused on how feedback as to the energy sources used and longitudinal data affects intentions for future behavioural change. Given that the students lived in accommodation in which energy bills were already included in their weekly rent and had no further incentive to save energy, it was possible to study potential behaviour changes in the absence of cost as a motivating factor. The findings suggested that, although sustainability was a concern for the students, they would be much more likely to adopt the technology when cost was once again a factor in their decision making. Moreover, the perceived need for energy use at certain levels and particular times of the day could not be challenged when sustainability was the only concern. Finally, the effectiveness of the feedback mechanism under any circumstances is contingent on a better understanding of the information that is being relayed to the user.

The fourth study (Appendix 5), focused on benefits realisation. Existing studies predominantly focus on the technical aspects of smart home systems, such as energy-saving capabilities and operational efficiencies. However, they seldom take into account user-centred outcomes or perceptions. Consequently, there is limited empirical evidence on whether smart home performance aligns with users' expectations regarding sustainability benefits. While users may anticipate substantial gains in sustainability, convenience and security, it remains unclear whether these expectations are consistently met. To this end, in order to understand whether prior expectation regarding the sustainability of smart home technology is confirmed, this study adopted a robust framework for examining the interplay between pre-adoption expectations and post-adoption experiences. This approach made it possible to establish that there is indeed a (mis)match in expectations and technology performance at a higher level.

The fourth and final stage of the project involved disseminating our findings to stakeholders. This was achieved in a number of ways, e.g. through a project dissemination event, practitioner presentations, academic conferences, journal publications and by making the reports available publicly.

Overall, the project offered a unique opportunity to approach technology adoption and user engagement, opening new avenues for research and practice. The Futures Close project allowed participants to learn about a range of new energy related technologies and experience them in the context of real life. Visiting the demonstrator site exposed participants to technologies that they were unfamiliar with, allowed them to see the technologies in operation and experience the look, feel and, in some cases, sound of the different technologies in a home environment. These three factors were found to be important aspects of successful customer engagement and can help with decision making. However, there were some limitations to the in-person visits, with logistical issues related to travel, cost, time, health and safety and the capacity of the site. One option to address these limitations is to move the experience online. Research suggests that greater exposure to smart home information, both online and offline, could enhance consumer willingness to engage with these technologies. An online platform could potentially address some of the limitations associated with the site visit and incorporate new features to create an interactive experience for larger numbers of people. This would build upon the valuable work carried out at Futures Close and open up new avenues for social research in this area.

Project Partners

This work forms part of the Energy Village – Technology Adoption and Consumer Behaviour project. The project has been delivered through collaboration between National Energy Action, Newcastle University, NGN, and the Energy Innovation Centre, with funding provided by Northern Gas Networks.

Energy Innovation Centre

The Energy Innovation Centre is a not-for-profit dedicated to supporting innovators throughout the innovation process, in gas, electricity transmission and distribution. In partnership with nine of the UK's energy networks, we strive to accelerate innovation to support the transition to a net zero power system by 2030.

Web: https://www.ukeic.com **||** **Team**: Jack Hewitt

National Energy Action

National Energy Action (NEA) is the national fuel poverty and energy efficiency charity. We've worked across England, Wales, and Northern Ireland for over 40 years, to ensure that everyone in the UK can afford to live in a warm, safe and healthy home. We work together with frontline practitioners, companies, regulators and the government for customers in vulnerable circumstances to make positive changes.

Web: https://www.nea.org.uk **||** **Team**: Helen Stockton, Michael Hamer, Jenny Dimas, Joanna Curtis, Niamh Storey

Newcastle University

Newcastle University's vision is to be a world-leading university, advancing knowledge, providing creative solutions, and solving global problems. We are part of the Russell Group of research-intensive universities where innovative research feeds directly into your teaching, creating world-class learning experiences. We push the boundaries of knowledge through innovation and creativity. Ranked as a Global top 130 University, our research and teaching are world leading.

Web: https://www.ncl.ac.uk **||** **Team**: Savvas Papagiannidis, Jo Swaffield, Dinara Davlembayeva; Davit Marikyan, Diana Gregory-Smith

Northern Gas Networks

Our vision is a fairer, greener future for the North of England. We deliver gas to 2.9 million homes and businesses, transporting gas through our vast network of underground pipes. We cover an area that stretches from northern Cumbria to the Northeast and much of Yorkshire.

Web: https://www.northerngasnetworks.co.uk **||** **Team**: David Lynch, Nathan Ekanem

Introduction

The focus on energy efficiency should be seen as the cornerstone of any transition to a decarbonised energy system, necessary to meet the current UK carbon budgets. Efficiency measures support the drive to lower the costs of transition by minimising the amount of energy required which reduces stress on the network, minimises customer bills and supports more rapid adoption across the country.

As we accelerate towards a decarbonised network, we need to better understand consumer decision making and the consumption patterns that might be seen with the advent of new efficiency measures being introduced. This evidence is influenced by several factors, such as the levels of energy efficiency technology adoption, the levels of energy efficiency achieved and whether the promised benefits are realised and any negative incentives / blockers that inhibit change.

There is a need to unlock technologies which will reduce the amounts of energy required to provide adequate levels of comfort, and to identify how these might be widely adopted as part of a long-term customer led decarbonisation pathway. These technologies have the potential to change the accepted demand patterns for our industry, therefore impacting long-term infrastructure and household investment strategies. On one hand, benchmarking technologies to test whether they deliver the performance expected is important in establishing their relative advantage compared to existing options. On the other, this is not enough and understanding the underlying factors that can encourage, or hinder, technology adoption can help positively influence consumer behaviour.

This not a trivial challenge. In order to meet the challenge of achieving net-zero by 2050, there is a need for complementary material change across all energy networks and all households. The UK needs to decarbonise an average of 20,000 properties each week for the next 20 to 25 years to meet its goal. This includes work to improve the energy and water efficiency of households, which will look at the technologies and appliances, as well as the building fabric itself. Such a large-scale implementation requires influencing household behaviours. Even small changes at the household level when it comes to technology adoption and consumer behaviour can result in a significant impact on energy suppliers and network operators when aggregated.

Convincing households that local change matters should be a priority. Still, for many households, there is an even greater challenge. Millions of households across the UK struggle with their finances, living in fuel poverty and/or water poverty. Many households are living on negative budgets, meaning their income does not cover their essential outgoings each month. These households are more likely to ration their energy and water use (if metered), and so their primary focus is on keeping warm, on staying healthy, and less on reducing the amount of carbon they use. For such households, it is imperative that their needs and special circumstances are taken into consideration and that appropriate strategies are put in place to support them.

Vulnerability does not only refer to finances and is complex and intersectional. As such, many households face multiple challenges, including struggles with their physical and mental health. These challenges can limit their ability to change their behaviours, to understand both the need for change and the change itself. Such households will all require additional, tailored support with any substantial transition, especially those which directly impact their home life.

In light of the above, what is required is a more holistic approach to how we enable change to low carbon technologies, how we aim to minimise the cost impact of the energy systems transition on customers, and how we positively influence a fair transition for all and not just the 'can pay' segment. Such a holistic approach can aim to both offer a technical assessment of the benefits expected as well as opportunities for end-users to find out more about the technology, how it can be installed, used and maintained.

To this end the current project has four stages. The first two are building the Futures Close experimenting platform and assessing a number of energy efficiency technologies. The third stage aimed to study consumer adoption and the factors affecting behavioural change from different vantage points. The final one aimed to disseminate our findings and to reflect on the lessons learned from the project. The sections below consider each of the stages in turn.

Detailed information about the outputs can be found in the Appendices.

Stage 1: Building the Innovation Infrastructure

Constructing Futures Close

NGN has addressed the challenges of decarbonisation by constructing the Net Zero Research Village (NeRV) at its Low Thornley site near Gateshead. NeRV is the UK's first combined whole-systems research, development, and demonstration facility that integrates gas, electricity, and water systems. It provides a collaborative space for innovative research and testing, aimed at optimising low-carbon, cost-effective decarbonisation solutions for UK households.

At the core of NeRV is Futures Close, a unique development of nine homes designed to represent five different construction eras. This specially designed street functions as a highly instrumented innovation and test environment.

The properties include:

- Three 1910s terraced houses
- Two 1930s semi-detached houses
- A 1950s bungalow
- Two 1970s flats
- A 1990s detached home

Photographs: Futures Close

Sensors and Data Collection

Each home is equipped with sensors to monitor metrics such as temperature, humidity, and gas, water, and electricity consumption. The data generated informs and shapes future decarbonisation strategies for the UK housing stock. Futures Close serves as a testbed for trialling retrofit net-zero technologies, enabling researchers to understand the practical challenges of scaling these solutions. The project provides data-driven insights into the energy solutions best suited to different types of homes.

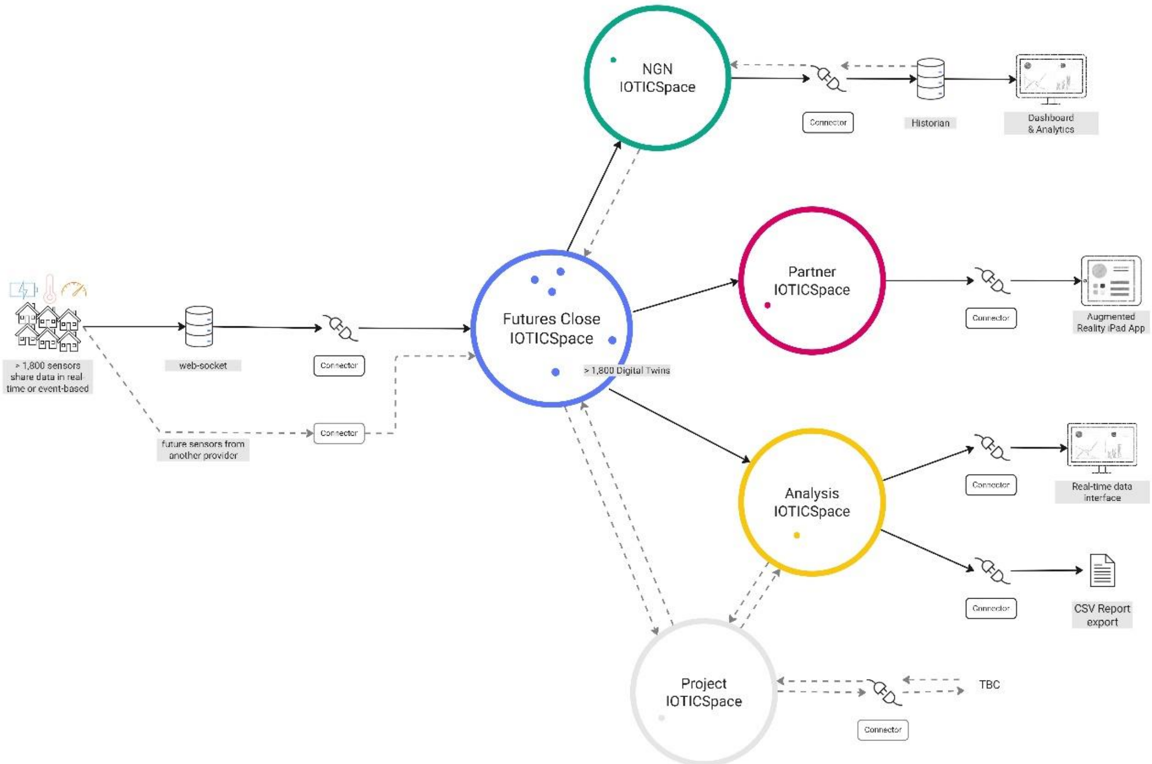
The table below illustrates the range of sensors installed within each property, the metrics they measure, their reference code and frequency of data gathering. Each sensor was calibrated to collate data at 3-to-5-minute intervals. Other 'dormant sensors' record an event taking place such as a tap being turned on, a window/ door opening/closing or an appliance being plugged into a smart plug socket.

Futures Close – Senor type and calibration summary

Device Sensor Type	Device Sensor Description	e.g. CO ref	Hosted Sensor values	Cyclical Sending	COV Sending
Theben CHEOPS Radiator Actuator	Electromotive valve actuator for radiator valve control	9_5_9	House 9_LivingRoom_HeatingControl_HeatDemand_Status	N	5%
CO2 Sensor - GIRA 2104 xx	Temperature	9_4_0	House 9_LivingRoom_Other_Temperature	3 mins	10%
	Humidty	9_4_1	House 9_LivingRoom_Other_Humidity	5 mins	3%
	CO2	9_4_2	House 9_LivingRoom_Other_CO2	5 mins	3%
Mains Energy Meter - ABB ZS/S1.1 Meter Interface Module, MDRC	Voltage	9_0_1	House 9_Global_Electric_Voltage	N	+/- 5v
	Current	9_0_2	House 9_Global_Electric_Current	N	+/- 500 mA
	Power	9_0_3	House 9_Global_Electric_Power	N	+/- 500 Watts
	AppPower	9_0_4	House 9_Global_Electric_AppPower	N	+/- 10 VA
	ReacPower	9_0_5	House 9_Global_Electric_ReacPower	N	+/- 500 var
	PowerFactor	9_0_6	House 9_Global_Electric_PowerFactor	N	+/- 0.02
	CumEnergy	9_0_7	House 9_Global_Electric_CumEnergy	15 mins	N
	CumReactEnergy	9_0_8	House 9_Global_Electric_CumReactEnergy	15 mins	N
	ACFrequency	9_0_9	House 9_Global_Electric_ACFrequency	N	+/- 0.2 Hz
Zennio ZEM Electric	Voltage	9_0_196	House 9_Global_Electric_Immersion_Voltage	10 Secs	+/- 300 Watts
	Current	9_0_197	House 9_Global_Electric_Immersion_Current	10 Secs	+/- 300 Watts
	Power	9_0_198	House 9_Global_Electric_Immersion_Power	10 Secs	+/- 300 Watts
	CumEnergy	9_0_200	House 9_Global_Electric_Immersion_CumEnergy	N	1kWh
Zennio KEM Water - Zennio ZEMKEM (inc WWHRS)	Temperature Sensor Value	9_3_10	House 9_Kitchen_Water_SinkCold_Temp	N	+-/ 1 °C
	Water Volume Consumption (L)	9_3_11	House 9_Kitchen_Water_SinkHot_Volume	10 Secs	+/- 1 L
	Water Flow (L/h)	9_3_12	House 9_Kitchen_Water_SinkHot_Flow	10 Secs	+/- 10L/h
Water Meter Pulse Counter - Arcus IMPZ1 SK01	Water Volume Consumption (L)	9_3_0	House 9_Global_Water_Meter_Volume	5 mins	N
	Calculated Flow Rate	9_3_1	House 9_Global_Water_Meter_Flow	5 Mins	N
Main Gas Meter Pulse Counter - Zennio **ZRX-KCI4S0**	Pulse Counter 1pulse = 1m3	9_2_0	House 9_Global_Gas_Volume	15 mins	1 m^3
Switch Actuators - e.g. ABB Switch Energy Function 12-fold 16A/1.2	Switch	9_0_66	House 9_LivingRoom_Electric_Lights_Control	N	Change of state
	Status Switch	9_0_67	House 9_LivingRoom_Electric_Lights_Status	N	Change of state
	Status Current	9_0_69	House 9_LivingRoom_Electric_Lights_Current	N	10%
	Voltage value	9_0_1	House 9_Global_Electric_Voltage	N	10%
	Power factor (cos phi)	9_0_6	House 9_Global_Electric_PowerFactor	N	10%
	Status Power	9_0_70	House 9_LivingRoom_Electric_Lights_Power	N	10%
	Status Total meter energy consumption	9_0_72	House 9_LivingRoom_Electric_Lights_CumEnergy	N	10%
Zennio Railquad - Zennio ZIO-RQUAD8	Door Contacts / Window Contacts	n/a	n/a	N	Change of state
ABB 4 channel analogue input	Pt100 sensor inputs (temperature)	5_4_200	House 5_LivingRoom_Other_IRTemperature	5 mins	N

A data platform and an open data repository were developed. NGN collaborated with external partners to support the creation of a data platform tailored to Futures Close. This system captured and managed information from each home while controlling access to this data. An energy "Open Data concept" was also developed as part of this initiative. Additionally, a website was created to display this information alongside project updates from NGN and its partners.

IOTICS Futures Close – Data Architecture



Approximately 500 sensors installed across the nine homes report data into the ‘Box PC' on-site at NeRV via a ‘GIRA Home Server’, collating data via each sensor to a central point. Data is then routed via an IOTICS Connector and is used simultaneously across three locations. 1) SAP Hana database, which is used to store the data historically and is made available via a self-service portal developed by NGN. This portal was used to download and provide data back to the Technical Team at NEA for analysis. 2) During the project, because of initial data accuracy concerns, a second portal (the data resilience portal) was developed in partnership with IOTICS to help improve resilience and data accuracy. This portal helped to track whether sensors were calibrated, active and reporting data correctly within the expected timeframe. 3) The ‘Digitalnauts connector’ was developed outside of this project as part of another NIA programme to enable parties interested in Futures Close to visualise the homes and interact with the technologies installed without the need to be physically on site.

Stage 2: Accessing and Benchmarking Innovative Technologies

The Energy Efficiency Challenge was successfully delivered through the Energy Innovation Centre (EIC), providing vendors with an opportunity to showcase their energy efficiency technologies, both physical and digital. The challenge required successful bids to secure a minimum of 50% match funding.

The initiative was designed to identify suitable technologies and solutions for inclusion within the project. The EIC utilised its extensive Innovation Community to source a range of Smart Home and Energy Efficiency solutions. Following the launch of the call for ideas, all submissions were assessed and narrowed down to a shortlist. These shortlisted concepts were presented to representatives from NGN, NEA, and Newcastle University, enabling a detailed evaluation of the proposed solutions to determine their suitability for the project.

Following the selection process, target technologies were identified, and installations were completed at Futures Close. The number of technologies installed was determined by their feasibility and practicality. The final selection of technologies was collectively agreed upon by all partners involved in the project.

Energy Efficiency Evaluation

The evaluation of energy efficiency solutions in different housing types was conducted for eight technologies. The technologies assessed are in the table below.

Table 1: List of selected vendors and technologies installed and tested

#	Company	Technology
1	Herschel	Infrared Heating Panels
2	Recoup	Waste Water Heat Recovery
3	Heatkeeper	Radiator Reflector Panels
4	AirEx	Air Brick
5	The Energy Savers	Quattro Seal
6	The Energy Savers	Window Coating
7	Wallrock	Thermal Liner
8	AirEx	Air Room

The common methodology across all the technology evaluations involved a structured process based on controlled experimental conditions and subsequent data analysis. Each assessment measured energy (gas and electricity) consumption, indoor temperature, humidity, and air tightness (where applicable) before and after the installation of the technology under consideration. Data was collected over set time periods, usually utilising the SAP 9 heating schedules (0700-0900 and 1600-2300) to maintain comparable test conditions. The Smart Heat Transfer Coefficient (HTC) was used to quantify thermal efficiency changes in some of the tests, and to extrapolate potential energy savings. In the case of the Wallrock thermal liner, extrapolation allowed for the test to be conducted in part of the building and then for an estimation of the savings for the entire flat (if the technology had been present in all rooms).

Blower door tests were used occasionally to measure air leakage rates before and after applying air tightness measures, e.g., Quattro Seal and Window Coating. Additional probe sensors measure temperature differences near windows to assess the effectiveness of insulation.

Historical weather data, specifically Heating Degree Days, were used to estimate annual energy savings. Additionally, cost calculations were performed using standard electricity and gas rates at the time of the study.

Reports

The following section provides a summary of the technical assessments conducted at Futures Close. It focuses on the technologies for which conclusive findings were established. The technologies include:

- ReCoup Wastewater Heat Recovery
- Herschel Infrared Heating Panels
- Wallrock Internal Wall Insulation

Full reports can be found in Appendices 1a, 1b, 1c. Tests for the other technologies were inconclusive due to several factors, and we are unable to publish the results.

Overall, there were several challenges and limitations common to the evaluation of all the technologies, which included:

- Lack of internet connectivity affected the collection of data from some of the technologies like AirEx.
- Lack of internet connectivity on-site also meant the evaluation team had no real [or near real] time visibility of the data, which would have allowed identification of some data issues whilst on site.
- Short testing period: each test period lasted around three weeks, which may not fully reflect long-term seasonal variations.
- Data Gaps: Missing data points limited the depth, reliability and confidence in the analysis.
- Unoccupied building conditions: as the buildings were unoccupied, real-world occupancy factors such as moisture and ventilation effects were not measured or used in calculations.

For more information about these tests, please contact a member of the NeRV team.

Stage 3: Adoption of energy efficiency technologies

The social research part of the project sought to understand how individuals respond to energy related technologies, with a particular focus on those who are vulnerable in the context of energy use and thermal comfort. Energy related technologies and smart devices are a standard feature of many modern homes but, in the case of older housing stock, there is a requirement to retrofit. Action in this area often relies on the initiative, funding and time of those who own and/or live in these properties. It is therefore crucial to understand how individuals respond to new technologies and what factors may encourage or prevent installation in the home. This is particularly important for those who are vulnerable and may face unique challenges when considering the adoption of new technology. The research involved two main projects, which examined the factors affecting technology adoption in general and ICT adoption in particular, as well as examining any similarities or differences between vulnerable and non-vulnerable groups. Two supplementary pieces of work were undertaken to explore similar themes related to the adoption of technology with the additional consideration of user engagement. These are outlined below.

For more information about each project please refer to the corresponding Appendix section.

Project 1: Customer Engagement at Futures Close

Study Objectives

While there is a wealth of literature considering the factors that influence technology acceptance and adoption in general, there is limited research into user engagement with technology and a tendency to overlook the complexities of vulnerability in the context of energy use. Moreover, policy in this area often prioritises “rational” considerations (e.g., cost), neglecting the nuances of individual lives. The first project used Futures Close to address these gaps, focusing on three main research objectives:

1. To examine the factors affecting adoption and the realisation of potential benefits
2. For smart products and services, to study the factors related to ICT adoption and acceptance
3. To examine any similarities or differences between vulnerable and non-vulnerable groups in the context of Objectives 1 and 2

Once the products were installed on-site they looked and operated as they would in a typical house, providing an immersive and representative experience for the exploration of energy related technologies in real life. Inviting members of the public to visit Futures Close and share their thoughts about the products was a unique way to address these research objectives.

Research Findings

The analysis identified a multitude of different factors affecting the adoption of new technologies and how these changed as a result of the research process itself. After engagement with the products on the website, most participants answered the introductory questions with reference to practical considerations, concentrating on cost, return on investment and the disruption of their home. There was some acknowledgment of the potential for products to save people money but more often there was a perception that the initial outlay or installation costs would be a major barrier to adoption.

Factors such as aesthetics had some bearing on initial appeal, but played a more important role in discussions during the walking groups and focus groups. Once participants had looked at the products in situ, they had much stronger opinions about the way they looked and felt, often reassessing their practical concerns in the context of a product they found particularly attractive or unappealing in real life. This kind of engagement with the technologies affected the weighting of the different factors, placing much more emphasis on hedonic considerations. Underpinning both sets of factors, however, uncertainty about new, unfamiliar and untested products remained a concern throughout the sessions, accentuating the challenges associated with risk, cost and disruption and, for most people, overriding the positive impact of the engagement process. Moreover, personal circumstances and proactiveness had a significant impact on how appealing the different products would be for each individual household.

Three out of the eight technologies on site could be considered ‘smart’, with features including automation, machine learning and information provision. These products were subject to the same concerns as the others regarding cost, disruption and hedonic appeal, with none of these factors playing a more or less important role based on the product being ‘smart’. Rather, it was factors associated with uncertainty and personal circumstances that had a bigger impact on the adoption and acceptance of smart technologies. Some participants were less confident about the reliability of products that required Wi-Fi and more concerned about their ability to fix them or find someone else who would be able to assist with this. Underpinning both of these things was the perception that smart technologies were more complicated and therefore a riskier investment.

It could be assumed that reservations about smart technologies were more pronounced due to the slightly older make-up of the research sample. However, only one or two participants made a direct association between their age and technology acceptance. Indeed, several ‘older’ participants were very enthusiastic about the benefits of smart technologies in terms of information provision and energy monitoring. Generally, concerns about these technologies were about their reliability rather than their usability and this was the case across different age groups. Finally, positive feedback about smart technologies was influenced by a personal interest in energy savings and the context of a larger household, which made automated technologies an advantageous investment.

In terms of vulnerabilities, there were some differences between the two groups. Participants that could be categorised as vulnerable emphasised affordability and practical solutions for heat retention, highlighting their heightened financial- and health-related concerns. Those categorised as non-vulnerable, though still conscious of costs and efficiency, placed greater weight on aesthetics and longer-term convenience and value.

Where there were shared priorities, it is the reasons for prioritisation that distinguish the two groups. Most participants were concerned about cost effectiveness, comfort, ease of installation and the importance of clear and trusted information. For vulnerable participants, however, cost is an immediate concern related to affordability in the first instance and the necessity of guaranteed ROI. For those who are non-vulnerable, a higher initial outlay can be weighed up against long term benefits. Taking a “*punt*” on something a little more expensive (as one non-vulnerable participant had done), was only an option for those who were in a more secure financial position. Similarly, minimising installation disruption emerged as a common concern but for non-vulnerable participants a more complex installation process could be worthwhile if it improved the value of the home or could be done alongside planned work.

While comfort was universally valued, it was seen as a necessity for more vulnerable participants, closely tied to health and age, whereas non-vulnerable participants tended to weigh it against other considerations, such as aesthetics or lifestyle fit. In addition, heat retention was less urgent for the non-vulnerable group since, in some cases, their homes had already undergone energy efficiency upgrades and so were better insulated.

Finally, both groups expressed a shared need for better communication about products and support, but potentially vulnerable participants sought reassurance and transparency to reduce financial risks, while non-vulnerable participants tended to focus on evidence of effectiveness and opportunities for hands-on experiences.

A follow-up survey three months later suggested that participants had thought more about ways to improve energy efficiency in the home, with some researching and installing energy related technologies. Respondents were more familiar with energy technologies in general and had taken the initiative to do further research into what they might be able to afford. Generally, however, any actions were modest, relative to the scale of the technologies on show at Futures Close, and focused on straightforward ways to maximise warmth and save money on energy bills. It would seem that, for most people, practical considerations such as cost and disruption remain barriers to the adoption of more expensive or structural options. However, it should be re-emphasised that the survey was distributed only three months after the workshop took place and it is likely to take longer than this for people to commit to big purchases and initiate large scale projects in their homes. Further follow-up work would possibly tell a different story about the long-term impact of the project.

Conclusions

The Futures Close project was a unique opportunity for participants to learn about a range of new energy related technologies and experience them in the context of 'real life'. The process provided insights into how vulnerable and non-vulnerable people respond to energy related technologies, but it also had a direct impact on those responses, increasing understanding and challenging low expectations or preconceived ideas. Overall, however, despite increased familiarity with the technologies during the site tour, the impact of in-person engagement was not influential enough to alleviate concerns about innovative products. While strong feelings about visual appeal and thermal comfort did lead to some reassessment of barriers, such as cost and disruption, for most people the risks associated with a new and untested technology remained an insurmountable barrier. This was the case for both vulnerable and non-vulnerable groups, albeit for different reasons.

Increasing the uptake of energy related technologies is dependent on the public becoming more aware of the range of options available for their home and more confident in the reliability and trustworthiness of new products and innovations. As a first step, exposure to new technologies through projects like Futures Close is essential for people who are unaware of the problem and who are unfamiliar with alternative options for improving energy efficiency. It is also important for those who are already proactive in this area and may be open to new ideas and their additional benefits.

Further to this, and crucial for acceptance and adoption, is clear and transparent evidence about the effectiveness and value for money of energy related technologies. Government-backed endorsements, independent reviews and recommendations of people who have tested the products themselves would also help to build trust and reduce concerns about risk and reliability. Finally, tailored solutions should be developed based on household circumstances, ensuring different groups have access to information about the technologies that best meet their needs. For vulnerable groups in particular, financial support such as grants and subsidies would improve accessibility and encourage investment.


NeRV
NET ZERO RESEARCH VILLAGE

Project 2: Large Scale Survey Work

Study Objectives

In the second project, the qualitative insights from Futures Close informed the development of two conceptual models: one focusing on perceptions of energy-efficient technologies and the other on smart home technologies. The energy-related technology model identified factors influencing the intention to upgrade existing energy technology with more advanced alternatives. The smart home technology model examined factors predicting the fit of smart home technologies for various tasks, along with their implications for autonomy, life satisfaction, and technology satisfaction. This second model was necessary, as some energy-efficient technologies used in field settings incorporated smart properties. To validate its applicability to the smart home context—where numerous devices offer energy-reduction features—the model was refined. Given the limited exploratory evidence on smart home devices (only three of the products were classified as 'smart'), the findings were further synthesised with empirical evidence from the literature to enhance the robustness of the model. Finally, both models were quantitatively tested to generalise the conclusions.

Model 1: Energy-Related Technology

Initial findings identified eight factors influencing the evaluation of energy-related technologies, relating to practical factors, uncertain performance and usefulness and uncertain usability. Participants talked about the initial outlay on the product as well as the cost and disruption of installation and the ongoing expense of maintenance and potential replacement. Second, a great deal of discussion revolved around product performance and usefulness. There was a perception of the general risk that something would go wrong and many conversations about the reliability of technology more generally. When talking about more specific benefits of the technology, the discussions were about how much difference the products would actually make in terms of saving energy. Third, as far as the usability factors were concerned, the respondents felt uncertain about the effort that would be required to install the energy-related technology. Non-vulnerable participants also prioritised ease of installation, avoiding products that required significant disruption or effort. This uncertainty about product usability stems from the lack of awareness of how the claimed benefits can be realised, unless they are observable, which is a particular concern when it comes to innovative products.

The barriers to seeing the value of energy-related technology appeared to stem from participants' vulnerabilities, including limited knowledge, age-related considerations and monetary concerns. Many participants were unfamiliar with the products outside of this project, while others felt overwhelmed by the range of available options. Monetary concerns often correlated with age: some older participants, while financially secure enough to afford the initial investment, worried that, at their stage of life, they might not see a return on that investment.

Given the above findings, the second project conceptualized the role of eight factors motivating people to upgrade energy-related technology, namely, perceived sustainability, price value, time cost, durability/reliability, observability, ease of use, usefulness and convenience. Three types of vulnerabilities were proposed that might influence the importance of the identified factors in making decisions to upgrade: the technology skill and knowledge gap, health-related vulnerability and financial vulnerability.

Model 2: Smart Home Technology

The Task-Technology Fit (TTF) framework was used to explore how the perceptions of smart homes by people with vulnerabilities influence the assessment of technology fit to their personal goals. Task-technology fit refers to the degree to which technology aids in performing specific tasks. A user's evaluation of task-technology fit is shaped by both the characteristics of the task and the technology's attributes. Task characteristics are assessed based on factors that may influence a user's reliance on specific features of the technology, while technology characteristics relate to the unique attributes or functionalities of the technology itself

The project synthesised the findings of the exploratory stage (used in Model 1) with empirical findings on smart home technology. Financial and time cost, ease of use and usefulness align with existing research on smart home adoption. Complex systems are discouraging, especially for less tech-savvy individuals, making usability an important driver where smart home technology matches skill levels and does not require cognitive effort. The usability of smart homes may be positively evaluated if their features and functions are easily observable.

Smart home services are perceived to be useful because they appeal to a large segment of users with various needs. Comfort/convenience (e.g., the automation of mundane tasks, voice control, and remote access to devices) underscores the value consumers place on technologies that simplify daily routines, and enhance user experience and satisfaction. Also, the features optimising the use of resources and energy consumption appeal to users seeking to save on utility bills and minimise their ecological footprint. Additionally, perceived usefulness (the degree to which a user believes that using smart homes will improve job performance) is important in shaping perceptions of technology fit for household tasks.

Using smart home technology for home-related tasks enhances user satisfaction. In addition, prior research suggests that for individuals seeking support, the main purpose of using smart homes is enhanced autonomy. The assistive capabilities of smart homes to achieve independent living, in turn, can increase satisfaction with the quality of life. Additional insights from the literature on smart homes enabled us to expand on the result and qualitative findings and conceptualise the role of the health-related benefit predicting technology fit and three implications, namely, autonomy, life satisfaction and satisfaction with the technology. The analysis of the predictors of intention to upgrade energy-related technology indicates that this intention depends on several factors: the perception that the technology provides sustainability benefits, the belief that it is worth the investment, the ability to observe its use by others, the minimal effort required for operation, its usefulness in optimising energy consumption, and its convenience. However, durability was not found to be a significant predictor.

Research Findings

The findings from the surveys provided insights into 1) the importance of the identified factors for energy-related technology adoption (including indicators of vulnerability) and 2) how the perceptions of smart homes by people with vulnerabilities influence the assessment of technology fit to their personal goals.

Model 1

The analysis of the predictors of intention to upgrade technology demonstrated that only the relationship between durability and the outcome variable was not significant. Sustainability, perceived price value, observability, effort expectancy, perceived usefulness and convenience all positively affect intention to upgrade technology. As a robustness check, the effect of the predictors was controlled by age, education and occupation status. However, the control variables did not impact the relationships between the predictors and the outcome variable.

The results of the moderation analysis showed that financial vulnerability positively moderated the effect of durability. Similarly, durability is moderated by the skill and knowledge gap, although the effect is negative. Lastly, physical disability positively moderated the relationship between perceived technology usefulness and intention to upgrade.

Model 2

The results of the analysis of the main relationships showed that seven out of nine predictors of task-technology fit were significant, explaining 62% of the variance. Sustainability, perceived value, durability, effort expectancy, perceived usefulness and convenience positively affect task-technology fit, while the effect of health-related benefit is close to zero. Consequently, task-technology fit was found to have a significant impact on autonomy, life satisfaction and satisfaction with the technology. The effects of the predictors were controlled for by age, education and occupation status. However, their inclusion has not affected the predictors' significance and effect size.

The results of moderation analysis show that financial vulnerability negatively moderated the effects of perceived value, effort expectancy, perceived usefulness, convenience and health-related benefit. Knowledge and skills in using the technology negatively moderated the effect of time cost and positively moderated the effect of effort expectancy. Both mobility and disability challenges negatively moderated the effect of perceived usefulness.

Conclusions

Two studies were conducted: the first examined the predictors of intention to upgrade existing energy-related technology to advanced alternatives that enable energy conservation, while the second explored the perception of smart home fit and its implications for individuals' autonomy, satisfaction with the technology, and overall life satisfaction.

The analysis of the predictors of intention to upgrade energy-related technology indicates that this intention depends on several factors: the perception that the technology provides sustainability benefits, the belief that it is worth the investment, the ability to observe its use by others, the minimal effort required for operation, its usefulness in optimising energy consumption, and its convenience. However, durability was not found to be a significant predictor.

The analysis of the predictors of task-technology fit indicates that the perception of fit increases when home dwellers view the technology as a sustainable solution, a worthwhile investment, durable, useful for home-related tasks, beneficial to health, convenient, and easy to use. The moderation analysis of financial vulnerability suggests that less financially vulnerable individuals are less likely to emphasise perceived value, the effort required for use, technological usefulness, convenience, and health benefits when assessing the fit of smart home technology for their needs.

Further insights emerged when examining this variable in the context of financial, knowledge- and skill-related, and health-related constraints. Financial vulnerability and knowledge and skills gaps influence how individuals perceive the role of durability in their motivation to upgrade technology. Specifically, the perception of durability increases motivation to upgrade only if individuals feel less financially distressed. Conversely, the larger the knowledge and skills gap, the more likely it is that durability becomes a motivating factor. Additionally, physical disability moderates the relationship between perceived usefulness and intention to upgrade, reducing the predictive power of perceived usefulness in these cases. The moderation analysis of skills and knowledge reveals that individuals with a greater knowledge gap are more sensitive to the time and effort required for smart home technology installation. Regarding health-related vulnerabilities, individuals facing mobility and disability challenges place greater importance on technological usefulness when evaluating smart home technology suitability for their homes.

Project 3: Smart Sockets: Adoption, Understanding and Behaviour Change

Study Objectives

The past two decades have witnessed an unprecedented growth in the availability of 'smart' energy technologies for the home, which can provide information about levels and patterns of energy use as well as indicating periods of peak demand. This ability to monitor and manage energy consumption has significant implications for consumers who are dealing with challenges such as the cost-of-living crisis and the reality of climate change. Indeed, these smart devices can be used to assess where and how people can reduce their bills as well as facilitating a reduction in carbon emissions. Historically, however, research has focused on the technological aspects of smart devices (e.g., function, optimisation), with only more recent studies considering the user perspective. Where research does consider the use and effectiveness of feedback, data has generally focused on overall household energy use via smart meters rather than information from individual devices.

The supplementary project addressed these gaps by focusing on the consumer experience and exploring how people respond to and act upon feedback from one particular type of smart technology that was installed at Futures Close: The Measurable Energy Smart Socket. This device automatically recognises when an appliance is plugged in and begins to measure its energy use and carbon emissions, with data accessible via an online platform. It is also able to provide information about the carbon intensity of the electricity coming into the plug socket via an LED traffic light system. The study investigated the appeal, comprehensibility and effectiveness of the device through a qualitative study with 21 university students in the Northeast of England. Specifically, it focused on students whose energy bills were included in their weekly rent and assessed the potential for the device to change behaviour in the absence of cost as a motivating factor.

The study contributed to the overall project by exploring motivators for technology adoption with a different group of consumers (students) as well as exploring how well people understand and respond to smart technologies. The students retained the socket for a period of three weeks, allowing the research team to measure the effects (if any) of prolonged exposure to the device compared to the one-day engagement process at Futures Close.

Research Findings

Most of the students talked about the appeal of the smart sockets in terms of making life easier, as well as being *interesting* and *cool*. However, many participants felt that the socket was too large and cumbersome. There were also many complaints about the brightness of the LED indicators, with several students getting in touch during the study to ask if and how they could safely cover them during the night.

Some participants referred to environmental motivations for conserving energy. They expressed concern about the environment and noted that sustainability was a consideration for them in their everyday behaviours. Despite the fact they were not paying directly for energy, a number of students highlighted the importance of cost as a motivator for reducing consumption. There was a strong awareness of the price of energy and the general importance of conserving it for this reason, even though it did not apply to them at the time. Many claimed that they would be inclined to purchase the device in the future when they were paying bills and keeping a closer eye on their energy use.

Once the LEDs were enabled at the end of the first week, almost all of the participants became aware of them. Some were confused about what the different colours meant, with one wrongly believing that the red light meant they had used too much energy and another worrying that the red light indicated a problem with the device. Generally, however, the participants understood that a green light indicated clean energy. There was also some confusion around the information provided in the data feedback and graphs proided. One student in particular stated that the graph was easy and obvious to interpret but proceeded to demonstrate a lack of comprehension. However, many participants did understand the graph and discussed high use items and the days/times they were consuming the most energy. There were several calls for more granular data to make the consumption information more detailed and easier to understand.

Generally, participants found the information provided by the LEDs of interest and a number reported waiting for the green light before plugging things in. However, many reiterated the necessity of using their devices and appliances at particular times and claimed that they could not wait for the green light before using energy. One participant stated that he felt better if it was green, but he could not do anything about it. Some participants said that they had tried to work out a pattern to the light changes and felt it would have had a bigger impact on their behaviour if they had known *when* the LEDs would be green.

The graph which was distributed at the end of the second week appeared to have less impact on participant behaviour. Most people stated that the information about their energy use had little impact on the choices they made when it came to plugging in devices and appliances. Several participants remarked that they had expected the socket to do more, specifically, that it should itself contribute to a reduction in energy use, by turning devices off automatically. They felt this would have had a bigger impact on their behaviour. Such functionality was a feature that the smart plugs offered, but in order to avoid inadvertently affecting participants' day to day activities such rules were not applied.

Conclusion

Differentiating itself from studies where cost and financial motivations are a consideration, this study explored how participants react to feedback about energy use when the only 'cost' is the impact on the environment. Notably, it considered responses to how much electricity is being used *and* the source of that electricity. The findings suggest that, although sustainability was a concern for the students, they would be much more likely to adopt the technology when cost was once again a factor in their decision making. Moreover, the perceived need for energy use at certain levels and particular times of the day could not be challenged when sustainability was the only concern. Finally, the effectiveness of the device under any circumstances is contingent on a better understanding of the information that is being relayed to the user.

Comparisons

There are similarities in responses to the device across Project 1 and 3. First, there was some shared enthusiasm about the importance of the information that could be obtained from the data feedback. Participants at Futures Close felt they could make better decisions about when to use appliances and what to plug in, while several students talked about buying more efficient appliances to decrease their energy use. In contrast, a number of participants across both projects agreed that the device was not useful for them, albeit for different reasons. For the Futures Close participants this was because they already turned appliances off at home and did not require prompts about energy use. For the students it was because they could not avoid using the energy. Knowing how much they were consuming was irrelevant because they "needed" to use it.

Returning to the overall aims of the project, both groups discussed the importance of cost as a driver for technology adoption. Futures Close participants were keen to see a return on investment, with differing views on whether or not the smart socket would deliver this. The students were generally more confident about return on investment but were reluctant to purchase the socket in the context of their current situation. Adoption was more likely when they were paying the bills. Interestingly, across both groups of participants, only one student raised concerns around privacy and the use of data. This is particularly notable considering it did not factor into any of the extensive discussions around risk and trust during the site visits.

Comparing the two qualitative projects provides some important insights into the differences that may exist between different groups of people and different sectors of society. It also highlights the need for various forms of engagement. While initial exposure during something like a site visit can be illuminating for people who are unaware of the problems related to energy efficiency, there is also value in exploring alternative ways in which users can experience new products. Future work in this area might usefully consider the long-term impact of exposure to new technologies and the engagement of users with these products in their own homes.

Project 4: Realising Sustainability? An Assessment of the Environmental Benefits of Smart Technology

Study Objectives

The UK government recognises smart homes as a key enabler of environmental decarbonisation. By leveraging digitally connected and automated systems, smart homes are positioned to address pressing challenges, including energy efficiency, climate change mitigation, and technological innovation. Despite the common consensus that the use and adoption of smart home technology are associated with being environmentally sustainable, significant concerns remain about whether these technologies consistently deliver the promised sustainability benefits. While these systems hold sustainable potential, their actual impact—especially from users' perspective—has not been adequately examined. Exploring the link between user experiences and sustainability outcomes is crucial to ensuring that smart homes fulfil their promise of individual and environmental benefits, aligning real-world performance with expectations. As the market for smart home technologies continues to expand, the impact of smart homes on sustainability needs further scrutiny.

Existing studies predominantly focus on the technical aspects of smart home systems, such as energy-saving capabilities and operational efficiencies. However, they seldom take into account user-centred outcomes or perceptions. Consequently, there is limited empirical evidence on whether smart home performance aligns with users' expectations regarding sustainability benefits. While users may anticipate substantial gains in sustainability, convenience and security, it remains unclear whether these expectations are consistently met. This gap highlights the need to examine the expectation-performance (mis)match and the underlying factors contributing to potential discrepancies. Understanding smart homes from the user perspective is essential, particularly in relation to the broader sustainability goals they are designed to support.

Secondly, while the theories on expectation-confirmation gaps/match measure perceptions of confirmation, they lack an ontological foundation to explain how individuals construct their perceptions. A key question arises as to how users assess the actual sustainability benefits of smart homes. This concern underscores the need to explore whether sustainability claims are grounded on measurable outcomes or merely on perceived or assumed benefits.

Thirdly, there is evidence that smart home technologies are capable of delivering health-related, environmental, financial and psychological benefits. Against the backdrop of the lack of clarity regarding how individuals develop an understanding of the realised sustainability benefits, further investigation is required into the motivations behind smart home adoption. Such an approach would allow for a comparison between user motivations and actual usage patterns, providing insights into whether smart homes are genuinely used for sustainability purposes or primarily for other functional advantages.

To address the above gaps, this study develops several sets of analyses. First, to understand whether prior expectation regarding the smart home technology sustainability is confirmed, the study adopts the expectation-confirmation theory (ECT), which is a robust framework for examining the interplay between pre-adoption expectations and post-adoption experiences. This approach makes it possible to establish if there is a (mis)match in expectations and technology performance at a higher level.

To examine the confirmation process at a more granular level and understand how individuals perceive smart home technology in relation to sustainability goals, we developed a set of questions to assess whether users actively engage with smart home functionalities to monitor and optimise energy consumption. This approach allowed us to determine the extent to which individuals rely on technology-driven insights to confirm that their smart home systems are contributing to sustainability outcomes.

Furthermore, to explore the underlying motivations for smart home adoption, this study measured the perceived importance of various smart home benefits in influencing adoption decisions. By assessing user priorities—whether convenience, security, financial savings, or environmental impact—we aimed to clarify whether sustainability is a primary driver or a secondary justification for adoption.

Finally, drawing on IT Identity Theory, which examines the degree to which individuals see technology as an integral part of their self-concept, we developed a research model to investigate the role of IT identity when it comes to smart home sustainability. Given that IT identity may shape how users justify their engagement with smart home systems, we explore whether this psychological factor influences technology use in a way that masks the actual intention behind adoption.

Research Findings

The study found that the use of smart homes contributes to achieving sustainability goals. This perception is shaped by users' expectations of smart home sustainability and their evaluation of actual performance. Ironically, however, smart home users form perceptions of sustainability achievement without necessarily using the technology to measure the degree to which sustainability is achieved. Specifically, it was found that, on average, users do not actively monitor the energy consumption of their smart home devices or track progress toward sustainability goals. This may be because other benefits are prioritised over sustainability. For the majority of respondents, measuring sustainability was perceived as a complex and unfamiliar process, made more challenging by a lack of time, expertise, and specialised equipment.

Secondly, the study investigated the motivations behind smart home adoption that could potentially outweigh sustainability-related benefits. The results indicate that financial savings, security, and convenience are the primary motivational factors for the majority of respondents. Although these findings are consistent with existing literature, they also clarify the relative importance of these benefits, as environmental benefits were ranked the lowest.

Finally, drawing on IT Identity Theory, the study empirically established that the usage of smart homes for sustainability purposes is driven by the belief that the technology helps users fulfil their identity. In other words, adoption is partly driven by the desire to align with the image of an environmentally conscious person. This identity is shaped by beliefs that smart home technology can support sustainability efforts, that it is convenient and easy to use. It is reinforced by pro-environmental concerns as well as social norms and expectations, encouraging smart home adoption.


Living room
Temperature
20,5 °
10:00 - 14.30
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday

Stage 4: Lessons from Customer Engagement

Reflections and limitations of in-person visits

The Futures Close project was a unique opportunity for participants to learn about a range of new energy related technologies and experience them in-person. Visiting the demonstrator site exposed participants to technologies that they were unfamiliar with, challenging their preconceived ideas and introducing them to the range of options that are available to improve energy efficiency in the home. It also allowed them to see the technologies in operation and ask questions about their use and effectiveness, thereby improving understanding and increasing confidence in the products. Finally, experiencing the products in situ conveyed the look, feel and, in some cases, sound of the different technologies in a home environment. These three factors were found to be important aspects of successful customer engagement, and such experience can positively influence adoption intentions.

However, there were some limitations to the in-person visits. First, there were logistical issues associated with bringing people to the site. The project covered expenses, but participants still had to arrange travel and/or work out how to drive to the location. Several people asked for assistance when negotiating bus schedules and booking taxis. In addition, expenses were paid retrospectively. Although there were no complaints, this may have caused problems for those who are financially vulnerable and cannot afford to pay upfront travel costs. Committing to a three-hour workshop also takes up time. The sample included many older and retired individuals, possibly indicating the flexibility of these people compared to those who are working and/or have busier schedules. Moreover, several people who had joined the project initially did not turn up on the day, which is perhaps also indicative of the commitment required to invest time in this kind of research.

Furthermore, Futures Close is a working site and, as such, in-person engagement required risk assessments as well as literature and briefings on health and safety for all participants. Finally, the 27 participants were split into five groups of 4-6 people. The site visit could only accommodate a certain number of individuals moving around the houses at once. It was not practical to host large numbers of people. This limited the potential to scale up participation and the impact that such engagement can have.

Moving from in-person to online visits

One option to address these limitations is to move the experience online. Research suggests that greater exposure to smart home information, both online and offline, could enhance consumer willingness to engage with these technologies. Broadening horizons and challenging preconceived ideas could feasibly be done via an online platform. Similarly, in-depth explanation of how the technologies work does not require in-person engagement; it requires some form of engagement with a person who is able to provide clarity. Also, despite the positive experience of the visit, many participants did not feel more confident about adoption, citing the importance of data about energy savings, backing from trusted sources and reviews from real people. This aspect of customer engagement could possibly be achieved more effectively online.

In addition, the limitations associated with transport, cost and time are less of a challenge in an online version of this customer engagement exercise. Participants could view the technologies and listen to the explanations in the comfort of their own home without factoring in any of the logistics. This could make the engagement more inclusive, taking into account those who are time pressed, financially vulnerable, or physically disabled and unable to travel.

Interactive Activities

There was a marked improvement in the engagement level of the participants between experiencing the products on the mock project website and experiencing them in situ at Futures Close. For those who sign up to take part in “online visits”, these must be more effective than a standard website with videos of installations and generic online interviews or focus groups. For example, an online platform could support a number of different features, appealing to both the users and vendors of technology:

Training/resources for companies developing new energy-efficient technologies

To support industry professionals, the platform could offer training materials based on the exploratory and supplementary academic work. These would ensure companies are well-equipped to communicate the benefits of energy-efficient technologies and provide high-quality installation and support. Online training sessions, interactive guides, and knowledge-sharing forums could help standardise best practices.

Virtual property tours

The platform could offer virtual tours of digital twins of the properties, allowing end-users to explore each home as if they were physically there. These tours could be interactive, with clickable hotspots providing detailed information on specific energy-efficient technologies, such as insulation, heating systems, or smart appliances. Users could “walk through” rooms and see how these technologies function in different settings, view real-time data on energy savings, and simulate changes in energy consumption based on their actions. Access to this kind of data could also help to alleviate some of the apprehension associated with risk and uncertainty.

Live demonstrations and Q&A sessions

To recreate the vendor demonstrations that typically occur on-site, the platform could host live/recorded sessions where companies showcase the installation, use, and maintenance of energy-efficient technologies. These sessions could be interactive, with users able to submit questions in real time, similar to a live workshop. Additionally, users could access on-demand videos.

Interactive storytelling and scenario-based learning

The platform could create engaging, scenario-based experiences that enable users to explore how different energy-efficient technologies might impact their comfort, energy bills, or environmental impact. Users can connect with the technologies emotionally and socially, through storytelling rather than just technical details.

Community engagement and peer sharing of case studies

Incorporating social features where users can share their experiences and thoughts with others could foster a sense of community and support around energy adoption. The platform could include user testimonials, or "virtual group tours", where users can interact with each other. The final two features of the platform would also help to reduce uncertainty around the products, providing the reviews and peer example that participants sought.

Measuring the impact of online visits

The process of engagement at Futures Close was assessed via a number of different methods. First, researchers recorded how often participants visited the mock project website and for how long, as well as noting down product preferences. On-site, participants were invited to rank the technologies on a display board both before and after viewing the products. Interviews and focus groups were also conducted, the latter including “walking groups”, where discussions were encouraged during the site tour.

The impact of online “visits” could be measured via similar means. Follow-up surveys and interviews could capture the impact of the experience and metrics on the platform itself could assess how long and how often participants engage with particular features. Links to further information about the products could also be monitored for interest. In addition, understanding of the products could be tested with quizzes measuring recall of particular features and participants could be asked to review their experience of the different features.

Potential limitations of online visits

There are, of course, limitations to what can be achieved online compared to “real-life”. There were one or two comments during the site visit about the “fictional” nature of the demonstrator houses and the hypothetical process of choosing products. This challenge would presumably be even more pronounced with an online version. In addition, one important aspect of the site tour was the experience of “feeling” the technologies. Participants talked at length about the sensory perception of thermal comfort and this is something that could not be replicated online. Finally, there are different vulnerabilities to be considered in the context of online engagement. An individual’s level of technological knowledge and skill significantly shapes their experience in using technology, meaning that those who are not technically literate will be unable to engage with the platform. This is particularly important because similar challenges will be faced by these individuals when engaging with energy related technologies and should therefore be a significant consideration for the research.