User-Centred Energy Systems

Social License to Automate

Executive Summary

Emerging Approaches to Demand Side Management

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UsersTCP

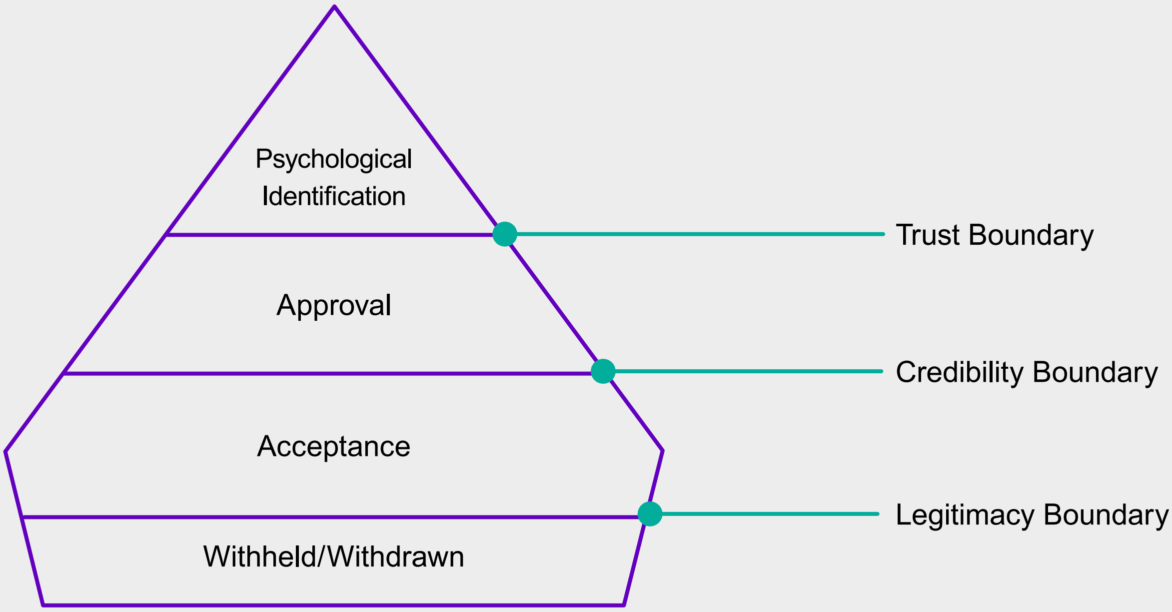
The Social License to Automate Task has investigated the social dimensions of user engagement with automated technologies in energy systems to understand how householder trust to automate is built and maintained in different jurisdictions and settings.

Who would you trust to control your air conditioner, electric vehicle, battery or washing machine? This question is becoming increasingly important as grid operators and aggregation firms trial automation projects to participate in markets, stabilise electricity delivery during peak periods and build flexibility in power grids increasingly characterised by distributed sites of generation, storage and consumption. Automation technologies facilitate load shifting and shaving in peak demand periods through direct load control and pre-programming of appliances in the home. Their automated character ultimately requires trust in organisations.

A Nissan Leaf EV used in Swiss EV sharing project OKEE (page 106 of full report)

What is a ‘social license to automate’?

The social license concept is based on a ‘social license to operate’, which was developed through experiences in the mining sector (see Full Report: Introduction). It refers to the extent to which an initiative has the approval or acceptance of communities of stakeholders and captures a cluster of factors beyond that of formal legal approval which can shape its reception. In the context of energy systems, the concept of a social license appears to sit between the formal and informal rules of conduct for the electricity companies, grid operators and network businesses trialling automation in DSM.[1]



Research on building a social license has shown that aligning citizens and project developers around a common goal builds trust. The 26 case studies analysed in this project presented participants with such goals as reducing peak demand, enhancing energy independence or stabilising the grid.

Issues of social license speak directly to the challenges of **democratisation** that arise from decentralisation. What involvement should users have in automated energy systems? This is a profound question for democracies that warrants a great deal of experimentation and testing. The projects described in this project could be seen as exemplary **social *and* technical experiments** in their efforts to redistribute agency between users, grid operators, and energy companies. Thus understanding how to involve users and gain legitimacy in such processes are important.

[1] Adams, S., Kuch, D., Diamond, L., Fröhlich, P., Henriksen, I. M., Katzeff, C., Ryghaug, M., Yilmaz, S. (2021). Social license to automate: A critical review of emerging approaches to electricity demand management. *Energy Research & Social Science*, 80, 102210

The concept of a social licence was developed to recognise the limits of formal state regulation of large resource projects. Building social license with communities requires a fair and open approach (see Introduction of full report). (photo: Sinn Fein, flickr).

CHARACTERISTICS OF THE CONCEPT OF 'SOCIAL LICENSE'

- Draws attention to the power of the community to halt projects with formal approvals
- Continuum of 'psychological identification' to 'withdrawal' of support useful nuance to accept/or reject binary
- Research in mining may have analogies in the energy sector, such as a dip in approval during the construction phase
- Provides a framework to assess how groups outside government can affect projects
- Critics claim it is ambiguous as to who has the power to grant social license, furthermore that the concept of 'community' is too malleable: too much power lies with social scientists to decide legitimate voices (criticism often levelled at mining companies using social science)

One of the 37 households in the QuartierStrom project in Eastern Switzerland. The project connected researchers with the local DSO to develop an innovative local energy trading system using PV and an automated community battery (see page 96 of full report).

The Social License to Automate Task has investigated the social dimensions of user engagement with automated demand side management (DSM) to understand how user trust to automate is built and maintained in different countries and cultural settings.

Energy users' roles in electricity systems across the world are changing. This report presents findings from original research involving 26 automation projects (mostly pilot and demonstration stage) across Australia, Austria, the Netherlands, Norway, Sweden and Switzerland. The framing of the problems to which automation is directed is distinctive in each of these countries. So too is the role of users. Our cases show that issues of equity, fairness, individual vs. collective responsibility, desirable roles for markets vs. regulation, and standards are negotiated in different ways in different places. These differences arise from assumptions about the energy user and their household as well as national-level energy policy directions.

We have developed a novel concept to help understand a key component of energy transitions that accounts for these distinctions: **a social license to automate.** This concept brings together findings from institutional and policy studies, Science and Technology Studies, energy sociology and Human-Computer Interaction studies to better characterise the social, technical and policy context in which automated control is permitted, trusted and functions successfully - or not.

Key Messages:

Users and Programme Design

1. **Users' want to help address shared problems such as avoiding blackouts and reducing greenhouse gas emissions. However, this is not appreciated by promotors of DSM programs.** The energy users in the case studies have diverse and even competing motivations: interest in new technology, financial savings, environmental concern, personally improved energy security, independence from the grid, contribution to grid stability and community orientation.

Innovative self-consumption optimisation for multi-family area development with local electricity exchange (page 94 of full report).

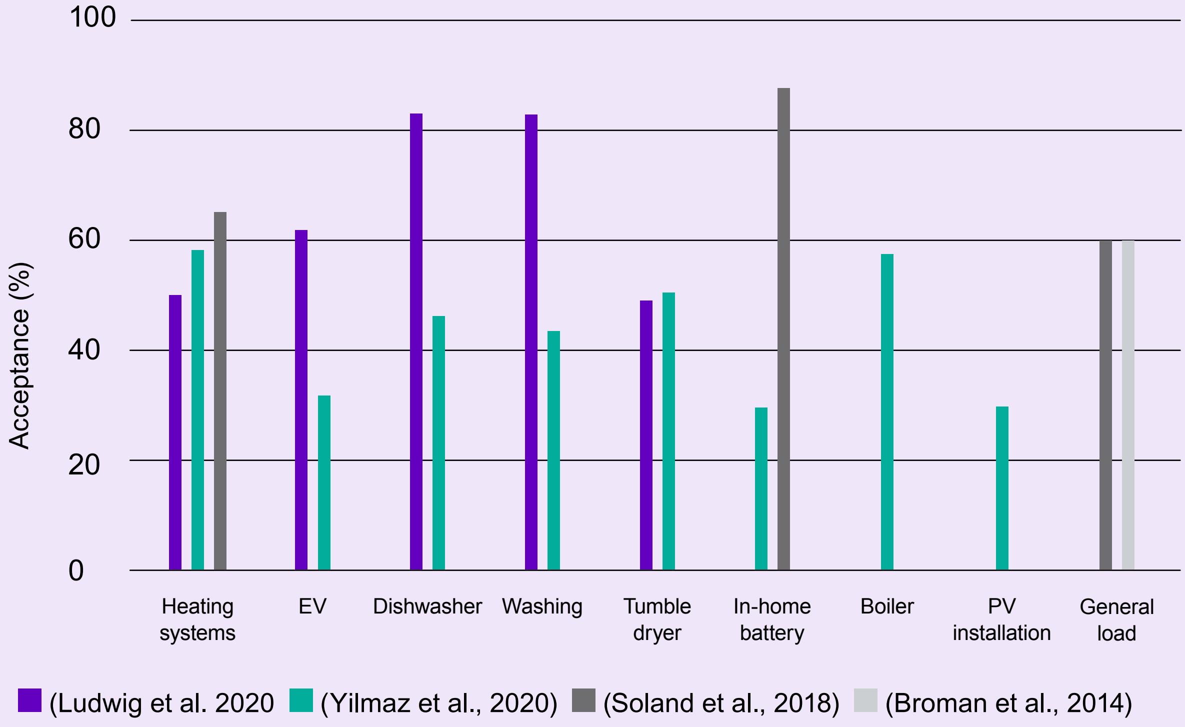
2. **Energy users take up automated DSM solutions to the extent that they align with their motivations and values.** For example, energy users who have purchased a home battery for environmental or financial reasons may be willing to participate in Virtual Power Plants, while those who are highly sensitive to grid disruptions and have purchased a battery to increase their energy independence and security will be less willing to.

> ‘Articulating the *why* is just as important as the *how* for the development of automated third-party control of household loads.’

Home batteries in both detached housing and community settings are used to manage peak loads, maximise self-consumption of energy generated from rooftop solar and manage ancillary services like frequency control.

3. **There are no 'one size fits all' solutions to successful user engagement** for automated programs directed at issues such as frequency control, peak load management, voltage management and grid augmentation. Obtaining a 'social license to automate' will need to be adapted to local, regional and national concerns, as well as to the technology domain of automation.

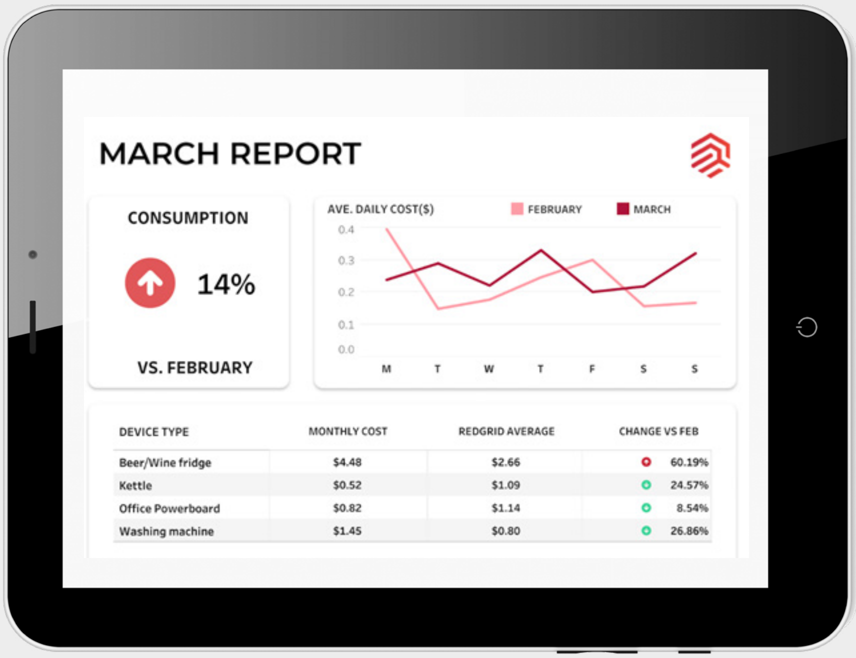
Rate of acceptance for automated control over devices



Swiss researchers have extensively surveyed energy user willingness to automate (see page 89 of full report).

4. **There is no one simple hierarchy of energy loads that are more or less amenable to automated control.** Acceptance of the automated control of household loads depends on a complex set of questions and contextual factors. These include how the individual and collective value of automated control is communicated to and perceived by users, and the impact that it may have on them. These also include users' experiences of interacting with the automation technology at the micro scale and how their engagement is shaped by institutional configurations at the meso-level or macro scale. Our cases show, however, some evidence of a hierarchy according to impact on users. The automation of loads associated with comfort or convenience, especially, is generally less acceptable to them. Loads with greater potential impact include washing machines and dishwashers, while loads with lower potential impact include batteries. Further research on these impacts on diverse households is needed.

5. **Program designers should communicate results and design user interfaces according to levels of automation.** We analysed automation at several levels, from manual load shifting of devices to full automation, which gives users no option to intervene. The role of these interactions with household participants of automated DSM is important in building a social license and varies between one of ‘helping’ and ‘reminding’ to ‘reassuring’ and providing transparency about the scope of the automation.



The RedGrid Smart Home Trial developed innovative approaches to rewarding consumers for having appliances remotely controlled through smart switches (see page 21 of full report).

6. **Automated DSM providers ultimately need to integrate automation into daily household routines for increased adoption among residential users.** Some households are already changing the times at which they use their appliances for various reasons and are looking to use automation and labour-saving technologies to help them do so. The energy industry should structure DSM to take these activities into account. An analysis of some of the ways that energy is used in the home revealed that they are approached and valued differently within households.
7. Finding ways to incorporate **both energy and grid aspects** into program design is an important future task for businesses and regulators to consider.
8. **The value for industry and users realised in the trials and demonstrations examined here will not necessarily be realised in ongoing or scaled-up programs.** For example, careful consideration is required of the utility of data gathered in trials that often are characterised by **one-off subsidies** to attract typically enthusiastic early adopters. The data gathered in trials conducted to date, including those set out in this report, may therefore have limited relevance in understanding the household settings, demographics and values of later adopters in future automation projects.

Governance and economic issues that affect a social license of automated DSM:

9. Separation of energy (the focus of retailers and aggregators) and grid (the focus of Distribution System Operators (DSOs)) through market liberalisation contradicts holistic solutions. Most of the projects thus focused either on energy markets or the grid depending on the actors involved. Reconciling these tensions remains an important task for all involved in the transition to renewable energy.

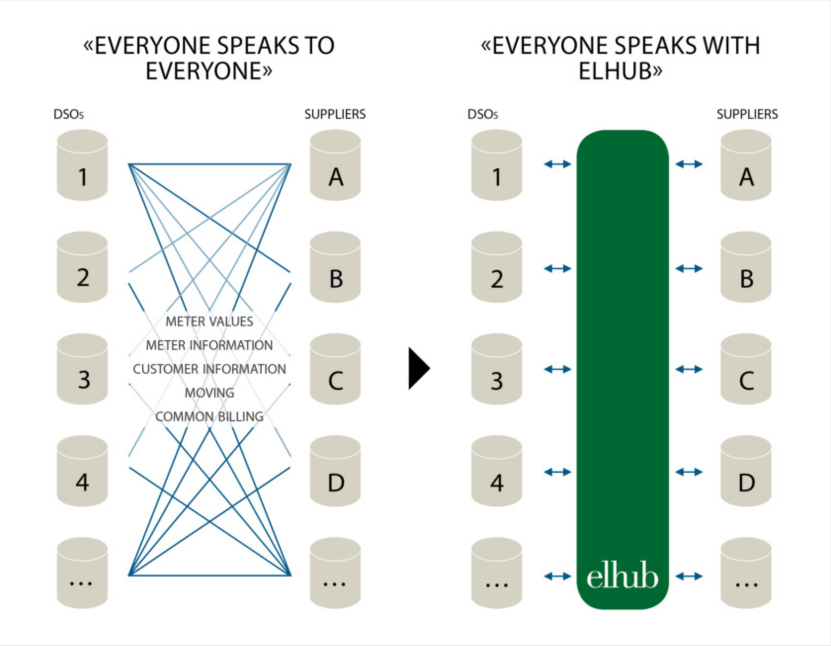
10. Bundling' or 'stacking' energy services presents communication and potential acceptance issues because the services provided often become hard to understand for the users. Projects with well-defined and easily communicable goals and common benefits are more likely to see users engage with the project. 'Stacking' may overcomplicate this.

11. It is currently unclear who determines how flexibility will be governed - for example, how different goals will be weighted or with which boundary conditions.

12. Business models optimising only for energy markets will not solve the problems of local grids and vice versa.

13. DSOs must increasingly collaborate with other actors in order to realise smart grid innovations. Evidence suggests greater collaboration with multiple sectors is more likely to lead to new forms of bundling and value stacking projects being accepted by consumers.

14. Well-defined roles in automation programmes are a key marker of their maturity, however this is often overlooked. Specifying remuneration (both paid and unpaid) can help build social license.



Government investments in technology has allowed Norway to develop new roles for consumers in energy markets. The Nordic country completed one of the earliest and fastest rollouts of smart meters in the world. In 2019, the Norwegian Transmission Operator, Stattnet, launched ElHub to automatically process metering data and improve operational efficiency *(see page 67 of full report).*

Governance and economic issues that affect a social license of automated DSM (continued):

15. The ideal business models and their relationships to different forms of automated DSM are still to be determined. This is because **the value of automation remains profoundly contested:** there is currently no agreement between the energy sector, regulators, government agencies and energy users about the value of automated demand-side controls.

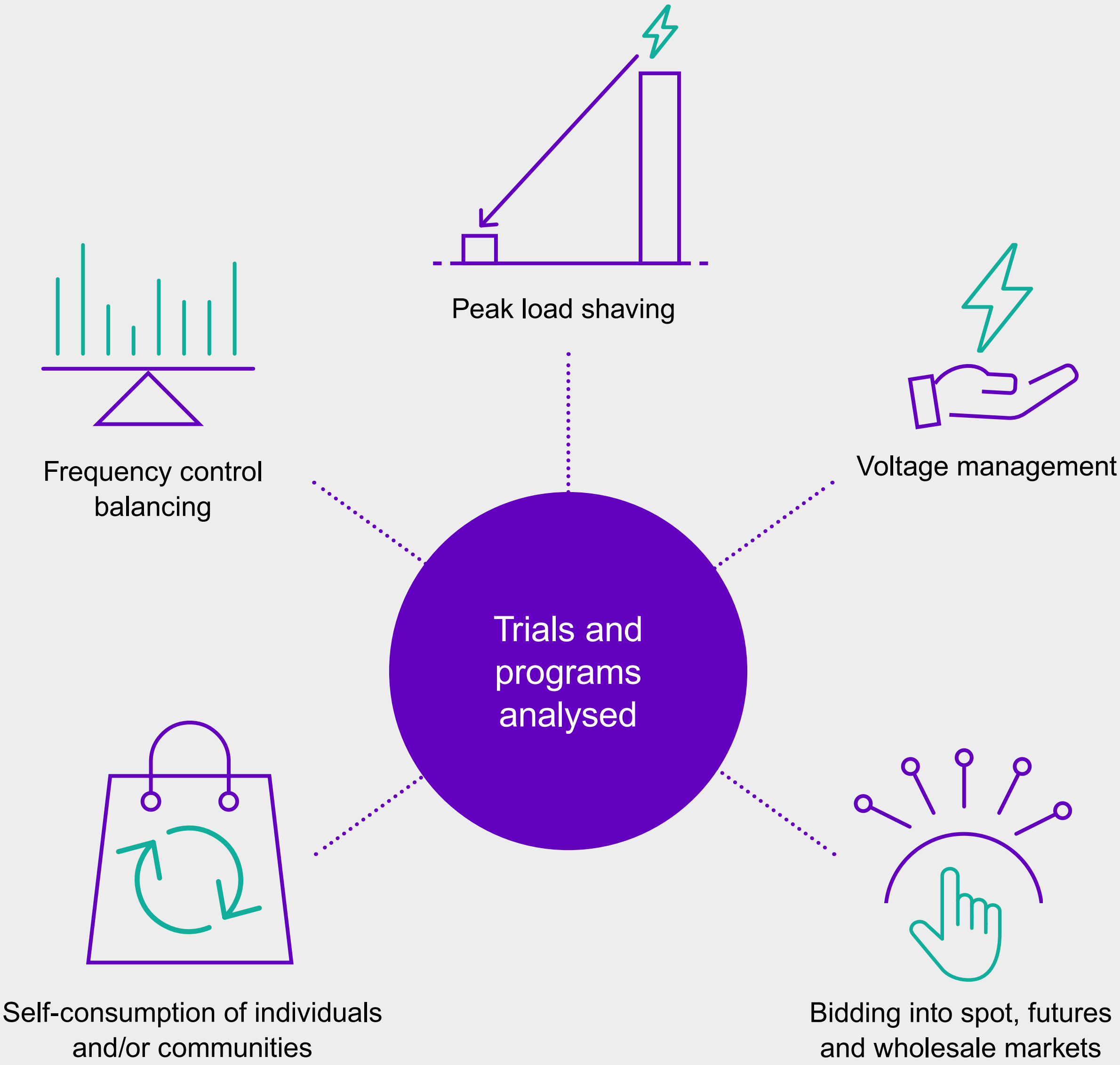
16. **Who benefits from automation projects will influence levels of acceptance and engagement by energy users.** The future may involve greater centralised control via digital platforms owned by large multinational corporations, relocalisation of energy or some combination of the two. This will be a significant energy policy decision to come in the years ahead.

> ‘The future may involve greater centralised control via digital platforms owned by large multinational corporations, relocalisation of energy or some combination of the two.’

17. Industry failure to grapple with the social diversity of settings where automation projects are being trialled is an existential threat to its ongoing viability.

18. Social science expertise has an indispensable role in the development, ongoing operation and evaluation of automated DSM programs.

Trials and programs analysed in this project addressed:



Research Approach

The research collaboration involved researchers across six countries who are deeply professionally engaged with energy policy and practice in each of their countries. Each researcher is based at an institution with multiple research projects that overlap with the concerns of this project. This expertise informed the framing and development of this project.

The case studies examined here are not strictly representative of the contexts from which they are drawn but offer insights into the commonalities and divergences of technologies, energy system reforms and social issues across the participating countries. The case studies came about through collaborations with research partners including DSOs, aggregators, energy retailers, local councils, housing providers and community organisations.

Part 1 of the full report presents profiles of each of the participating countries and the case studies of automated DSM conducted in each.

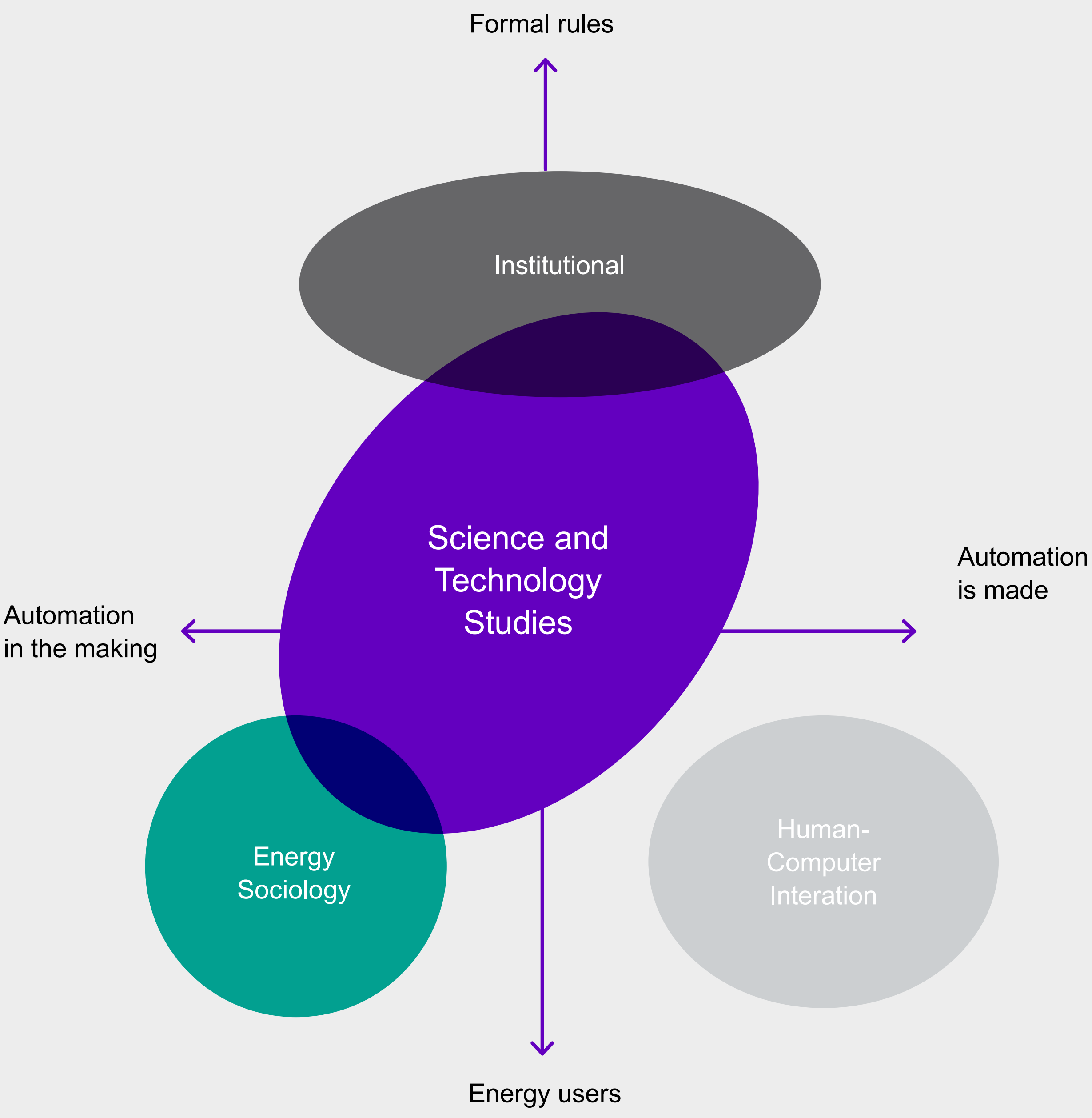
Part 2 presents an analysis of these same case studies from different disciplinary perspectives.

We collectively developed a template to collect data in each of the case studies, which incorporated aspects of automated DSM that were identified by the research group as having the potential to influence acceptance and engagement. The template was used to gather data on:

- context, aims and framing
- the actors involved and the regulatory context
- technical parameters of automation and impacts on users
- incentives for users
- information provided to users
- user interaction with the automation system
- project outcomes.

> ‘The case studies came about through collaborations with research partners including DSOs, aggregators, energy retailers, local councils, housing providers and community organisations.’

The research collaboration brings together different perspectives on what automation is, and attention to both formal rules and existing energy users' practices.

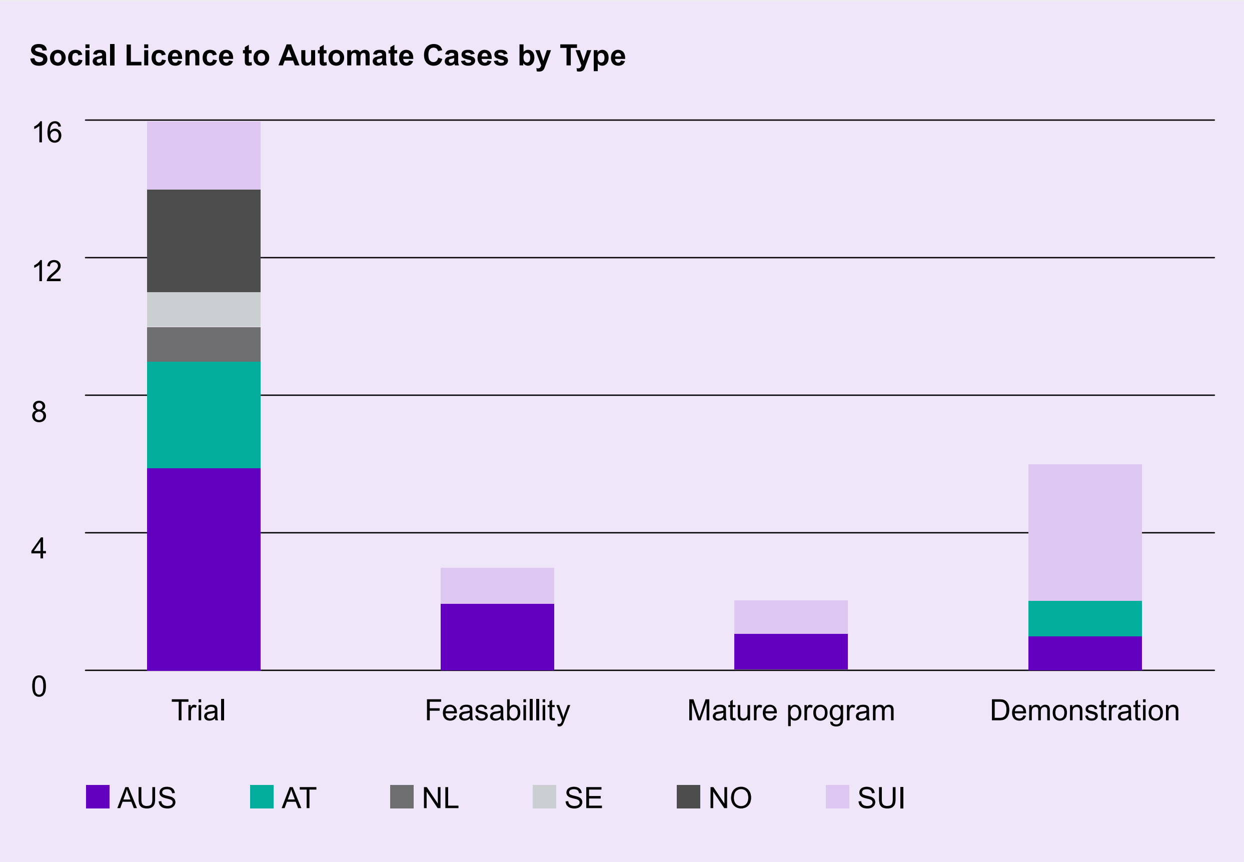


Workstream approaches to automation and scale

RESEARCH APPROACH	SCALE AND SUBJECTS	METHODS	RESEARCH QUESTION ADDRESSED
Human-Computer Interaction studies	Micro: user interaction with made technology	User surveys and interviews	How can interfaces be designed?
Energy sociology	Micro: householder and their energy activities make technology	Cultural probe methodology with user interviews	Which energy activities can be time-shifted through automation?
Science and Technology Studies	Cross-scalar: socio-technical actors (humans + technologies)	User and expert interviews, and critical documentary analysis	What are the solutions offered by automated DSM and to what extent are these aligned with users' values and interests?
Institutional and policy studies	Macro: Citizens and policies contend with rules that are re-made	Policy documentary analysis and analysis of 'institutional settings and rules' in the real-life project cases. Ostrom's Institutional Analysis and Development (IAD) framework	How can common electricity resources be effectively governed?

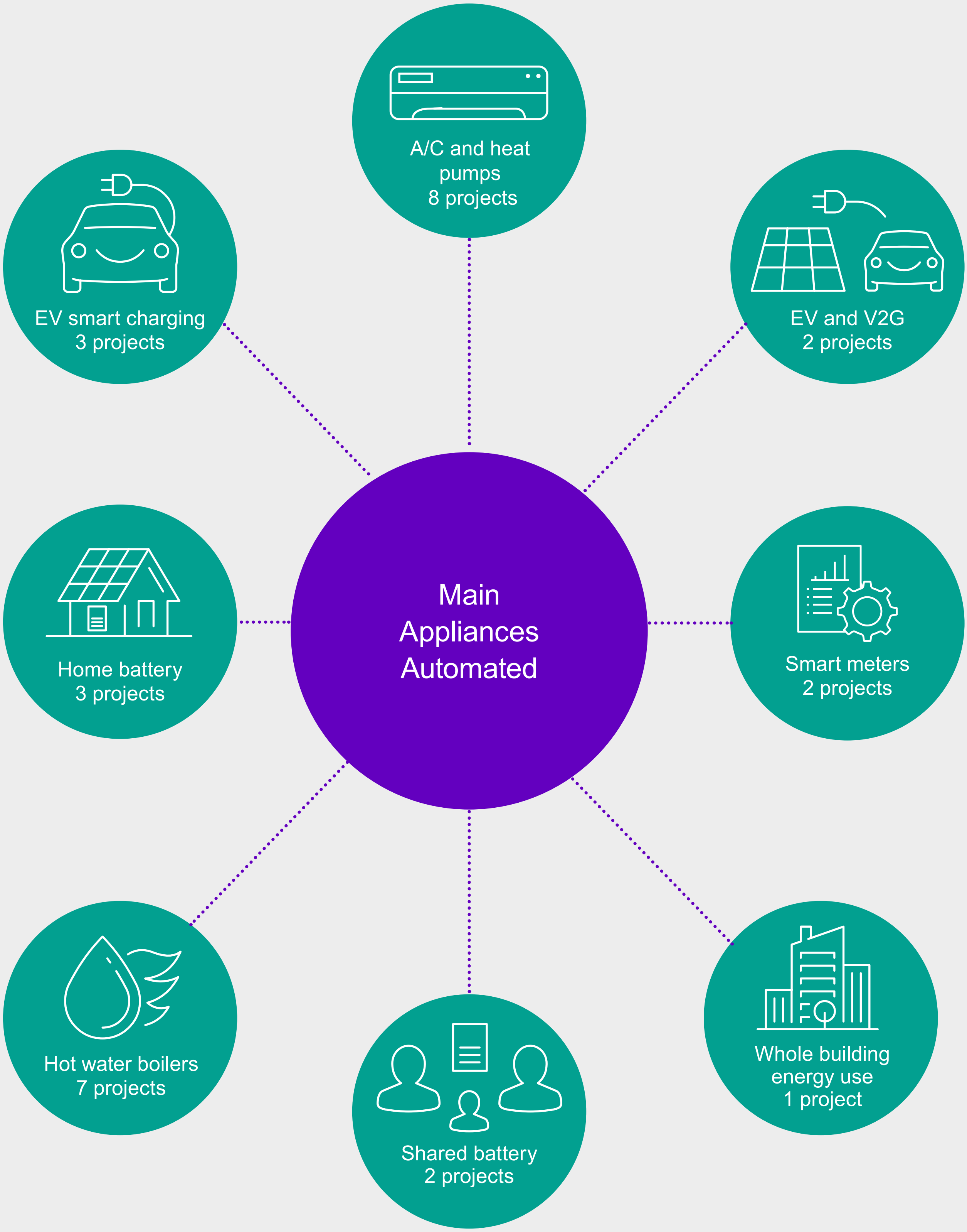
Workstream approaches

Case Study Overview



Forms of Evidence in Case Studies

- Surveys before, during and after projects
- Information events
- In-depth interviews with consumers,
- Expert interviews


A/C and heat pumps
8 projects
EV smart charging
3 projects
EV and V2G
2 projects
Main Appliances Automated
Home battery
3 projects
Smart meters
2 projects
Hot water boilers
7 projects
Shared battery
2 projects
Whole building energy use
1 project

Automation Levels

Figure: Levels of Automation

- **(Low) Automation Level 1: Manual.** Load shifting or saving is done manually by the user (automation aspect only with regards to automated notifications regarding target consumption / peak shaving phases).
- **(Low) Automation Level 2: Manual Automation.** Load shifting or saving is done via manual programming of devices or systems by the user.

- **(Med) Automation Level 3: Consensual Automation with acceptance.** The user is actively contacted by the system and must agree to an automation event, or it will not be carried out.
- **(Med) Automation Level 4: Consensual Automation with veto.** The user is actively contacted by the system and offered the chance to veto the automation event; if they do not do so, the automation is carried out.

- **(High) Automation Level 5. Restricted Automation.** The user has the possibility to restrict automation to specific requirements such as time periods or comfort zones and can monitor automation and interrupt it via the system if necessary.
- **(High) Automation Level 6: Full Automation.** The user has no possibility via the provided interaction system to interrupt automation events.

AUTOMATION LEVEL	CONSUMER INTERACTION SUCCESSES ACROSS 15 TRIAL AND DEMONSTRATION PROJECTS	INTERACTION ISSUES AND OPPORTUNITIES
Low Automation Level	• Energy consumption data well received • Consumption of savings potential • Monetary savings achieved • Energy use Forecasts	• Missing benefit communication • No personalisation options to indicate flexibility potential at specific times • Insufficient degree of interaction to motivate manual consumption shifting or shaving • Insufficient information in app notifications about saving opportunities to directly act on without visiting another platform
Medium Automation Level	• Control via ‘accept/ reject’ • Weekly reports • Market transparency • Interface simplicity (e.g. LED lights indicating PV production)	• Limited active acceptance of automation across the cases • Translation of carbon emissions and kWh to action problematic • Missing social comparison • More information on benefits • More actionable information
High Automation Level	• Participants liked choice of setting automation parameters • Communication of benefits • Interfaces were used very little • High automation was infrastructure – largely invisible • Clarity of whether interface was designed to inform or encourage action	• Participants appreciated the possibility of setting automation parameters when possible, the transparency provided on automation (mentioned most often) and communicated benefits • There were struggles with automation parameter settings and in one case there were noticeable transparency issues, leading to complaints from participants not knowing/understanding what was happening in their houses

Figure: Human-Computer Interaction Successes and Issues across 15 projects (see Chapter 8)

Example Case Studies

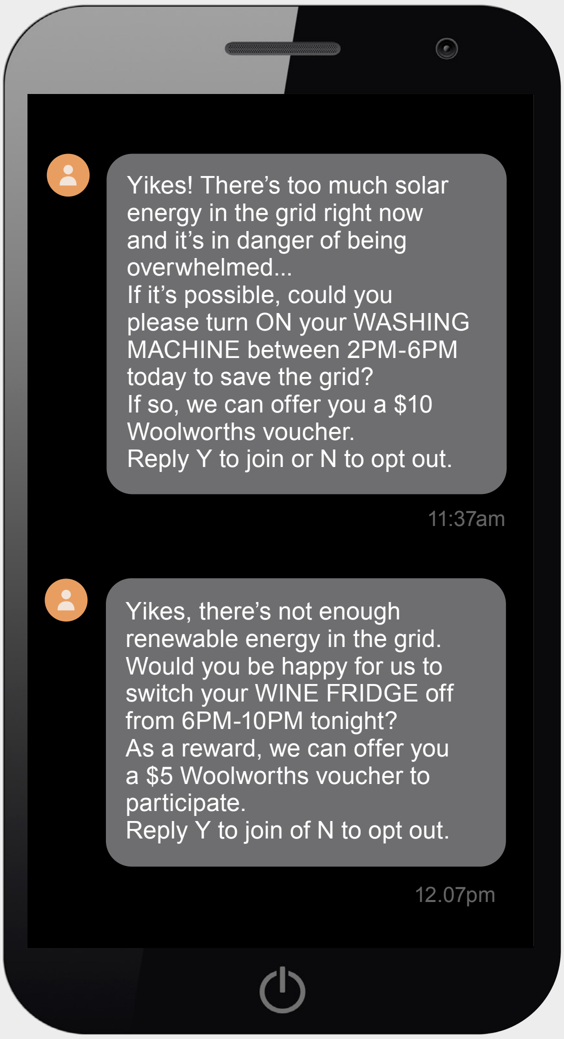
LEAFS PROJECT: LOW-MEDIUM AUTOMATION

- 250 households in Eberstallzell, with allied projects across three regions in Southern and Central Austria
- Objective communicated with users: consume as much of the produced electricity locally, by actively shifting their consumption to solar production hours to get a ‘Sun Bonus’
- Main stakeholders: distribution grid operators, who controlled automated loads and the prosumers themselves
- 250 households signed up for the program (~1/4 of households); 200 were active; and there was a post-survey with 185 households

LEAFS Project - central storage sytem in Heimschuh photo: Energie Steiermark/Symbol

REDGRID: MEDIUM AUTOMATION

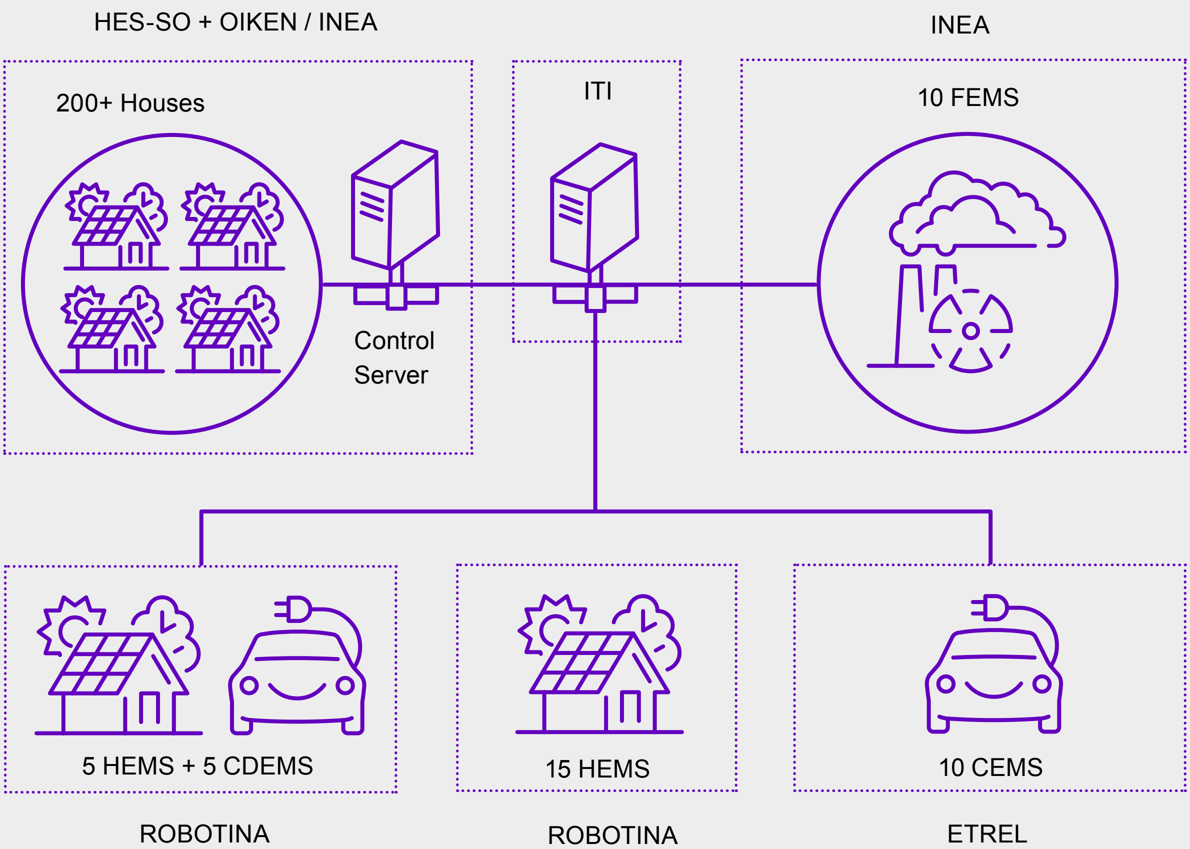
- Smart appliance control automation trial in Australia
- Rationale communicated to users: help grid during high or low demand events and receive vouchers
- RedGrid is an Australian startup company working in partnership with Universities and a housing company
- Data analysed from 20 household trial project



A text message inviting a RedGrid trial participant to join in a demand response event (see page 21 of full report).

GOFLEX: MEDIUM AUTOMATION

- Energy Community demonstration project with heat pump, electric boiler, electric heater and EV control in Valais, Switzerland
- Rationale communicated to users: peak load and energy market participation
- Project led by local Distribution System Operator
- 200 single family households and 6 EV≈ stations involved with extensive qualitative data
- Transparency of electricity consumption



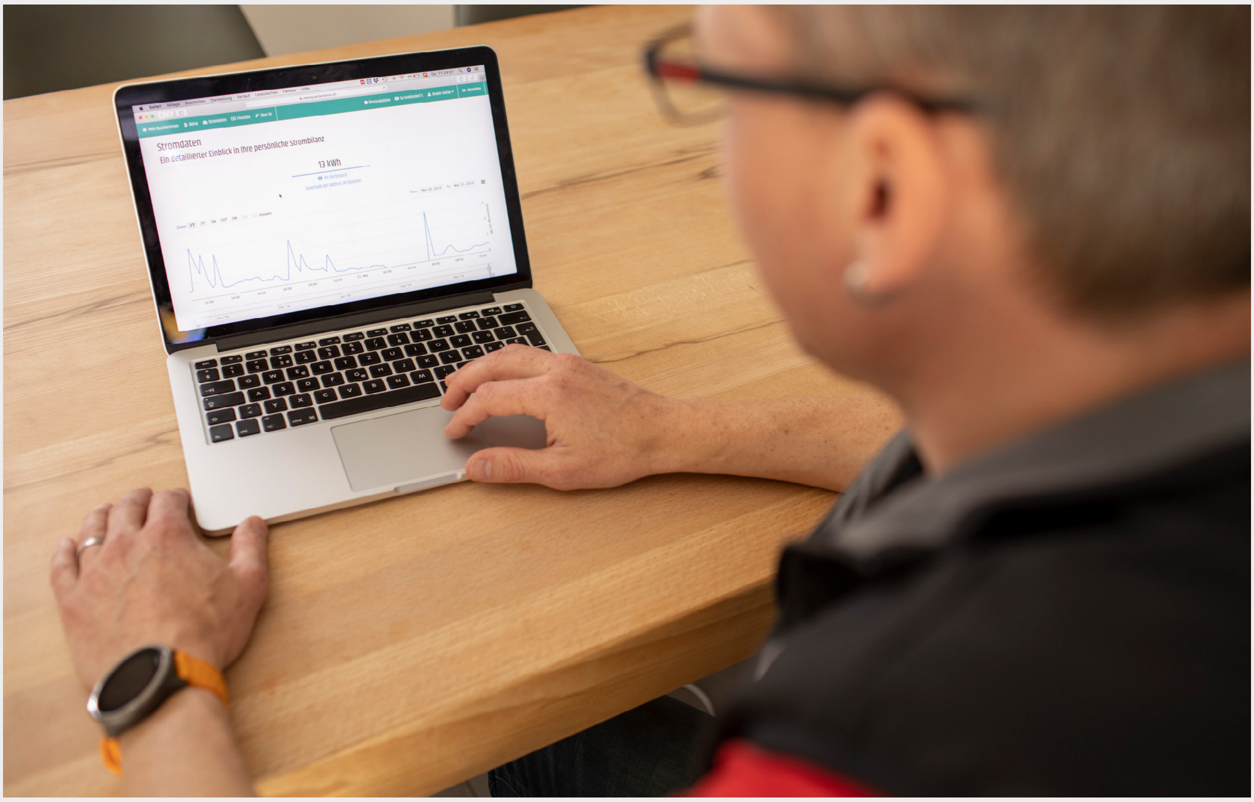
GOFLEX project peak load and balancing project (see page 99 of full report).

Aerial view of 4 apartment buildings, site of Innovative Self-Consumption project (see page 94 of the full report).

PEAKSMART: HIGH AUTOMATION

- Air-conditioning Peak Load Management program in Queensland, Australia
- Rationale communicated to users: demand management during heatwaves rewarded by cashback
- Project led by local distribution company
- First developed in 2012, now over 90 000 participants. Program is integrated with Air Conditioning sales

The Australian PeakSmart project (page 26 of full report) used cashback incentives during air conditioning purchase to enable participation in summer peak demand management events.



The QuartierStrom interface as seen by the 37 households participating in the local energy market (see page 96 of the full report).

Lessons from the case studies and analytical chapters

Lessons for project developers

- Develop and communicate a clear goal shared by the participants (e,g. avoiding blackouts during peak periods) following informed consent protocols,
- Compensate users in ways they deem fair, and
- Update users about progress of the trial or program in a suitable manner

Outcomes of mature projects:

- Organisational: People have well defined roles; business case
- Technical: achievement of goals. Meaningful, verifiable, (though rarely consulted) figures of energy use shifted or shaved
- Socio-technical: ‘invisibility’ or becoming infrastructure (users trusting and not having to think about their own role)

The rapid uptake of solar and wind energy in each of the six countries has been met with different technology responses (image: iStock).

Broader Lessons

- Public support for renewable energy does not translate into support for demand side management programs. The question of which changes automated DSM will bring to energy users' lives is crucial to a social license to automate, rather than whether the amount of renewable generation is increasing.
- A history of automation in DSM (especially ripple control of household loads such as hot water systems) aids distribution service operators in successfully developing automation programs across all countries.
- Better penetration of smart metering facilitates automation pilots and programs but does not also lead to a social license to automate. Smart meter roll-outs raise further issues for energy users that do not necessarily lead to acceptance of automation.
- Assumptions about the context of automation, and the framing of the problems to which automated DSM is directed, are embedded in culturally specific planning systems. These systems carry different assumptions about how to live well, and what should be shared. The relationship between the built environment and the framing of problems to which automation is addressed is a key distinction across the countries. For example, in Australia, 'end of pipe' automation technologies directed to users in detached households are prominent, whilst energy communities are increasingly the locus of automation technologies in Europe.
- There are no simple lessons about user acceptance at different levels of automation.
- **Articulation of shared problems** underpins a social license and collective responsibility.

The Human-Computer Interaction analysis

… revealed how technology can best support acceptance by users through interfaces and system interaction features depends greatly on the level of automation implemented.

Crucial at all levels of automation are the communication of benefits and transparency about the scope of the automation. **The role of HCI in DSM changes depending on automation level (and the related impact on and effort required of participants), shifting from one of helping, reminding, teaching, providing feedback and encouragement, to one of reassuring, justifying, and providing transparency and accountability.**

At **low levels of automation,** which involve manual shifting or manual programming of devices, actively reaching out to participants and providing them with actionable information and feedback is crucial. These can support long-term behaviour change, as will dedicated intervention strategies such as commitments, prompts, social norms communication and rewarded goal-setting. Furthermore, interfaces need to provide users with ways to indicate preferences and specify available flexibility.

At **medium levels of automation,** which involve participants' active opt-in by providing consent, or active opt-out by veto, the need to actively engage participants is reduced, but the importance of transparency about the automation increases and the need for personalisation options to accommodate the preferences and lifestyles of users remains.

At **high levels of automation,** which may or may not allow participants the possibility to restrict automation to particular parameters, the importance of actively and regularly engaging participants and providing personal noticeable benefits is reduced once they are on board with the program objectives.

The energy sociological analysis

…revealed how the prospects for a social license vary for different energy activities in the home.

This analysis explored how people are engaged in activities in the home that use energy, focussing on EV charging and the use of home appliances, particularly washing machines and dishwashers. For example, various charging routines have emerged with the take-up of EVs, each of which has its own rhythms, including: charging to maintain battery close to fully charged, charging when the battery has been depleted to a certain minimum level of charge, charging when needed, charging by default, charging around other tasks, charging when solar energy is available, and charging to minimise costs.

The considerations that are already influencing the timing of household energy activities include balancing need, cost, effort, and the availability of renewable energy. Some households are effectively already changing when they use appliances for various reasons, and some are using technology to support their energy activity planning around these priorities and considerations, using the settings of their home appliances or EVs, or associated apps, to program start and end times. The ways that people are already using technology to support their planning offer insights into how automated DSM can be designed to fit into and support household activities.

Peoples' responses to the possibility of automated control differ according to the energy loads affected and the routines and meanings associated with those loads in individual households. This aligns with earlier findings about the importance of 'flexibility capital'[2] to participation in DSM. People are more likely to be more open to automated DSM if it supports the existing approaches to energy activities in the home. Furthermore, monetary incentives alone are insufficient for participation, given the range of household, social and material factors that influence the capacity of householders to shift their use of energy to other times of the day.

Electric Vehicles are emerging as important energy resources, however more research is needed into how users, technology developers and middle actors can work together to realise their potential (see Science and Technology Studies analysis in full report) (image: iStock).

[2] Powells, G. and Fell, M.J. 2019. Flexibility capital and flexibility justice in smart energy systems, Energy Res. Soc. Sci. 54:56–59. https://doi.org/10.1016/j.erss.2019.03.015

The Science and Technology Studies analysis

… explored the problem and solution framings of automated DSM, and how the technology and the solution framings aligned with the interests and values of users. Such framings vary for direct load control, smart EV charging management and Virtual Power Plants.

The analysis followed the translation process from the establishment of the problem, the articulation of the automated DSM solution by the actors involved and their appeals to the interests of the household participants, to how these participants accepted or resisted the solution. Automated DSM is primarily seen to address challenges for grid management, and is seen as a step towards a decentralised energy future.

The way that the translation of these solutions occurs varies according to the context and actors involved. A variety of actors are involved in the negotiation processes related to automated DSM. This includes electricity retailers, network operators, aggregators, customer service representatives, electricians, automation technology manufacturers, vehicle manufacturers, consumer representative organisations, housing boards, and even energy users not participating in DSM programs or projects. Thus, the contextual specificity and contingency of the translation process must be taken into account when assessing and seeking to learn from trials and programs.

The case study participants gave several reasons for why they wanted to participate in the trial or program. Some of the reasons given were interest in new technology, financial gains, environmental concern, and community orientation.

Energy users are not isolated actors but connected to their communities, virtually and in their local neighbourhoods. These connections shape how they engage with new technologies. (image: iStock)

Energy users seem to take up automated DSM solutions, and the new or changed roles envisaged for them, to the extent that they see value in them – either at a collective or individual level. Their willingness to participate in these automated DSM solutions reflects the extent to which these solutions align with the users' motivations and priorities around energy, including the extent to which respondents expect automation to relieve them of any energy management work they would prefer not to do. Thus, the STS analysis reveals that the extent to which users see value in automated DSM solutions tends to be highly influenced by:

- **their understanding of DSM and the challenges it seeks to address.** The case studies examined in various ways how to increase 'grid sensitivity'[3] as participants became more familiar with these challenges in the energy system.
- **visibility of how their batteries, appliances or other loads are being controlled.** Access to information proved important for many users - even if they do not actively or regularly use it.
- **control over how their batteries, appliances or other loads is being orchestrated.** The ability to override or opt out of automation events is seen as important by trial and program participants. However, energy users want control that goes beyond the option to opt out: as they want to control the parameters of their participation - such as the timeframes or battery range within which their EV must be charged, for example. Automated DSM has the potential to 'help' and relieve participants of energy work *and/or* to enable them to be empowered, active participants of the energy system, depending on their preferences and how the program is set up. Most importantly, the participants in automated DSM trials voiced the need to influence and even choose the scope and terms of their participation in automated DSM programs.

> Energy users want control that goes beyond the option to opt out: as they want to control the parameters of their participation - such as the timeframes or battery range within which their EV must be charged, for example.

[3] Skjølsvold, T.M., Ryghaug, M., and Throndsen, W. 2020.European island imaginaries: Examining the actors, innovations, and renewable energy transitions of 8 islands, Energy Res. Soc. Sci. 65: 101491. https://doi.org/10.1016/j.erss.2020.101491

The Institutional and Actor analysis

…showed that many actors are required to make automation work successfully.

Where the Science and Technology Studies analysis examined the relationship between the users and the problem formulation and framings in the field of automation, the actor analysis provided evidence that **automation trial programs are profoundly collective endeavours:** initiating actors were coalitions of stakeholders, and only in some cases individual entities. DSOs often partnered with research organisations and nascent aggregation businesses specialising in communication systems and remote operation.

Second, the **most common actors across the case studies analysed were vertically integrated retailers** with supply assets. Energy retailers coupled with aggregators through VPPs to help manage price volatility across day-ahead and spot markets and take advantage of low price periods. Thirdly, the **aggregators were also the sole actors** involved in the projects with their VPPs to control the automation that can potentially earn money by offering **flexibility on imbalance settlement periods** in the balancing markets.

Municipalities were involved in initiating or implementing only a few projects analysed, and remain marginal actors compared to technology developers, DSOs and Federal agencies. Further research could look at local and municipal governments and their renewed role in energy service provision. In Australia, for example, organisations such as the Moreland Energy Foundation (now Australian Energy Foundation) and Yarra Energy Foundation are well placed to become a form of communal aggregator considering their longstanding engagement with energy efficiency and household PV systems.

Information access to granular household level comfort and other information profoundly affects the quality of predictions, however its relationship to user acceptance is complicated. Our case study analysis does not support specific rules prohibiting any specific forms of data from being shared. In many of the cases, DSOs only had access to smart meter power demand readings, without access to any other data (household temperature, etc.) that might enable more accurate automated control algorithms to ensure household comfort.

Further research is needed into how a social license to automate is gained and maintained throughout the energy transition (image: iStock).

Directions for future research

- The **climate policy implications** of the policies and programs we have analysed are complex. In particular, the alignments between declared country-level policies in NDRCs and energy efficiency, demand response and associated programs requires further analysis. On one level, some key national policies are listed which have a clear and direct role with pilot programs; however there are clearly multiple forces governing how decisions are made across different scales which will require careful analysis. Our research shows that energy users in the countries analysed are likely to respond more positively to programs framed as explicit climate change policies; and that **the broader benefits of automated demand side management tend to be undersold.** Further research is needed into how to communicate such broader benefits in a comprehensible and tangible manner to users with different value-frames.
- **Relevance of household level trust to other energy users** could be probed - for example, where there are principal/agent issues in shared housing such as a tenancy arrangement or similar.
- The analysis revealed that automated DSM prioritises certain **energy futures over others.** However, there is a need for more analysis to understand what futures these solutions construct, how these futures are being shaped and what their implications are. It would also be fruitful to analyse in more detail what elements are *not* made part of the framing and what automated DSM narratives *exclude.*

Where are the missing masses? Our trials overwhelmingly used early adopters who enthusiastically opted into new trials. These users are not representative of the wider population. (image: iStock).

- Further analysis is needed to understand the role of **cultural forces.** COVID-19 has obviously constrained our ability to conduct fieldwork *in situ* where the cases analysed have been conducted. This project initially envisaged visits to the sites of trials and programs by social scientists who are both trained in ethnography and sensitive to the institutional dilemmas driving the uptake of automated system, however this was made impossible due to COVID-19. Comparative analysis remains an ongoing research need.
- The analysis of users of automated DSM solutions reminds us of the importance of considering **who is not being included in automated DSM pilots and who is excluded.** This is likely to have ramifications for how these technologies and solutions will work. Currently, automated DSM solutions and services are being designed for and refined by participants of these trials and studies which predominantly are typical early adopters, many of whom are financially comfortable and take a special interest in technology. Some of the research methods employed in our case studies are also more inclusive of other participants. Research with more diverse energy users are needed to get more robust results.
- **The diversity of actors that are important for mobilising support** for the implementation of automated DSM solutions and services is often overlooked. Particularly, typical middle actors or intermediaries (such as housing boards, electricians etc) have been ignored and should be given more attention in future research as they have proven important in the process of enrolling energy users in automated DSM. Such attention to these actors also means thinking about procedural and epistemic justice - ensuring a diversity of ways of knowing are accommodated in policy and planning, not just economics and engineering.