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Social License to Automate 2.0

Inclusive and Community-Oriented Approaches to a Social License to Automate

FINAL REPORT

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Contents

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Abbreviations

DR - Demand Response

DSM - Demand Side Management

EC – Energy Community

ECI – Energy Community Initiative

IEA – International Energy Agency

EV - Electric Vehicle

PV - Photovoltaic

DLC - Direct Load Control

HEM - Home Energy Management

SLO – Social License to Operate

SLA – Social License to Automate

TCP – Technology Collaboration Programme

List of Figures

List of Tables

Executive Summary

Background and Motivation

The shift to a carbon-neutral energy system requires balancing energy supply and demand, especially as renewables like wind and solar are intermittent. Automated demand-side management (DSM) is crucial for this balance, adjusting consumer energy use to align with grid needs. Success relies on consumer acceptance, making the concept of the "social license to operate" (SLA) essential. A strong SLA fosters trust and ownership among consumers, which is vital for the acceptance of automated systems.

Traditional DSM approaches often treat households as homogeneous, neglecting diverse needs and motivations. Implementing diversity-sensitive strategies based on factors like gender and socio-economic status is essential for an inclusive energy transition. Energy communities can empower consumers as active participants, lowering barriers for those apprehensive about new technologies and providing support to build trust. The “Social License to Automate 2.0” Task conducted research and analysed case studies to assess flexibility potential among diverse demographics, developing a framework for inclusive DSM programs. By analysing energy communities, the Task identified features that enhance social license and reduce barriers for underrepresented groups. Re-analysing load profile data with a focus on diversity revealed insights into energy flexibility across different socio-economic contexts.

The findings highlight significant variations in consumer readiness for demand response, influenced by capacity, ability, and willingness. Recommendations focus on inclusivity in DSM, building social energy communities, and improving data collection standards for an equitable energy transition. Overall, the SLA2.0 Task provides actionable insights to foster user acceptance and design scalable DSM programs that emphasize diversity and community involvement.

The **social license** can be defined as

> “…*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.*”
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> 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. https://doi.org/10.1016/j.erss.2021.102210

Diversity Factors in Flexibility (Subtask 1)

A literature review on demand-side management (DSM) revealed gaps in how diverse user perspectives, especially gender, age, and income, are addressed. DSM technology often targets male, tech-savvy users, which limits engagement from women. Low-income households struggle to access DSM-enabling technology, risking exclusion from cost-saving options. Age disparities also impact participation, with the elderly facing digital literacy barriers and younger people constrained by limited control and information. The findings underscore the need for DSM design to account for intersecting identity factors to create fair, scalable solutions.

Ten case studies (from Austria, Ireland, Norway, Sweden, and cross-country European) were analysed regarding insights into attitudes and motivations, the social embeddedness of flexibility and the role and insights of middle actors. Key findings show that women, especially younger and more advantaged ones, are more open to energy-saving actions and home automation if incentivized. Men, in contrast, focus more on energy efficiency than on curtailment. Age also matters: Younger individuals favour automation and local wind projects, while acceptance decreases with age, particularly after 55. Higher self-reported living standards correlate with increased energy-saving actions but reduced curtailment among the wealthiest. Additionally, renters, urban residents, and larger households displayed unique energy behaviors, emphasizing the need for tailored demand-side management strategies.

Social dynamics within households are crucial for the adoption of energy flexibility, but current strategies often focus too narrowly on one household member, ignoring the ongoing negotiations and interactions that shape energy consumption. Studies from Austria, Norway, and Sweden reveal that gender roles, mental workload, and household responsibilities—particularly for women—affect participation in energy-saving practices. For example, mothers with young children often face time constraints that limit their ability to engage with sustainability measures. Additionally, while wealthier households have greater flexibility due to access to smart technologies like electric vehicles and solar panels, lower-income and elderly groups face significant barriers. Older women, though often open to energy flexibility, may lack the financial means to fully participate. In contrast, male-dominated households with access to automation technologies tend to lead energy-saving initiatives, though issues with app design and functionality can deter sustained engagement.

Middle actors, such as energy advisors and EV dealers, serve as intermediaries between policymakers and the public, helping make energy-saving technologies more accessible. Energy advisors are crucial in guiding households, but they often face challenges in reaching vulnerable groups, such as those with language barriers, limited technical skills, or financial constraints. These advisors typically engage with more affluent individuals or those undergoing major life changes, rather than younger or at-risk families. Similarly, EV dealers, if trained appropriately, can help promote automated charging solutions for electric vehicles, which is essential for managing energy use.

Case study results show that willingness to be flexible with energy use varies by gender, age, household composition, and income. Women tend to engage in manual load shifting, while men prefer technology-driven solutions. Both genders are motivated by saving money, but women are more focused on sustainability and show more socially derived flexibility due to household roles. Age influences ability to be flexible, with younger and older individuals more able to shift loads. Families with young children, especially working parents, struggle with flexibility, while flexibility improves as children grow. Higher income allows for more technology-driven flexibility, and homeowners have more control over energy systems. Ownership of technologies like electric vehicles increases willingness to shift loads.

Engagement efforts should promote shared responsibility for sustainable energy practices within households. Family-oriented workshops could provide an opportunity to educate all members about energy systems, with particular attention to young families and older individuals. Accessible education should be offered to low-income and older groups through diverse communication channels, while intergenerational knowledge sharing should be encouraged. Tailored support for underserved groups, such as older women or immigrants, should be prioritized, utilizing culturally sensitive, multilingual resources and simple digital tools. Community-based initiatives and collective goals should be promoted, particularly for older women.

Community Potential to Support a Social License for Flexibility (Subtask 2)

Energy community (EC) initiatives are crucial for advancing local renewable energy projects like solar PV and wind turbines. They promote equitable energy prosumption by encouraging community involvement in energy production, consumption, and decision-making, strengthening democracy and citizen control. Key features of ECs include shared ownership, technology mix, governance models, and value propositions such as social, environmental, and economic benefits.

In Subtask 2, a typology of ECs focused on social dimensions, emphasizing factors that build social license was developed. Dimensions considered were energy justice (distributive justice, recognition justice, and procedural justice), energy democracy, social capital and community empowerment. Key characteristics include initiation modes (top-down or bottom-up), which affect how values and perspectives are incorporated, and the actors involved (citizens, academia, public bodies, or third parties), which influence energy justice. Decision-making authority within ECs can rest with various actors like NGOs, households, or businesses, affecting empowerment. Financing and ownership models, such as self-financing, community financing, and crowdfunding, determine control over energy resources. ECs also rely on value dynamics like autonomy, environmental benefits, and equity to build trust among members. Governance structures, such as P2P trading or energy distribution keys, influence decision-making and legitimacy, while energy resource operation and cost allocation models (bottom-up, top-down, or co-governance) determine how costs and benefits are shared. These elements shape the social license and fairness of EC initiatives.

Focusing on their initiation and governance phases through 14 case studies across six countries (Switzerland, Austria, the Democratic Republic of the Congo, Tanzania, Senegal, and Brazil) were analysed with regards to the previously defines social dimensions. Energy justice primarily addressed distributive justice, with many Global North case studies focusing on minimizing costs and investment disparities. Swiss and Austrian cases emphasized equity tailored to community needs, while Tanzanian cases prioritized fair payment plans for low-income users and democratic participation. Sub-Saharan African projects involved local communities in planning and decision-making. Energy democracy was less emphasized in most cases. Swiss and Austrian projects mainly focused on financial concerns, with limited democratic participation. In contrast, Sub-Saharan African initiatives engaged communities through education and broad participation in planning, though diverse group involvement remained limited. Social capital, which fosters cooperation and trust, was crucial for the success of energy communities. In Sub-Saharan Africa, initiatives built social capital through training and job creation. Swiss and Austrian case studies showed less emphasis on building social capital, focusing more on outreach rather than fostering community identity or long-term engagement. Community empowerment was essential for strengthening social license. In the Global South, it involved training to increase local autonomy, while in the Global North, it focused on information sharing with limited direct involvement in decision-making, particularly in Austrian cases. Analysis of the cases studies regarding the potential to further a social license and DSM showed that energy community initiatives (ECIs) can help establish a Social License to automate by promoting legitimacy, credibility, and trust. By ensuring community ownership and direct benefits from energy provision, ECs distribute benefits more equitably. Democratic decision-making and community engagement in key energy issues further enhance legitimacy. Transparent communication and involvement of community leaders build credibility, while fostering social capital strengthens trust in automation technologies. Regular engagement and shared goals also contribute to long-term trust.

Although smart grid and automation technologies are mature, ECIs still face challenges such as knowledge gaps, lack of funding, and regulatory barriers. Policy support, including subsidies and alignment with regulations, is needed for successful EC implementation. Acceptance of renewable technologies is a key enabler of automation, as indicated by regional studies and interviews.

Diversity in Consumption and Data Collection for Flexibility (Subtask 3)

In ST3, four datasets with load profiles from Austria and Switzerland were analysed, containing 15-minute electricity consumption data along with socio-demographic and technology details at the household level. The Austrian datasets were from field tests, while the Swiss data was survey-based. Additionally, a survey in the Green Village, Netherlands, collected data from 8 households on energy practices. The analysis focused on evaluating energy consumption flexibility by examining consumption patterns, including load profiles, peak periods, and seasonal variations. Load curves were plotted across different socio-economic categories, and peak periods were defined for each dataset. Regression analysis assessed the impact of various factors on peak consumption, followed by heat map visualizations comparing households with and without specific appliances like saunas and heat pumps.

Results showed men to have generally had higher baseline consumption, while women experienced higher consumption peaks, especially in winter. Age had minimal impact on consumption, though younger households tended to have higher consumption peaks, possibly linked to income or household structure rather than age itself. Income played a significant role in consumption, with higher-income households exhibiting much higher baseline consumption and peaks, particularly in winter. Education showed a slight influence on consumption, with higher peaks in households with tertiary education, though education was often closely tied to income, which had a greater impact on consumption. Households with children or more members typically had higher energy consumption, with earlier peaks during the day. Households with retired or unemployed members had lower consumption, particularly in the evening. Dwelling type also mattered: homeowners and those living in houses had higher baseline and peak consumption compared to renters and those living in flats. Technology use also affected consumption patterns. Households with heat pumps consumed more energy, especially at night, while those with oil or gas heating had more constant consumption. Households with solar PV systems had higher daytime peaks, especially in summer, and those with more appliances had higher peaks. Additionally, households with saunas showed higher variability in energy consumption.

A survey conducted in the Green Village, Netherlands, aimed to address gaps in existing datasets and provide deeper insights into household energy use. It collected data on socio-demographics, appliances, and energy practices, revealing significant variability, particularly with teleworking, which influenced energy consumption. Appliance use patterns varied, with some households adhering to regular routines, while others had more flexible approaches. Seasonal factors were important, with heating influencing winter consumption and cooling habits affecting summer use. Future research should include data on electric vehicle charging and task allocation within households, offering insights into how roles impact energy consumption.

Future data collection should focus on a broad range of socio-demographic factors, including age, gender, income, and technology ownership, using targeted sampling for underrepresented groups. It should also capture detailed household behaviors like teleworking and cooking routines, as well as time-use data to identify energy consumption patterns and gender differences. Appliance-specific data, while costly, is important for understanding individual contributions to household energy use. Gendered patterns of energy use should be explored to enhance energy management programs, and intersectional factors like age, gender, and income should be considered to tailor demand-side management strategies effectively.

Flexibility Profiles

Flexibility readiness in demand response (DR) depends on various diversity factors, influencing three key dimensions: capacity, ability, and willingness. These dimensions collectively shape a household's readiness to adapt their energy usage in response to external signals or needs.

Flexibility Capacity is the physical potential for flexibility, such as prosumer technologies and shifting household loads. Men, high-income households, and homeowners show higher capacity due to access to enabling technologies. Women’s capacity is linked to their temporal flexibility, while households with and without children exhibit varying capacities based on household loads. Low-income households, tenants, and younger consumers face challenges, often due to limited access to technology. Flexibility Ability refers to knowledge, control, and awareness of energy consumption. Middle-aged individuals, men, and homeowners demonstrate strong flexibility ability through control and understanding of energy practices. Young people are adaptable but may lack control or resources. Women display it through awareness and practices. In contrast, low-income households, tenants, and older individuals struggle due to limited skills and information, hindering their flexibility ability. Households with children also face difficulties balancing time demands with energy management. Flexibility Willingness involves the motivation to engage in flexibility, often linked to technology affinity. Men, high- and medium-income households, and younger consumers show high willingness due to interest in technology. Homeowners are motivated by both incentives and technology. Low-income households are more influenced by incentives than by intrinsic willingness, while older individuals exhibit reduced willingness due to lower technology affinity.

High flexibility readiness is seen in tech-savvy, higher-income households with access to advanced technologies. Men and women both show readiness, driven by different motives: women by environmental benefits and men by technology and financial interests. Homeowners also show high readiness. Medium flexibility readiness includes younger consumers and households with children, who are interested but face limitations in resources or flexibility. Tenants also fall into this category due to restricted options. Low readiness is typical of low-income households and older consumers, who struggle with financial barriers, limited technology, and lack of knowledge. These profiles highlight how diversity influences flexibility readiness, with high readiness linked to income, homeownership, and technology, while low readiness is common in more vulnerable groups.

Diversity in flexibility readiness and the need for an expanded and more in-depth approach to the social license

Results show that incorporating the perspective of user group heterogeneity into the Social License (SL) concept enriches the analytical framework by ensuring that voices often overlooked are heard. It brings to light the diversity within households and broadens data collection efforts by introducing additional dimensions that must be considered. By accounting for these varied perspectives, the SL concept can more accurately reflect the complex realities of different user groups.

Further, community-based energy initiatives can support the development of a social license by distributing the risks, costs, and benefits of projects more equitably. Democratic decision-making and collective cooperation encourage legitimacy, ensuring diverse needs are considered. Credibility can be strengthened by transparent communication and the involvement of community leaders. Building social capital through regular engagement, shared responsibility, and cooperation can foster long-term trust and strengthen community ties.

Finally, effective data collection and analysis are crucial for supporting a social license for flexibility. By analysing load profiles and user characteristics, energy programs can better understand the specific needs of households and provide tailored recommendations. This enhances legitimacy and credibility by demonstrating the real impact of load-shifting and ensuring the alignment of energy initiatives with household values. Transparent communication of benefits and the involvement of users as active partners in decision-making can foster trust, making users feel included and valued.

Recommendations and Conclusions

The energy transition risks being both inequitable and unsustainable unless gender and diversity factors are embedded in DSM policies. Inclusivity of flexibility programs is essential not only to ensure a just transition but also to safeguard grid stability and accelerate adoption rates. Inclusive participation in Demand Side Management (DSM) should eliminate financial and technological barriers, ensuring that participation does not require costly investments or new technology. Tailored support for low-income households, through subsidies and participation opportunities via housing cooperatives, is essential. Policymakers should focus on reducing cost burdens and distributing benefits fairly. Low-tech solutions must be available for those with limited digital skills, and energy-saving initiatives should be designed to fit into everyday routines. Support for digital and energy literacy through accessible materials and workshops is key, particularly for hard-to-reach groups like women, the elderly, and low-income households.

Community engagement should focus on trust-building, transparent communication, and fair distribution of costs and benefits within energy communities (ECs). Local actors should inform citizens, especially marginalized groups, about EC participation opportunities and energy suppliers should expand their services to engage more actively with ECs and train staff to respond effectively to inquiries. Simplifying participation procedures and consolidating billing will also enhance accessibility. Fast-tracking legislative changes to support inclusivity in ECs, collaboration with practitioners, and integrating financing with government incentives will further support diverse and social energy community initiatives.

In data collection, it’s crucial to collect demographic data such as gender, age, income, and housing status, explore household roles, habits, and routines to identify gender or role-based differences in energy use. Intersectional research should inform policy design, and further investigation is needed into the effectiveness of financial incentives and the impact of energy prices on low-income groups.

Introduction

The global shift toward a carbon-neutral energy system requires more than simply replacing fossil fuels with renewable resources; it demands a new balance between energy supply and demand to accommodate the intermittent nature of renewables like wind and solar power. Automated demand-side management (DSM) has emerged as an important tool to support this balance by adjusting end-user energy consumption in response to grid needs, improving system stability, and enhancing efficiency. To be successful, however, these automated adjustments rely not only on advanced technology but also on consumer acceptance and active engagement. The role of customers, as active participants in DSM, becomes crucial—particularly when shifts in consumption happen automatically in response to grid demands. An essential element in facilitating automated demand-side management (DSM) is the concept of the "social license to operate," which emphasizes the importance of community acceptance and support for energy initiatives. A social license refers to the ongoing approval and acceptance by stakeholders and the public for projects and processes that affect them. In the context of automated DSM, obtaining a “social license to automate” (SLA) is critical for ensuring that consumers are not only aware of the benefits of automated systems but also feel comfortable and confident in their implementation. The application of the SLA concept as a tool in DSM programs can serve to foster a sense of ownership and trust, which are vital for the acceptance of automated solutions.

While DSM holds substantial potential, traditional approaches have often taken a one-size-fits-all perspective, treating households as a homogeneous group and neglecting the diverse needs, motivations, and capacities of different user segments. Diversity-sensitive DSM strategies that take into account factors such as gender, socio-economic background, household structure, and cultural influences are therefore an important in order to ensure an equitable and just energy transition that ensures the inclusion of vulnerable groups. By identifying and integrating these factors, DSM programs can become more inclusive and responsive, better aligning with varied energy-use patterns and household dynamics. This tailored approach can enhance user engagement, ensuring that the unique preferences and challenges of different demographics are addressed, thereby increasing the likelihood of successful participation in DSM initiatives, and granting of a social license to automate.

Energy communities present an especially promising pathway to support social acceptance of DSM. As collectives that manage renewable energy sources collaboratively, energy communities enable consumers to shift from passive energy users to active participants in the energy system, fostering trust and engagement through shared goals and social support. Further, community-based approaches can create accessible entry points for those with limited financial means or apprehension towards new technologies, as participation can often begin with minimal technical requirements. For technology-sceptical individuals, energy communities can provide gradual exposure to DSM tools through trusted community members, building incremental trust and easing concerns over automation. Moreover, these communities can serve as platforms for education and capacity building, equipping members with the knowledge and skills necessary to navigate the evolving energy landscape.

Alongside community-based engagement, understanding the flexibility potential of different consumer groups becomes essential. Load profiles, which capture detailed consumption patterns, can reveal how energy use varies both across demographics and within households over time. Leveraging this data helps DSM initiatives to identify distinct flexibility markers, allowing for more targeted engagement strategies. These insights also enable standardization in data quality, enhancing the reliability of load profile analyses for DSM applications and shaping future data collection practices. A more nuanced understanding of consumption patterns can inform the design of tailored incentives and support mechanisms, driving greater participation across diverse user groups.

In response to these identified needs, this “Social License to Automate 2.0” Task undertook several key initiatives to advance understanding and support of automated DSM among diverse user groups and in community settings. In Subtask 1 it conducted a literature research and case-study based analysis to identify the flexibility potential of various consumer demographics, developing a diversity-sensitive framework that considers the specific needs and motivations of different user groups. This framework provides actionable insights into how energy providers can design their programs to appeal to a broad range of consumers, ensuring that the interests of underrepresented populations are not overlooked. In Subtask 2, energy communities were closely examined to assess their potential to drive DSM engagement, developing a typology of energy community and characteristics of theirs that impact social license building and revealing though international case study analyses spanning both the global north and south how these collectives can effectively facilitate social acceptance of automation and reduce barriers for underrepresented populations. By emphasizing shared benefits and collective action, energy communities can empower individuals to participate in DSM, transforming them into advocates for energy efficiency and sustainability. In Subtask 3, load profile data from previous studies was re-analysed, using a gender- and diversity-sensitive approach, to reveal patterns of energy flexibility that align with demographic markers and household specifics. By comparing data across participating countries, the project generated insights into how flexibility varies in different socio-economic contexts and through identified gaps suggests data quality standards to guide future DSM profiling and data collection. This systematic analysis of load profiles not only enhances understanding of user behavior but also contributes to developing best practices for future research and policy implementation.

Finally, integrated results of these initiative provide diversity-specific flexibility profiles that highlights significant differences in consumer readiness to engage in demand response (DR) initiatives, influenced by factors such as capacity, ability, and willingness (Subtask 4). The findings further highlight potential impacts different diversity dimensions and community aspects can have regarding SLA building and show how data collection and analysis can contribute to the granting of a social license. Recommendations for fostering inclusivity in DSM, the building of social energy community initiatives and data collection standards to support an equitable energy transition are presented at the end of the report. Country profiles that describe relevant core characteristic regarding demographics, tariff structures and energy communities can be found in *Appendix 1: Country Profiles*, descriptions of the case studies of Subtask 1 and 3 in *Appendix 2: Case Studies* (an overview of the Subtask 2 case studies is included in the respective result description).

Through these efforts, the SLA2.0 Task contributes actionable insights for industry and policy stakeholders on fostering user acceptance and designing DSM programs that are inclusive, adaptable, and widely scalable. By prioritizing diversity and community involvement, the project aims to create a more equitable energy landscape where all consumers have the opportunity to participate in and benefit from the energy transition. The findings presented in this report provide a foundation for a more equitable and effective energy transition, strengthening DSM initiatives through a more inclusive and community-oriented understanding and application of the social license concept and setting the stage for broader public adoption of automated energy management systems. Ultimately, the Task's insights contribute to paving the way for more resilient and sustainable energy systems, ensuring that the transition to a low-carbon future is not only achievable but also inclusive for all stakeholders involved.

Following, we present the detailed results of the Social License to Automate 2.0 Task.

The role of gender and diversity factors in flexibility

Households have often been treated as a homogeneous group in Demand Side Management. However, research (including SLA1.0) has shown different motivations, needs and scope of action potential for different consumer groups. There are also indications that different groups may be disadvantaged depending on the implementation of Automated Demand Side Management, and that there is a need for target group-specific incentive mechanisms and participation opportunities. Specifically, previous research has shown that gender as well as other dimensions of diversity such as income-level, age, housing, and family situation impact energy consumers motivation and ability to engage with automated demand side management. Therefore, Subtask 1 has aimed to 1) understand the role of gender and other diversity factors in energy consumption flexibility and identify key demographic markers and 2) identify appropriate diversity-specific individual and collective engagement approaches that can support participation in automated DSM.

The work of Subtask 1 has comprised the following steps:

- An analysis of existing literature to establish state-of-the-art and delineate relevant questions for the Subtask
- Data collection and analysis based on case studies contributed by the participating countries
- A synthesis of the results as a gender- and diversity-sensitive flexibility and engagement framework

Countries participating in this Subtask were Austria (4 use cases), Ireland (2 use cases), Norway (2 use cases), Sweden (2 use cases) and Switzerland (1 use case). Overall, 14 use cases were analysed.

Analysis of existing literature

A systematic literature review was carried out in Scopus and Web of Science to identify papers concerning the interplay between DSM (including energy consumption and flexibility) and gender and diversity factors. A total of 58 papers were included in the review (search and selection procedure is further outlined in Henriksen et al., 2023).

The literature analysis shows knowledge gaps regarding the extent and depth to which diverse perspectives of energy users and their domestic contexts have been considered in research. Only a smaller subset of the literature found had engaged with the topic in depth, and then primarily in the gender category, and mostly gender, age and income had been considered among the many diversity dimensions characterizing vulnerable groups. However, the analysis also points to relevant themes within the literature in relation to gaining a social license to automate and demand side flexibility in general. We find three primary barriers:

- *In relation to gender, there is an unresolved tension between DSM technology being perceived as a masculine domain and the home as a feminine domain* (e.g. Elnakat & Gomez, 2015; Grünewald & Diakonova, 2020; Mechlenborg & Gram-Hanssen, 2022). Contributing to this is a tendency to design DSM technology and communicate its availability and benefits typically with male, technology affine users in mind, failing to engage women sufficiently. Failure to recognise the household practices to which energy is tied in with this issue.

- *In relation to income, low-income households face challenges in accessing the technology needed to enable both flexibility and savings* (e.g. Crawley et al., 2021; de Leon Barido et al., 2018; Johnson, 2020). Energy saving practices are already part of the everyday life of the energy-poor but the homes they live in are often energy-inefficient and the resources for increasing energy efficiency and DSM-enabling technology are not available. This brings the risk of excluding low-income households from the cheapest available energy when it is made dependent on being able to afford specific technology.
- *In relation to age, disparities in opportunities for youth and the elderly to participate in DSM programs and their complex reasons are insufficiently considered* (Barnicoat & Danson, 2015; Bouzarovski et al., 2013; Fjellså, Ryghaug, et al., 2021; Fjellså, Silvast, et al., 2021). The literature shows that participation of the elderly is challenged by lacking digital literacy and apprehension towards new technology, while participation of younger consumers is limited by social constraints that impact their ability to exercise control over household flexibility potential, as well as lack of information about participation options and complexity of procedures enabling participation.

Results therefore show that gender, income and age impact motivations and ability to participate and based on these findings we argue that user diversity needs to form a starting point in DSM program design for fair and scalable solutions. However, user diversity *cannot only be conceived through separate identity category variables but must be understood as overlapping and possible mutually reinforcing marginalizations. Such overlaps need further consideration.*

Case Studies Analysis

Based on the results of the literature analysis and an internal expert workshop, work within the subtask continued in three workstream addressing different perspectives of gender and diversity inclusive automated DSM program:

1. **Attitudes and motivations:** Attitudes and motivations to automated DSM in relation to gender and other aspects of diversity are important parameters that allow insights into group-specific differences on a large scale and can serve as pointers for engagement approaches. Three large datasets (2 European and 1 Irish) served as use case base for this workstream.
2. **Social embeddedness of energy flexibility:** The social embeddedness of energy consumption plays a crucial role in optimising the potential of DSM is often overlooked in applied strategies which fail to acknowledge the continuous process of negotiation and social interaction that impacts consumption patterns. The interrelation between household composition and household dynamics and their impact on willingness and ability towards

flexible energy behaviour formed the focus this workstream and was explored in 5 use cases from Austria, Sweden, and Norway.

3. **Middle actors:** Middle actors play a crucial role in making DSM as a concept more accessible, integrating it into users' everyday experiences and in reaching user groups that are otherwise hard to reach and engage through existing connections, trusted relationships, and insight knowledge. The workstream aimed to understand how this role is interpreted and carried out, who is engaged, and which insights middle actors can provide to their role. This was explored in 3 cases studies through interviews and focus groups with Swedish, Austrian and Norwegian middle actors.

To support comparability and the development of the flexibility framework, methods employed for data collection in the 10 case studies of this subtask including interview and survey questions were discussed and coordinated.

Attitudes and Motivations

The Attitudes and Motivation workstream brought together data from the 3 case studies Co-Wind (IE), Flash Eurobarometer 514 Survey[1] (EU analysed by IE) and ECHOES (EU analysed by AT) to gather more insights into the concrete impact of gender, age, and income on the willingness to be flexible with energy, as well as to identify further demographic markers with important influence. Analysis of the 2 large international data sets Flash Eurobarometer 514 (Ryan et al., 2023) and ECHOES (Garzon et al., 2023) provide broad insights into group-specific differences on a large scale. The ECHOES data set specifically deals with the question of direct load control from the grid operator, while the Eurobarometer data concerns energy saving actions more broadly.

Both analyses find gender differences in attitudes. The Sparks of change-analysis shows clear divergence between male and female energy saving roles. In almost all EU27 countries analysed (except for Italy, Portugal and Romania) females undertake a higher average number of energy-saving actions relative to males. Larger divergences exist for the Netherlands, Denmark, Finland, Austria, Malta, and Slovenia. In relation to the subgroups of actions, females carry out more curtailment on average across the countries in the data set, while males carry out more energy efficiency actions.

From the ECHOES analysis, women are more likely than their male counterparts to believe that allowing automation in their home would be beneficial to the energy transition. Similar differences are visible when it comes to remote control of appliances in exchange for a discount – females are more likely than males to accept automation in their homes if they were offered a discount. This result is statistically significant. The ECHOES data shows intersectional effects with gender and other demographic categories. Gender influences attitudes towards energy efficiency, but it varies across other categories, such as age groups and social status. Interestingly, the difference between gender responses is stronger when it interacts with social status, compared

[1] GESIS-Suche: Flash Eurobarometer 514 (EU's Response to the Energy Challenges)

to age. Being (or identifying as) male does not make a difference across social status categories, whereas being female does. In general, we see that young, advantaged females are the consumer group that would be most willing (or the least not unwilling) to accept automation.

Regarding age differences, in the Flash Eurobarometer 514 dataset, age displays non-linear effects with adopting higher numbers of curtailment energy saving actions (inverted U-shaped relationship) and transport energy saving actions (U-shaped relationship). There is a statistically weak relationship with adopting higher numbers of efficiency energy saving actions with increasing age. Comparatively, the Co-Wind case shows that younger respondents are more likely to accept a local wind farm. In the ECHOES data, younger respondents have a stronger belief that automation benefits the energy transition compared to older age groups. Stronger differences in attitudes towards automation are visible when it comes to the actual willingness to allow automation in their homes in exchange for a discount: younger people are more willing to accept automation compared to other age groups. The age group 55+ shows the lowest levels of acceptance.

In relation to income, neither Flash Eurobarometer nor the ECHOES data cover income aspects directly. Instead Sparks of change reveal insight about intentions connected to self-reported standard of living - having better self-reported standards of living is associated with higher numbers of all types of energy saving actions, although there is some evidence of a reduction in curtailment actions at higher standards of living levels. Similarly for accepting a local wind farm, Co-Wind shows an increased acceptance with higher annual household income. For the ECHOES data, self-reported social status impacts the attitude towards DLC. The less advantaged group shows lower levels of willingness to acceptance automation, compared to better-off groups. Nevertheless, this difference is not as large as, for instance, in the age group comparison. When regressing social status on responses to DLC but with discount, only the highest best-off category is statistically significant, pointing at the fact that belonging to more socially advantaged groups increases the willingness to allow automation, but that belonging to other social status categories is not a significant predictor of such willingness.

The Flash Eurobarometer analysis contributes further aspects of diversity that impact attitudes and motivation. For example, people who rent their home are less likely to engage in higher numbers of efficiency-related energy actions but are more likely to adopt higher numbers of transport related energy actions. There is no statistical relationship with being a renter and higher numbers of curtailment actions. Those living in urban areas are more likely to undertake higher numbers of curtailment actions and higher numbers of transport related energy saving actions.

Household composition also appears to have an impact. With more adults in the home, the likelihood of adopting higher numbers of equipment purchase related energy actions increases but there are less discernible effects on curtailment or transport related energy actions. The presence of children in the home increases the likelihood of adopting higher numbers of efficiency related energy actions but decreases the likelihood of adopting higher numbers of curtailment actions like turning off the lights, or unplugging appliances. The ECHOES analysis however found that other variables such as education, employment or having children/children under 14 are not significant predictors in any of the analysed questions regarding the acceptance of automation.

Engagement insights from Attitudes and Motivations

To enhance engagement in sustainable energy use and acceptance of automated demand-side management (DSM), targeted strategies are essential. Women, particularly younger and advantaged, are more open to home automation when incentivized; programs could leverage this by emphasizing automation's environmental benefits and offering tangible rewards like discounts. Further, women are more open to curtailment actions which should on one side we considered when targeted measures are designed but on the other side providing females with opportunities to engage in efficiency or investment actions needs to be explored. Men, who tend to focus on efficiency actions, might respond better to messaging about automation's long-term savings and technological benefits. Younger consumers, already more open to automation, may engage further with app-based DSM tools, while for older adults, building trust and familiarity with automation's safety and reliability is crucial. Lower-income households, for whom cost savings are a primary motivator, could benefit from subsidized or low-cost DSM options that offer immediate financial returns. Households with children, who favour efficiency actions over curtailment, could benefit from automation tools that reduce the need for active monitoring, such as smart thermostats or automated lighting. Renters, who engage less in efficiency actions, might be encouraged by flexible, non-permanent DSM solutions like smart plugs. Overall, a balance should with kept with targeted approaches that respond to inclinations visible in the results and support them while also exploring how specific user groups could become engaged towards actions, they are less likely to perform through a better understanding of barriers and improvement of framework conditions.

Social embeddedness of energy flexibility

As the literature review revealed, the social dynamics in the household and outside play a crucial role in realising the adoption and potential of DSM. Current engagement strategies appear to overlook this, focussing only on the contact person in a household without acknowledging the continuous process of negotiation and social interaction that impacts energy consumption patterns and the ability to be flexible. Therefore, a more in-depth analysis was performed on the interrelation between automated DSM, household dynamics and other social aspects using insights gained from the 5 case studies biscuit4all (AT), Serve-U (AT), JustFleks (NO) and HousingFleks (NO), and the Swedish household interviews (SE).

Flexibility and household labour

The results of biscuit4all underline that flexibility in sustainable practices varies across different life phases, affecting the frequency of activities such as washing or laptop use, daily routines, and mental workload. Mental workload, time constraints and other priorities, especially for women or parents, can restrict their ability to engage in sustainable practices. At the same time, sustainable behaviour is seen as important for setting a good example, particularly for parents. JustFleks find similar patterns in interviews with mothers with children under the age of 10, with a very routinised daily life with time constraints. While most JustFleks study participants aimed for equal responsibilities at home, the mothers took on more of the "third shift" – the mental workload of coordinating family life to keep everyone happy (Ericsson et al., 2021). Incorporating energy-saving and flexibility into this third shift requires careful planning and management. Mothers working from home showed more ability to shift activities, and more willing to do so than men working from home.

The gendered division of household labour is visible to a lesser degree in Serve-U and Swedish Interviews. In Serve-U, which developed an energy management platform to motivate consumers to manually shift energy loads, household chores related to appliances were indicated as mostly shared among household members or handled by spouses (respondents were predominantly male), with only a few participants directly managing these tasks. However, male participants typically took responsibility for energy provider choices, bill payments, and provider communications. In the Swedish Interviews with households who already engaged in load shifting, energy-demanding household chores were also stated to be more evenly shared, even though women do more laundry and more of the third shift planning labour. The male partner often handled energy provider choices and payments, even if many households divided that work as well.

In the Swedish interviews, manual load shifting was often the responsibility of the person performing the household activity, but also something they discussed with each other – asking “is now a good time to start the dishwasher, have you checked the energy price?”. Dishes and laundry were the activities most frequently shifted due to current energy price or available solar energy; however, the shifting could not impinge on comfort. In the biscuit4all families, it was often the female partner who carried out manual energy-shifting tasks, indicating a relationship between gender roles. Older males tended to have a limited perspective on potential shifting activities, focusing primarily on saving energy through actions like reducing standby consumption on devices like televisions, without considering housework-related energy use.

This gendered division of household labour including the “third shift” highlights the need to involve all household members in energy projects.

The intersections of age, income, and flexibility

The JustFleks project provides important insights with regards to the reasoning among people of older age in Norway. Co-creation workshops with elderly and representatives of the DSO show that the elderly customer group is willing to save, but unsure of which measures are appropriate, and often makes choices based on assumptions. The workshop also showed that the elderly participants were not motivated by economical gains to save energy, as they had little to gain. However, they highlighted the importance of community and social justice as motivations. They could i.e. accept to use less hot water out of solidarity, even if hot water was included in their rent. Doing what is best for the community, and knowing that your neighbour is also saving, emerged as core motivators. One participant stated: *“I would like to get* *a little less if it means that more people can get something".* However, if solutions did not entail just consequences, this could be demotivating. They wanted luxury consumption to be sanctioned and were provoked by the fact that some saved while others squandered – wasting the community's resources (by e.g. neighbours heating their driveway, while they were freezing in their apartment).

The JustFleks project further interviewed customers with rheumatism, a group often overlapping with elderly. Rheumatics have critical needs for electricity compared to other customers, as they need heat (incl. showers and saunas) for pain relief and to function in everyday life. The rheumatic customers gave insight into the benefits of being physically active in the house, and how manually turning on/off lights or heating can boost health by moving the body. Rheumatics thus gives us insight into a different kind of everyday life, where electricity and heat are important for quality of life, and where automation can promote passivity. In combination, the JustFleks use case can provide some insights into why the elderly group may be more positive towards energy curtailment as they are motivated to contribute, but more negatively view automation of energy flexibility as they have little to gain financially, but possibly also fewer flexible needs.

For those participants in Biscuit4all with low-frequency device use, such as older individuals or smaller households, there is more flexibility to shift energy usage and older individuals are indicating somewhat more ability to be flexible than younger ones. However, there is scepticism about the usefulness of shifting energy for small household loads, which can be linked to income and privilege. Students show mixed results regarding flexibility; while they have some freedom, they often lack control over their university-related schedules due to age. For those living in shared facilities, options for energy-shifting are limited, influenced by income, age, and gender. A lack of awareness or missing information also hinders shifting opportunities, especially in lower-income or urbanized areas.

The JustFleks interviews with older women also show them as promising participants of DSM programs: they are energy-conscious, and they show that their everyday rhythms are flexible, and that they are happy to shift their consumption. Because of their age, they are more detached from institutional rhythms such as daycare, schools and work. At the same time, economic conditions affect their freedom of choice and flexibility; many older women lack flexibility capital due to low income. This had the consequence that they often were freezing in their homes during winter. Being too cold in the house is not recommended, especially not for the elderly as it leads too low internal temperature and increased the risk of early death. The JustFleks interviews with low-income women of younger ages show how this group also has little energy flexibility. All informants were very concerned about electricity prices, and everyone knew what they paid for the electricity. However, they had little opportunity to change their energy consumption, because they already use minimal energy and have little power to change. Several of the informants lived in municipal flats with poor insulation, and several of them were freezing. They were not well informed about energy, 7 out of 9 had not visited their suppliers home page or knew what a DSO is. Three out of 9 had installed an app that showed electricity prices, and 1 of these did not speak Norwegian, so she had an agreement with a friend who called her every day and told her when it was cheap to vacuum and cook. They were locked in by electricity prices and other prices that govern where they will go and when they will do housework – forced to be flexible – displaying so called "locked-in flexibility".

Privilege and automation

Biscuit4all also shows that material wealth, such as owning a sufficient number of items (e.g., clothes, large appliances), allows greater flexibility in shifting energy usage, highlighting the role of income and material wealth in sustainable practices. Owning an electric vehicle (EV) or other forms of electric mobility can shift perspectives on the value of automation, reflecting class and privilege. People who perceive themselves to be socially better off also indicate overall somewhat more willingness towards providing flexibility. However, some participants perceive automation as unnecessary since they can perform tasks manually. This perspective is especially common among women and people in urban areas, who may have lower technology affinity and fewer opportunities for prosumer activities. Participants who generate their own energy, through photovoltaic systems or heat pumps, already engage in energy-shifting practices, which again reflects privilege.

This was confirmed in the Swedish interviews with participants who already had invested in automation and often had EVs, solar panels and other smart technology to support their energy-shifting practices. These participants were generally well off and they had plans to invest in more smart technology and to automate more parts of their home. This included investing in solar panels, EVs and smart heat pumps when the time came. Despite their economic situation they were generally interested in energy prices as shifting to save cost was the main motivation. Sustainability was also a motivator, particularly for children in the households. However, tracking consumption and introducing automated and smart technology into the home was a male-dominated task, even if big investments were a joint decision. Lighting, space and water heating, and EV-charging were the most commonly automated features in the home.

In the Biscuit4All results, a perceived tension between sacrifice for sustainability (green asceticism) and the idea of earning luxuries or the right to engage in unsustainable activities, justified by convenience and health reasons, emerged. This reflects a privileged perspective where individuals have the choice to opt for sustainable or unsustainable behaviours. Further, sustainability shows itself as tied to identity with some individuals viewing it as a way of life, rooted in values like respect for the environment. This identity is shaped by different life roles, such as parenthood, which affects daily routines.

The roles of gender and technology for automation

The self-chosen automation from the Swedish interviews was driven by the male partner of the household and it was mainly men who signed up for the interviews. The initiatives in Serve-U and HousingFleks also show that males were the ones who engaged with the platform and app respectively. In Serve-U, the gender gap was evident, with only male participants engaging in workshops. Female participants dropped out before the trial's end, and many non-responses suggest missed insights into household dynamics. Cited barriers leading to limited involvement were challenges such as language barriers or lack of interest from family members. Technical issues also limited app effectiveness for several participants.

In the HousingFleks studies, the main contact (35 of 38 were men) was the one who had downloaded the app. The app was perceived as useful only to “the man in the house” as it was not user-friendly and other household members lacked interest (as was observed in Serve-U). In the Swedish interviews the service and maintenance required to run the automation was exclusively performed by the male adult in the household. While some female partners and children had been more involved at the start, they had grown frustrated with the “bad apps” and their inability to do something about them, leaving the responsibility to the more tech interested men. Several Swedish households reported conflicts related to malfunctioning or hard-to-use automation especially when critical household comforts such as warm water or lighting was temporarily unavailable or not possible to control in the normal way without the apps. Similar conflicts were seen in HousingFleks, but not in Serve-U. In Sweden, many family members had developed workarounds to avoid dealing with badly designed apps and technology. This has consequences for long-term engagement as when the technology does not work seamlessly, but creates friction, it is easier to lose those users who are initially not very interested. Design of apps and similar platforms is also important for age-inclusive DSM. The elderly users in JustFleks emphasised the need for user-friendliness of the app; it has to be reader-friendly (large print), possible to give feedback, and the app had to be informative and recognisable. All participants used smartphones and apps to pay for parking and bus tickets, and felt they could learn to use the app; two of them were very clear in that they did not see the point of yet another app that demanded attention.

In addition, monitoring energy consumption and programming smart home technology takes time and had often become a hobby for the men in the Swedish interviews. They did some things because they had to, to keep the system running, but mostly because they wanted to. The hobbification of automation and load shifting however reveals tendencies that the engagement with DSM becomes a temporary phase, when the initial excitement of seeing savings or tinkering with the technology wears off.

Engagement insights from social embeddedness of energy flexibility

From an engagement perspective, biscuit4all highlights savings, environmental protection, responsibility towards future generations and autonomy as core motivators for sustainable energy consumption habits and prosumer activities that should be considered in communication and feedback on both individual and collective levels. As important barriers for sustainable energy consumption and engagement with DSM, investment costs, lack of opportunity due to housing situation or similar, convenience and limited temporal capacity are underlined. The older women from JustFleks highlight their social motivation as often higher than the financial one. That you should work together to achieve a common goal is a norm they have internalized, and if the community encourages them to reduce and relocate electricity use, they do so. The Swedish households also highlighted community, in addition to cost-saving, especially in relation to DLC – if they were to hand over control of their flexibility to an outside actor they needed to trust the actor behind the technology, so that they could make sure that shifting loads benefitted the community or the grid, and not the company making profits.

To engage diverse households in sustainable energy practices, it is vital to involve all members, not just the primary contact who often are men. Since women typically handle manual energy tasks while men manage finances and digital tools, strategies should promote shared responsibility. Tailoring engagement by household composition is crucial — families with young children have limited flexibility, while older individuals, especially women, have more capacity to shift energy use. Energy literacy is a major barrier, especially for low-income women. Simple, accessible education and financial support for energy-saving technologies can help overcome this. While automation appeals to some, many prefer manual control, so solutions should offer both options. Wealthier households tend to participate more in energy-saving efforts, so programs should offer incentives for lower-income families and promote community-based initiatives. Addressing the gender gap by involving both men and women in energy decision-making is key to fostering more inclusive and sustainable energy practices.

Middle Actors

Finally, the subtask has explored the potential of various forms of middle actors to engage a more diverse set of households in energy flexibility, and to engage the whole household through the 3 cases studies Enough?! (SE), biscuit4all (AT), and secret EV-buyer interviews (NO). ‘Middle actors’ is a concept introduced by Janda & Parag (2014) to describe influential actors between policymakers (top-level) and the general public (bottom-level). Middle actors are said to play a crucial role in making technology more accessible to users and bridging the gap between technology and its effective use. They can include individuals or entities like consultants, installers, advisors, or service providers who facilitate the adoption and integration of technology into everyday practices and interactions. Insights from energy advisers and salespeople could be gathered in the 3 case studies biscuit4all (AT), Enough?! (SE), and Secret EV-buyer interviews (NO).

In Enough?! energy and climate advisors were interviewed as a potential middle actor for DSM. The advisors work under the directive of the energy agency, but also within the local structure of their municipality. They are therefore constrained in which issues they can prioritise to address, but this can also be influenced. They represent an interesting middle actor for DSM as they already have contact with households and established channels for engagement. They also provide advice on the full range of strategies from behaviour change, fully utilising existing technology to investments in new technology. From an inclusionary perspective, they are tasked with providing impartial (non-commercial) advice that meets households “where they are”. However, they themselves see limitations in their role as the people who seek their advice are not always the ones who need it. Advice-seekers are mostly men (two thirds), middle-aged or older, affluent but economy-driven, and looking for confirmation on their planned investment. The energy and climate advisors wish they could reach young (soon-to-be) families in the market for their first house as there they can be of greatest help to avoid people getting locked into non-optimal heating systems, building plans and insurance issues. Instead, they meet these clients later when the systems or building no longer works from an energy perspective, or when they undergo big life changes (kids moved out, partner passed away). Especially older women whose partner passed away and that are overwhelmed and do not know their energy system and cannot afford to pay for comfort heating with one income/pension. Their experiences in trying to engage a more diverse group of people reflects in many ways the same challenges as DSM have.

A workshop with energy advisors in Austria who regularly work with vulnerable consumers provided insights into the particular situations and needs of these consumers. Similar to Enough?!, these advisors are constrained with regards to their access to vulnerable consumer groups and only able to provide their services (for free) to consumers they were directed to through energy providers or social organisations because of payment issues. According to the interviewed advisors, motivations for sustainable behavior among the vulnerable consumers they work with vary, with climate being a weak motivator, especially for people with a migration background, who often show little interest in climate-related issues. Older Austrian women on minimum pensions, however, tend to be more concerned about climate change, often expressing frustration that they make efforts to be sustainable while others are wasteful. Key barriers and challenges include a lack of familiarity with energy-saving practices, such as heating efficiently or understanding thermostats, particularly among migrants. Many do not know their rights or have general knowledge of the social systems in the country, such as housing, cooking, washing, or waste separation, due to language barriers or literacy issues. Differences in values also play a role, with practices like cycling being associated with poverty or low status, and large refrigerators or meat consumption linked to providing for one's family as a symbol of status. What is unfamiliar is often rejected, highlighting the need for tailored communication strategies. Digital solutions are difficult for some groups, making paper brochures with images more effective. Even when digital devices are available, many lack the skills to use them properly, often resorting to photographing websites rather than engaging with them. For example, accessing the Vienna website with its login system is a challenge. Trust is not a major issue, but the overall system is not well understood. In general, their costumer group struggles with a multitude of intertwined challenges that often include health concerns, unemployment, and other problems, forming cascading vulnerabilities that cannot be solved separately but need to be addressed in their compounded form.

The secret buyer interviews with EV-dealers in Norway represent a different kind of middle actor. Selling EVs with the infrastructure for automated charging was a new challenge to them and their attitudes and knowledge varied. Out of 51 sellers, 20 were inclined to package solutions for electric car sales that included charging box, electric cable and electricians. They also represented automated charging differently to the buyers – from something only for the particularly interested to a simple set up for everyone. The EV sellers can, if they get the proper training, be an important middle actor to get the social license of new EV owners to automatically charge there EV to avoid peaks.

Engagement insights from middle actors

Middle actors provide a number of important insights into engaging diverse groups of consumers. To engage vulnerable users in sustainable energy practices, in-person workshops at community centres can contribute to bridge literacy and digital gaps and collaboration with community leaders to shift status symbols towards smart, resource-efficient living. Simplified guides and personal consultations should be provided for marginalized consumer struggling to managing energy costs to ensure a safe space and help them to identify applicable solutions in their current situation. Communication material should be made available in multiple languages and formats, including physical materials for those less comfortable with digital tools. Young families and first-time homebuyers and builders should be engaged with advice on important early energy-related decisions such as heating systems and insolation that have long-term cost and sustainability effects and family-oriented workshops to engage all household members and offer ongoing support for households after major life changes can be another important tool. Middle actors have an important role in reaching hard-to-reach and vulnerable consumer groups that should not be underestimated.

Flexibility Framework

To summarise the insights gained from the three workstreams and the literature study, results were integrated into an overview framework providing insights on consumer flexibility. The framework aims to delineate the insights gained in relation to demographic variables that together show the flexibility diversity of different user groups. However, the integrated analysis shows that is not straight-forward and results from case studies are not as clearcut as literature would indicate. There are important intersections of gender, age, and income with aspects such as interest in technology and technological literacy, division of household labour, children in household, amount of, their age, and the working situation of the parents, home ownership and the control to make investments in home, as well as the ownership of technology like EVs, PVs and smart tech with large loads. The framework tries to highlight these intersections and how they affect individual’s willingness and ability to adopt automated demand side flexibility.

For the framework development, willingness and ability were split into four connected aspects to further clarify how different people are differently willing and able to adopt automated demand side flexibility. The four aspects are:

- Willingness to be flexible with energy, which describes a general willingness to shift or reduce energy loads
- Acceptance of external control, which describes the specific willingness to allow an outside actor to shift energy loads
- Technology-derived ability to be flexible with energy which describes flexibility derived from ownership of energy technologies which directly afford flexibility (Powells & Fell, 2019)
- Socially-derived ability to be flexible which describes flexibility from changes to daily activities and routines (Powells & Fell, 2019)

Gender, household labour and technological interests

In relation to gender, we can see that regarding the *willingness to be flexible* with energy use, women have been shown to engage more in load shifting behaviour than men, and women state that they are willing to be flexible if it fits into household routines and does not interfere with everyday life. Some men also appear interested in load shifting if they can automate the shifting - enabling them to shift “without noticing” the effects on everyday life. Saving money is a core driving force for all, but more men are also driven by a strong technological interest and more women by sustainability motives.

Regarding the *willingness to accept external control* of load shifting, results are mixed. For women, some results showed a higher likelihood to allow direct load control and see the benefits of automation for the energy transition, some show automation as perceived to be unnecessary because the small everyday loads will not contribute enough, and other show that gender does not have an effect on the willingness to accept external control of load shifting.

Larger differences between genders appear when looking at *ability to be flexible* with energy use. Due to their increased technology-affinity, men are more likely to have *technology derived flexibility* ability. Men show a higher tendency to take a technology-driven perspective on load shifting, including PV, heat pump, smart homes, and investing in energy-efficiency technology. Women on the other hand are more likely to have an activity-based perspective on load shifting, more willing to do curtailment activities, and perform more of manual load shifting in households already. However, women also do more of the shiftable activities and therefore obliged to do the load shifting as well – relying on *socially derived flexibility* (or at the mercy of socially derived flexibility).

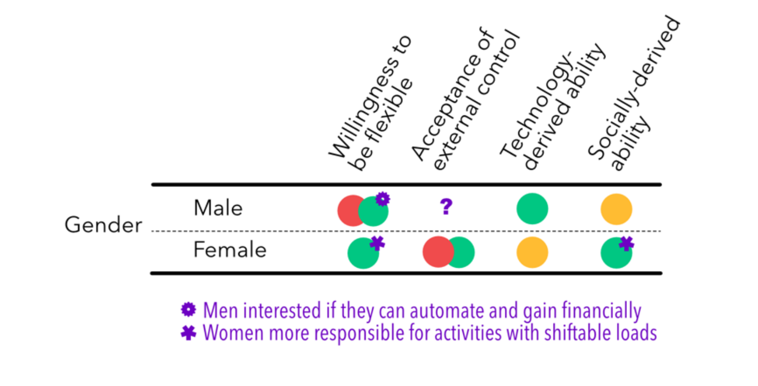

Figure 1: Gender Flexibility Framework

Age, life stage, and household composition

Willingness to be flexible with energy use varies with age. The willingness to shift energy loads to support system balance is higher among younger and older individuals, than among people of middle age. Willingness to shift is a U-curve, while willingness to accept external control decreases with increased age, with young, advantaged, women as the most willing (or the least not willing) to accept automation.

The *ability to be flexible* with energy use is mixed across ages and seems to be dependent on other factors rather than age itself - circumstances often connected with stages of life. Socially derived flexibility comes with less strictly structured days; e.g. being a pensioner or student with less rigid schedules, not having children. However some younger people have inflexible schedules, and some elderly have needs that make them inflexible. The technology derived ability is also mixed where younger people are more likely to own smart devices, but less likely to have control over their energy systems or housing, and more likely to share facilities. For individuals who are older, ability varies with house ownership, technology interest, income, and health.

In relation to age, families with children stand out among the life stages. Families with children stand out as a life stage where motivation is conflicted, and *socio-temporal ability* is low. Families with young children and working parents appear to have lowest socially derived flexibility, especially noticed by women, and flexibility increases somewhat as children age. Families with children are more likely to have *technology-derived flexibility* and adopt equipment to reduce energy consumption.

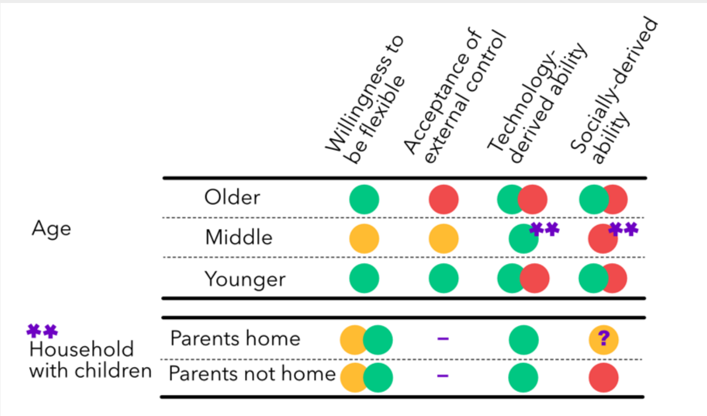

Figure 2: Age Flexibility Framework

Income and ownership of technology

Regarding differences in income, there were indications of differences in *willingness to be flexible* with energy use, pointing to higher willingness with higher income, but also data indicating that both high- and low-income groups are willing to shift, which may indicate an interest in general. There also seem to be no differences in relation to income when it comes to the willingness to accept external control or automation of load shifting. However, *ability to be flexible* with energy use varies with income, especially *technologically derived ability*. Low-income households have low tech-derived ability as they have less money to invest in energy tech and are more reliant on old appliances and other technology. They thus must rely more on *socially derived flexibility* if they wish to be flexible.

House-ownership stands out as a factor impacting willingness and ability to be flexible in relation to income. House-ownership implies control over the house and its energy system, the ability to make investments and alterations to increase the *technology derived flexibility*. However, making such investments also requires a higher income, and low income houseowners can become locked into their inefficient houses, unable to invest in measures that would lower electricity consumption or shift to when it is cheaper. People who do not own a house have less reason and ability to be flexible as they do not have control over installations like prosumer technology. People who do not own a house are also more likely to share facilities, like laundry rooms, which limits potential load shifting as washing happens in communal space when time slots are available. Ownership of other goods also has an impact. Owning EVs or prosumer technology seems to increase willingness to be flexible as it is easy to understand the benefits of load shifting in relation to those technologies. Households that produce their own energy or own an EV seem to shift loads already. Owning many resources in the form of clothes or dishes can also enable shifting of laundry or washing practices.

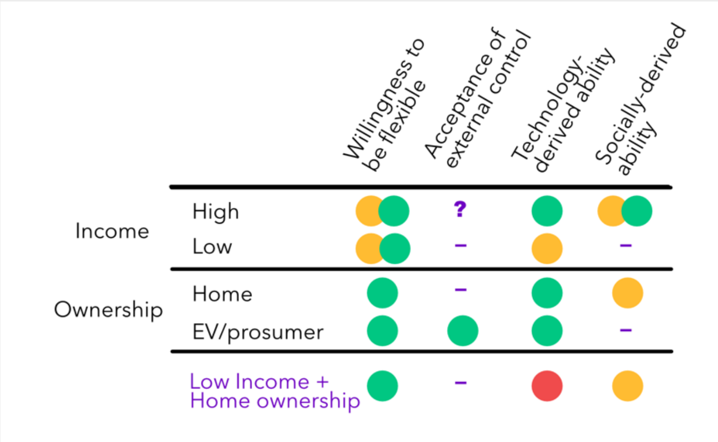

Figure 3: Income and Ownership Flexibility Framework

Engagement of Diverse User Groups

In order to engage diverse user groups, promoting shared responsibility among household members is crucial, as sustainable practices are a collective effort. Special attention should be given to supporting women, particularly those with limited flexibility, by providing resources and energy-saving tips tailored to their routines. Family-oriented workshops should empower all household members to understand their energy systems. Proactive outreach to young families is recommended, guiding them early in their housing decisions with tailored communication materials and workshops.

Engagement efforts should further recognize the willingness of older individuals, especially women, to shift energy use and highlight the health and cost benefits of energy flexibility, as well as support community activities in this context. Accessible education is essential, particularly for low-income groups and older individuals with low energy literacy, using diverse communication channels, including printed materials and community workshops. Additionally, supporting intergenerational knowledge sharing by involving older women as role models and younger consumers as digital experts can enhance sustainability efforts.

Tailored support for underserved demographics, such as older women or immigrants, is necessary, utilizing local community centres and partnerships to extend reach and inclusivity and provide safe spaces for marginalized groups. Communicating in multiple languages and culturally sensitive formats is important for engaging diverse communities. Offering simple apps and analog solutions can help those uncomfortable with digital tools, while emphasizing convenience alongside automation is vital, especially for women who prefer manual control. Community-based initiatives and collective goals resonate well, particularly for older women.

Table 1 below maps individual and collective engagement recommendations regarding diversity dimensions.

Table 1: Gender- and Diversity-specific Engagement Recommendations

Engagement Recommendations	Gender	Age	Income	Culture & Ethnicity
Inclusive technology design: Ensure that energy management technologies are designed for ease of use by all household members, not just the primary contact (often men). Interfaces should be intuitive and user-friendly, accommodating different levels of tech literacy, especially for women who often manage energy-related household chores.	x	x		
Shared responsibility: Promote shared responsibility for energy management within the household by involving all family members, including children and spouses. Campaigns should emphasize that sustainable practices are a collective household effort, rather than an individual task.	x	x		
Family-oriented workshops: Create energy workshops or advice sessions that involve the whole family, emphasizing intergenerational knowledge-sharing and ensuring that all members understand the energy systems in their home. This could empower more household members to make informed decisions.	x	x		
Proactive engagement of young families: Design outreach campaigns aimed specifically at young families or those entering the housing market for the first time to reach these households early in the decision-making process, helping them avoid suboptimal heating or energy systems. Create communication materials or workshops tailored to this life stage, focusing on long-term cost savings, optimal building plans, and energy-efficiency investments.	x	x		
Support for women in energy-shifting: Acknowledge that women, particularly mothers, often have limited flexibility due to their time constraints and	x			

responsibilities, while at the same time have a positive intention towards shifting. Provide resources that cater to their specific needs.				
Targeting older individuals: Older people, especially older women, are often more willing to shift energy use due to flexible schedules. Encourage this group by highlighting the benefits of energy flexibility for health (e.g., maintaining warmth in winter) and savings, and ensure that solutions are easy to adopt.	x	x		
Support intergenerational knowledge sharing: Create intergenerational knowledge-sharing opportunities with younger generations who are more digitally literate and tech-savvy and older generations, specifically women, who are climate conscious and more flexible.		x		
Multilingualism in communication: Ensure that information is disseminated in multiple languages and culturally sensitive formats, using trusted local intermediaries to build engagement. Ensure that these tools are adaptable to different languages and literacy levels.				x
Accessible education: Many participants, especially low-income groups and older participants, have low energy literacy and digital skills. Provide educational materials in various formats (e.g., workshops, brochures, videos) to ensure everyone can understand energy systems and how to optimize them.		x	x	
Diverse channels of communication: Use accessible, non-digital channels like printed materials, in-home consultations, and community workshops, as many hard-to-reach groups have lower digital literacy or may be less inclined to seek advice online. Use a variety of digital channels to reach different generations.	x	x	x	x
Simple apps and analog solutions: Create simple apps for managing energy or provide analog alternatives (such as printed schedules for energy-saving times) for households that struggle with digital tools. Support these efforts with physical materials and phone-based services.	x	x	x	x
Community-based initiatives: Older women and those with higher social motivation respond well to collective goals and working towards a common purpose. Promote community energy-saving challenges, where households work together to meet energy targets.	x	x		x
Promote long term engagement: By redirecting communication away from the stereotypical male, tech-interested, money-saving, profile who tend to see energy management as a temporary hobby, engagement can be made more long-term.	x	x		

Use community centres and leaders to access hard-to reach groups: Organize in-person workshops, practical demonstrations or training sessions in local community centres with community leaders to bridge literacy or digital gaps.	x	x	x	x
Partnerships with local community groups: Existing DSM programs and energy communities could collaborate with local municipalities, women's organizations, or migrant associations to extend their reach and meet diverse communities where they are.	x	x		x
Flexible program offerings: Energy advisers, who already have established contact with households, should be empowered to adapt their advice based on household-specific needs, going beyond the constraints of their standard priorities and enabling them to address specific vulnerabilities.	x	x	x	x

Conclusions

The integrated results of Subtask 1 stress that intersectionality is a crucial perspective in the development of DSM initiatives and systems. The intersection of demographic variables, along with other aspects such as interest in technology etc., appears to impact both willingness to join these programmes but also centrally the ability to be flexible. Depending on how programmes, associated technologies and incentivization are designed, automated DSM risks advantaging already privilege users while disadvantaging others who may already be energy poor. This is especially true if the incentivization and motivation focuses solely on financial means.

Our results show that many groups would be willing to shift their energy use to benefit community and the environment, given that the conditions for doing so are just. A diverse group of people may accept automated demand side management, if it is accessible, does not unjustly impact them economically, is not "noticeable" in practice and does not allow some people to waste energy while others have to save – this must be considered for a social license to automate, and in the designs of programmes and policy.

The relationship between household and individual is also crucial to address. Much research on attitudes and motivations is conducted at an individual level, while pilots and the case studies forming the base of the presented results show that the household, its composition and preconditions have a large effect on the willingness and ability. Together this implies that to engage a diverse population long-term in DSM, the household as a whole must be engaged, the technology involved designed with multiple users in mind, and the diverse motivations of household taken into account and catered to.

Subtask 2: Contribution potential of energy communities

This chapter explores the contribution potential of energy communities for the social license (to automate) with a mixed-methods approach which combines both conceptual analysis and empirical analysis. We aimed at synthesizing theoretical frameworks with real-world data to offer a comprehensive understanding.

Firstly, the conceptual analysis involved critically examining and clarifying the key ideas, concepts, and theories relevant to the energy communities, social dimensions of energy communities and social license concept. We created a typology for energy communities guided by 'social impact' and 'social license' as sensitising concepts that move beyond focusing on the techno-economic outcomes and business models of EC initiatives but draw attention to the diverse community of stakeholders and social processes. We asked the following research question to develop a typology of energy communities to analyse EC initiatives to explicitly identify where social dimensions can become tangible:

- *What are the pertinent features of an EC typology that delineate the social dimensions of EC that are elemental to building social license?*

Secondly, the empirical analysis involved collecting and analysing via in-depth interviews with the stakeholders of individual case studies of EC initiatives, such as energy community managers and/or members/inhabitants of the energy communities from diverse countries under the community typologies framed in this study. We aimed to provide in-depth empirical insights into practices, experiences, and knowledge regarding how different actions, roles, and mechanisms have been undertaken to address social aspects and strengthen the social license (to automate) in EC initiatives. We asked the following research questions:

- *Whether and how are social dimensions addressed within the existing diverse EC community initiatives?*
- *What are the processes, strategies and instruments that have been / should be included in energy communities to help the development of social dimensions in energy communities hence building the social license for local energy communities, and activities within such as automation and other demand side management schemes?*

Conceptual framework for developing a typology for energy community initiatives

Concepts with regards to energy communities, social dimensions and social license

Energy community (EC) initiatives are considered essential instruments to boost the diffusion of renewable generation units such as rooftop solar Photovoltaics (PV) and wind turbine parks in local regions. Models of community-based renewable energy projects with local actors are seen as an ideal opportunity to promote socially more equitable models of renewable energy prosumption (energy production and consumption), to strengthen democratic decision-making and citizen control over renewable energy, and to stimulate energy citizenship. Indeed, when defining energy communities, regardless of their specific forms, they share the common characteristic of high levels of citizen agency and involvement in ownership, management, and benefit distribution. The collective nature of these initiatives is emphasized through the concept of 'ownership' as a ‘collective commons’, wherein community members exert control over the development, production, and consumption of energy. In energy communities, community members, both individually and collectively, act as residual claimants of the benefits generated by the initiative.

While the importance of incorporating the social dimensions of Energy Community (EC) initiatives into research is often highlighted, many studies still focus on categorizing these initiatives by business models and typologies rather than social processes. Common characteristics identified include the value propositions (political, social, environmental, economic, technological, and energy autonomy), technology mix, main activities, and governance models.

Methodology

We employed a multistage research methodology to develop the typology. In the initial phase, we established the foundational framework for the typology based on theoretical conceptualisation of energy communities and critical review of the literature with regards to conceptualisations of energy communities. We aimed to create features for the typology that capture the social dimensions of energy communities (ECs), essential for building social license.

The second phase involved designing a sampling strategy, which was grounded in real-world case studies that reflect the identified characteristics, enabling us to explore the available options. During the third phase, after several iterative refinements, we created a typology consisting of 27 Energy Community (EC) initiative options. Table 2 synthesizes key themes of these dimensions, drawn from literature reviews and the social license concept, highlighting common elements.

Table 2: Synthesis of key elements of social impact and social licence concepts, and pertinent features of Energy Communities

Social dimensions of EC initiatives	Link to Social License concept	Features in the typology of the energy communities
Energy justice		
Distributive justice	• Social license is achieved through the application of distributional justice principles (MacPhail et al., 2023). Questions such as “who will benefit from new initiatives, who will lose, and who will have access to them?” lie at the heart of the prospects for a project (Whitton et al., 2017). The way how costs/risks and benefits of projects are distributed is important to develop legitimacy and	- Governance of energy resource operation and cost allocation - Financing options

	acceptance with citizens. People reject situations where they perceive the distribution is unfair.	
Recognition	• SLO concept brings the attention to the recognitional justice where diverse needs, expectations and values are considered and engaged in the dialogue (Adams et al., 2021). Acknowledging and respecting these points and encourage cooperation to achieve agreement, a key aspect of earning legitimacy.	- Mode of initiating the EC - Actors initiating the EC - Actors within the EC initiatives - Value dynamics of the community
Procedural	• Procedural fairness is integral to the granting of a social license such that the procedures are fair (Mercer-Mapstone et al., 2017): Communicating and debating the needs and values through including voices in decision-making processes inclusively and representatively, and making these processes transparent in the context of participatory approaches help to create credibility (Moffat, 2014).	- Community governance (community-level management & decision-making) - Actors initiating the EC
Energy democracy	• Energy democracy plays a central role as a driver for legitimacy where the initial basis comes from engagement with all members of the community and providing transparent access to information on the operation/project to build credibility (Bowles et al., 2019).	- Community governance (community-level management & decision-making)
Social Capital	• Building and maintaining a Social License to Operate in the long-term often involves building social capital, by nurturing and enhancing relationships and networks between families, interest groups and institutions to have a shared vision, attitude in order to build trust towards the project (Koya et al., 2021).	- Values - Actors initiating the EC - Actors within the EC - Community governance (community-level management & decision-making)
Community empowerment	• Community empowerment is a key factor in strengthening the Social License in that procedures reflect the active citizenships such as co-creating knowledge, giving voice to communities and development of knowledge and skills set. These developments play a vital role in meaningful engagement contributing to legitimacy and trust building (Demajorovic & Pisano, 2022).	- Community governance (community-level management & decision-making)

Results

Table 2 shows the typology that is structured according to the features and options found in our review. We first give the descriptions of the features below and then give the descriptions of the options in a separate table (see Table 3Table 3).

Table 3: Features of typology and options of energy communities

<table>
<tr><td>Mode of initiating the EC</td><td colspan="8">Top-down</td><td colspan="5">Bottom-up</td></tr>
<tr><td>Actors initiating the EC</td><td colspan="3">Citizen initiative</td><td colspan="5">Academia</td><td colspan="3">Public initiative</td><td colspan="2">Third-party</td></tr>
<tr><td>Actors within the EC initiative</td><td colspan="2">NGOs / NPOs</td><td>Private households</td><td colspan="5">Small and medium enterprises</td><td colspan="3">Large enterprises</td><td colspan="2">Public institutions</td></tr>
<tr><td>Financing options</td><td colspan="3">Individual self-financing</td><td colspan="5">Community financing</td><td colspan="3">Crowd financing</td><td colspan="2">Third-party financing</td></tr>
<tr><td>Values</td><td>Self-sufficiency</td><td colspan="3">Autonomy / independence</td><td colspan="2">Local benefits</td><td colspan="3">Environmental benefits</td><td colspan="2">Equity and equality</td><td>Innovation driver research</td><td>Less expensive electricity</td></tr>
<tr><td>Governance of energy resource operation and cost allocation</td><td colspan="7">Energy allocation via P2P Trading</td><td colspan="6">Energy allocation via distribution keys</td></tr>
<tr><td>Community governance (management & decision-making)</td><td colspan="5">Bottom-up</td><td colspan="5">Top-down</td><td colspan="3">Shared (co-governance)</td></tr>
</table>

Mode of initiating the EC initiatives: This feature examines the strategies and methods employed to launch the EC initiatives, including approaches such as addressing fundamental or broad elements, constructing from the ground up, or deconstructing specific components. These methodologies significantly influence energy justice, particularly in terms of how various values, needs, and perspectives are incorporated or excluded during the development of the EC initiative and its objectives. There are four options under this feature, namely, top-down and bottom-up.

Actors initiating the EC: This feature identifies the various actors who are responsible for the initial launch of the EC initiatives. It is crucial for understanding energy justice, especially procedural and recognition aspects, as it reflects which groups' needs, interests, and representations are included or overlooked at the outset. Additionally, the social capital of existing networks plays a vital role in the empowerment of diverse participants. There are four options under this feature, namely, citizen initiative, academia, public initiative and third-party which include industry, private and so on.

Actors within the EC initiative: This feature details the different actors involved in the EC initiative who have decision-making authority, regardless of their role in the initiation phase. Similar to the initiating actors, this has significant implications for energy justice, including procedural and recognition dimensions, and affects the social capital within the network, which is essential for the empowerment of diverse actors. There are five options under this feature, namely, NGOs / NPOs, Private households, small and medium enterprises, large enterprise and public institutions.

Financing options for EC initiatives' related infrastructure investments and resulting ownership model: This feature explores the various financing options and ownership models for infrastructure investments related to EC initiatives. The nature of the investment and the parties involved often determine the ownership structure, which has significant implications for energy justice, particularly in terms of shared ownership, control over energy production and distribution, and the resulting distributional effects. There are four options under this feature, namely, individual self-financing, community financing, crowd financing, third-party financing.

Value dynamics of EC initiatives: This feature analyses the value dynamics—social, economic, and others—within the community as it establishes and maintains the EC initiative. Trust and confidence among community members are influenced by shared values, norms, and identities, which are crucial for social capital. Understanding these dynamics is essential for maintaining a social license that aligns with community perspectives and expectations. There are seven options under this feature, namely, self-sufficiency, autonomy, independence, local benefits, environmental benefits, equity and equality, innovation driver research, less expensive electricity.

Community governance (community-level management & decision-making): This feature describes the management and strategic direction of the EC initiative, focusing on decision-making authority and processes. It has significant implications for energy democracy and justice, particularly regarding procedural fairness and recognition, as well as the inclusivity of diverse perspectives in governance structures. This influences the legitimacy and social license of the initiative. There are two options under this feature, namely, energy allocation via P2P trading and energy allocation via distribution keys.

Governance of energy resource operation and cost allocation: This feature addresses the governance of energy resources within the EC initiative, including the management of energy flows and the allocation of costs and benefits. It directly impacts energy justice, particularly in terms of how benefits, burdens, and costs are distributed or shared among members of the EC initiative. There are three options under this feature, namely, bottom-up, top-down and shared (co-governance).

Empirical Analysis of Energy Community initiatives

Data collection and case studies

As mentioned in the Introduction, in order to investigate the social impacts within energy communities, our analysis focuses on the internal processes of these communities, specifically the initiation phase (e.g., organization) and the subsequent governance of the community post-initiation. We employed a comparative case study research design to explore renewable energy communities, with a particular focus on solar energy. This approach allowed us to perform both within-case and cross-case analyses, examining how four key social dimensions—energy justice, energy democracy, social capital, and community empowerment—are operationalized in practice. The comparative case study method facilitates the identification of complex causal mechanisms and patterns across different settings, enabling a more nuanced understanding of the variations and commonalities between cases. This approach provides valuable insights into how different contextual factors and configurations shape the outcomes of energy community projects.

This analysis focuses on six countries (Switzerland, Austria, The Democratic Republic of the Congo, Tanzania, Senegal, and Brazil) in four specific regions (Switzerland, Europe, Sub-Saharan Africa, and South America). The 14 cases selected (see Table 4 for an overview) allow for diversity of empirical understanding across the Global North, mainly the European Union, Switzerland as well as Sub-Saharan Africa, and other countries such as Brazil. As mentioned, despite the interview not being conceived to frame the complexity and specificities of each case study, it allowed us to appreciate the diversity and the context-specific aspects of the energy community initiatives.

The fourteen case studies were selected according to precise inclusion and exclusion criteria. The first criterion we considered was the status and longevity of the initiative. Initiatives that are currently in a planning status were not considered. Pertaining to the technology, a limit was imposed, the technological focus of the analysis being the facilitation of matching demand and supply (automation and demand flexibility), the technologies included in the scope of research have been narrowed down in this respect. Here is a non-exhaustive list of the technologies considered: Solar PV, Solar Home Systems, Heat pumps, Wind, district heating, cooling, EV, batteries, and thermal storage. Including energy communities that have been going on for a long time allows us to have a full picture of the planning, processing, and implementation. The different communities were identified in different ways, each one was a different case. However, we reached out by email to all the communities.

Table 4: Case Study Overview Subtask 3

Case country / region	Name of the project	People interviewed
Switzerland	Lugaggia Innovation Community	Academia (part of initiating stakeholders)
Switzerland	Connect	Academia partners, Utility, and citizens
Austria	Poechlarn	Engineer
Austria	Göttweigblick	Board member
Austria	Grätzl Energie	Co-founder, Board member
Austria	EEG Scheibbs	Chairman
Austria	EEG Bad Schallerbach	Board member
DRC	Altech Group	Project manager, CEO
DRC	NURU	Project managers, Business manager
DRC	GoShop Energy	Environmental engineer
Tanzania	Photons Energy	Head of Engineering
Tanzania	D.light	Head of engineering, head of HR

Brazil	RevoluSolar	CEO
Senegal	ASER300	Project Manager

Analytical framework of the semi-structure interviews

The five sections of the interview (see Table 5) aimed to frame different aspects. The main point was trying to understand if a social license (to automate) is being built within the energy community, and how.

Table 5: Analytical framework of the survey and information collected

Part	Interview / Questionnaire analytical framework	Links with social dimensions	Information collected
I	General description of the project		Descriptive data
II	Initiating the energy community	Procedural justices in the planning, social capital	Data collected on processes such as who was included in the planning
III	Governance of the EC initiative	Energy justice (distributional, procedural, recognitional), Energy democracy (who is involved in decision-making)	Data collected on processes such as the form of decision-making, the distribution of the benefits, and surplus
IV	Developing social cohesion to empower the community and create social networks	Social cohesion, trust, identification energy citizenship	Data collected on social cohesion, community trust, and the importance of automation
V	Contribution of Energy communities to social license for decentralized renewables and automation	Empowerment, skills and knowledge development	Data collected on processes that can eventually lead to the formation of a social license

Results

Energy justice:

Energy Justice is referred to as a “global energy system that fairly disseminates both the benefits and costs of energy services, and one that has representative and impartial energy decision-making” (Sovacool & Dworkin, 2015, p. 436). Based on the conceptual framework, social license is closely linked to the principles of distributional justice, which focus on how the costs, risks, and benefits of projects are shared among stakeholders. Achieving legitimacy and acceptance hinges on addressing questions about who benefits, who loses, and who has access. When people perceive the distribution as unfair, they are likely to reject the project. The concept of Social License to Operate (SLO) also emphasizes recognitional justice, where diverse needs and values are acknowledged and incorporated into dialogue to build legitimacy. Additionally, procedural justice is crucial; fair procedures and transparent decision-making processes that inclusively involve all relevant voices help establish credibility and gain acceptance. Below, we present a summary of the interview findings derived from various case studies with regards to whether and how the project managers have approached and addressed the energy justice points in energy communities:

Below, we present a summary of the interview findings derived from various case studies with regards to whether and how the project managers have approached and addressed the energy justice points in energy communities:

In general, most of the case studies thought of distributive justice in the context of energy and cost distribution and mainly concerned for minimizing costs and addressing initial investment disparities. Specifically, in Global North, the case studies that explored distributive justice in energy projects, have focused on minimizing costs and addressing investment disparities, notably Switzerland and Austria. In Tanzania, the case studies highlighted the economic capacity of villagers and the need for fair payment plans to avoid financial burdens on low-income users. One Tanzanian case promoted democratic participation by involving village leaders and villagers in the project planning process, ensuring that community voices are heard and considered. They hold frequent meetings with village leaders and villagers to emphasizes transparency and fairness in benefit distribution. Addressing doubts through honest communication helps mitigate potential issues related to justice. In Switzerland, the emphasis was on equity rather than equality, advocating for support tailored to individual or community needs rather than treating everyone equally, therefore focused on the recognition justice or, in other words, acknowledging that different communities or individuals may require different levels of support to achieve fair outcomes. In contrast, Austrian case studies focused primarily on cost concerns without considering community perspectives, or specific needs, perspectives and/or aspirations of the community.

Energy democracy:

When developing the interview questions with regards to ‘energy democracy’, we relate to (Szulecki, 2018) who synthesised energy democracy as: “[A]n ideal political goal, in which the citizens are the recipients, stakeholders (as consumers/producers) and account holders of the entire energy sector policy. Governance in energy democracy should be characterized by wide participation of informed, aware, and responsible political subjects, in an inclusive and transparent decision-making process relating to energy choices, with the public good as its goal." Indeed, Energy democracy plays a central role as a driver for legitimacy where the initial basis comes from engagement with all members of the community and providing transparent access to information on the operation/project to build credibility for the activities of installing solar PV panels, automation, and other DSM activities.

Diverse insights were given by the actors of the energy communities from different case studies. Most of the case studies showed a limited focus on energy democracy when planning and implementing energy community initiatives. In Switzerland, the emphasis was on fairly distributing benefits, with less attention to democratic involvement in decision-making, and policies were needed to address disparities in solar PV installation. Austrian case studies similarly focused more on financial concerns. In contrast, cases from Sub-Saharan Africa actively involved communities in project planning and education about renewable technologies. One Swiss case study highlighted participation in eco-district planning, but there were concerns about limited engagement from diverse groups, creating a risk of "echo chambers." Democratic practices varied across cooperatives, especially in housing associations.

Social Capital:

When analysing 'social capital', we refer to Putnam (Putnam, 1994) and interpret it as a system of shared norms, values, culture, and beliefs embedded in networks of relationships that influence prosocial norms of cooperation, reciprocity, and trust (Giacovelli, 2022). Building and maintaining a Social License to Operate in the long-term often involves building social capital, by nurturing and enhancing relationships and networks between families, interest groups, and institutions to have a shared vision, and attitude in order to build trust towards the project. With the interview questions, we specifically attempted to understand communicative and behavioural interactions within the energy community with all its stakeholders and inhabitants and all investigated the outcomes of such social processes of dialogue in terms of the social capital (e.g. nurturing and enhancing relationships).

Across various case studies, social cohesion has been identified as a crucial element for the autonomy of energy communities, as it fosters cooperation, collective action, and strengthens community identity and engagement. However, efforts to build or measure social capital—essential for sustaining these communities—were generally limited. In Switzerland, some signs of growing community engagement were observed, with participants increasingly considering the collective impact of their actions, particularly in supporting renewable and automation technologies. However, the lack of active relationship-building meant there was little impact on overall community identity.

In Sub-Saharan Africa (SSA), efforts centred on building long-term trust with community leaders and locals, including training programs and creating job opportunities, which helped strengthen community ties. In particular, solar installations generated community pride, contributing to social capital. In contrast, Austrian case studies took a less comprehensive approach, with minimal emphasis on building social capital, and some interviewees showed scepticism toward addressing the social aspects of energy communities. Their strategies were limited to basic outreach and engagement activities, such as smart meter information. The same reflection could be extended to Swiss as in one case the outreach was limited to the people who owned a house and showed sufficient levels of proximity to the grid, while in the other, outreach was undertaken five years prior to the completion of construction.

One Swiss case highlighted cooperatives that fostered social cohesion through shared spaces and community management, with working groups focused on common goals like environmental concerns. This structure encouraged interaction, collaboration, and collective decision-making, which helped build social capital. However, the project partners noted that many narratives focused less on energy issues and more on other sustainability topics, such as food, biodiversity, and waste management.

Community empowerment:

We define “community empowerment” as the ‘process of an individual, group or community increasing their capacity and contextual power to meet their own goals, leading to their transformative action.’ (Coy et al., 2022). Community empowerment can be facilitated via developing psychological abilities from individuals, interpersonal (between inhabitants, municipality, and other organisations), and communities as well as structural opportunities such as being part of the governing entities of the energy community. Community empowerment is a key factor in strengthening the Social License in that procedures reflect active citizenships such as co-creating knowledge, giving voice to communities, and development of knowledge and skills sets. These developments play a vital role in meaningful engagement contributing to legitimacy and trust building, therefore building social license for renewable technologies for communities and other automation and DSM activities.

Across the Global South, empowerment often translates into training options for local communities. The purpose of the training is to eventually empower local communities by providing them with a high degree of autonomy.

In the Global north case studies, empowerment mainly happens in the form of information sharing, i.e. helping to build contextual power by providing understanding about the energy issues. Most of the time, people are not expected to become autonomous in most cases, as their direct involvement in decision-making is rather limited, as illustrated by some of the Austrian cases.

Potential Analysis and Evaluation

In this section, we discuss the contribution potential of energy communities (EC) and other community energy approaches towards establishing/ granting a Social License to automate by developing legitimacy, creating credibility, and constructing trust.

- Community approaches can ideally contribute to developing legitimacy and acceptance as the ownership of the provision belongs to the community. Therefore, the benefits of projects are distributed more equitably with community members receiving the immediate and direct benefits. This approach can definitely build legitimacy and credibility for automation appliances.
- Democratic decision making as part of the community model can be a driver for developing legitimacy where community is engaged in the problem definition of the flexibility, energy provision etc. Similarly, in community approaches, it is collective decision-making and encourage cooperation recognising the diverse needs, expectations, and values.
- Community actors, community leaders that are included within the processes may increase the credibility of the project with transparent information. However, significant efforts should be put by the third parties to communicate with the community in terms of information, reliability of solutions.
- Existing social capitals or building social capital in energy communities can significantly nurture and enhance relationships building trust for the PV installation, flexibility, and automation problems.
- Fostering a sense of community through regular engagement and shared goals can build long-term trust when strengthening community ties. Such cooperation, reciprocity, and shared responsibility increase trust in the project's success and fairness, hence and contribute significant to the social license of automation technologies. Additionally, the shared responsibility within community may lead to increasing trust.

Smart grids and automation are well-known topics among scholars and industry professionals. Across Europe, numerous demand-response initiatives have been tested and continue to be tested, leveraging this technology to reduce peak demand and mitigate grid congestion (Kakran & Chanana, 2018). While the integration of the Internet of Things (IoT) presents additional potential for increased technology efficiency and higher performances (Avancini et al., 2019), the technology underpinning Home Automation Devices and smart meters is already sufficiently mature to support widespread automation implementation across Europe. As demonstrated by Oh et al. (2020), the analysis of electrical load using 1-hour interval smart meter data is robust, rendering a higher time resolution (e.g., 15 minutes or 1 second) unnecessary, albeit potentially useful. Consequently, no further technological advancements are required at this stage.

From a technological perspective, further developments are not needed, but from an economic point of view, policy support for ECs should increase, as several challenges are faced now. Busch et al., (2021) identified potential challenges to the implementation of ECs in literature. Namely, lack of knowledge relative to the different technologies, the presence of subsidies (availability of capital is central to the implementation of energy community initiatives) and feed-in-tariffs (FiT), and lack of experimentation (pilot projects). A project implementation ensuring equality is fundamental for the success of the initiative (Hoicka et al., 2021). Finally, it is pivotal to ensure that national regulation complies with RED II & III regulations, to avoid overlapping and conflicting laws (Montini, 2024; Sokoloski, 2015).

Both policy analysis and stakeholder interviews across different geographical areas illustrate that acceptance and familiarity with renewable technology are an enabling factor for automation (Busch et al., 2021).

Conclusions

In our task we showed that there is a great potential that the energy communities can contribute to social license to automate granting with an opportunity over socially more equitable models of energy pro-consumption (energy production and consumption), strengthen democratic decision-making and citizen control over renewable energy.

However, our studies show that the social license is not automatically given. Different aspects characterise ECs, namely, mode of initiating the EC, actors initiating the EC, actors within the EC initiative, financing options, value dynamics, governance arrangements, and governance of energy resources operation and cost allocation. We showed that these different combinations have diverse implications for the social dimensions of the energy communities which underpin building improving social license of EC initiatives, renewable generation units and accepting increased levels of automation in this regard. We found different strengths and weaknesses of the different EC initiatives and provided nuanced understandings of what social aspects are addressed, and the addressed social aspects vary depending on the diverse foci. Specifically, the social dimensions, notably energy democracy (active participation); three tenet energy justice (recognition, distributive, procedural); social capital (nurturing relationships and cohesion), and community empowerment (developing contextual power and capacity) should be cultivated in order to develop legitimacy, create credibility, and support trust building. Our studies showed that first there is a different understanding of these notions in different countries, therefore context dependent practices and activities are key for building social license and should be considered with attention. Secondly, different focus on addressing social dimensions is due to different needs, aspirations, and perspectives of the investigated societies.

Load Profile Analysis and Data Quality Requirements

This chapter presents the findings of the quantitative component of the SLA2.0 project and is divided into two parts. The first one presents the results of the analysis conducted on four datasets from national projects with the purpose of identifying consumption profile markers that indicate existing user flexibilities. The outcomes of this analysis are discussed in the second part of the chapter to define quality criteria for future data collection. In this context, a use case survey from the Netherlands conducted within this Subtask is presented to provide an example of sound data collection to assess user flexibility.

The datasets analysed to derive flexibility profiles include detailed load profile information from household electricity consumption in four areas of Austria and Switzerland, complemented by their socio-demographic data and household-specific technology characteristics. Based on gained ST1 insights, we formulated four bundles of hypothesis to guide our analysis for the following categories: household structure, technology type, gender and income:

- *Hypothesis 1: Household structure affects consumption patterns.* We expect that households with children will exhibit more consistent and less flexible electricity consumption patterns. The tight weekly schedules typical of these households leave little room for change. Higher-income households with children are expected to demonstrate greater flexibility in their electricity usage.
- *Hypothesis 2: The types of technology used affect consumption patterns.* Heating and cooling activities are likely to be less flexible compared to the use of other electrical devices. The type of heating also influences consumption patterns. For instance, the use of heat pumps may lead to significant variations in load profiles, with pronounced peaks in the morning and evening, especially in the morning. In contrast, the use of space heaters results in different patterns. Additionally, the presence of electric vehicles (EVs) and the ownership of PV is expected to contribute to variations in energy usage.
- *Hypothesis 3: gender influences energy consumption patterns.* The precise nature of this effect will be determined by the analysis.
- *Hypothesis 4: Income affects energy consumption.* Higher-income households display both higher consumption levels and greater flexibility (the effect of discounts on energy consumption (price elasticity) than low-income households.

Analysis Criteria and Methods

In ST3, a total of four datasets were available for analysis, derived from previous projects in Austria (PEAKapp and LEAFS) and Switzerland (FLEXI and CREM). All data sets included 15-minute electricity consumption data and specific socio-demographic and technology information at the household level. However, while the Austrian data sets were part of field tests with treatment, the Swiss data sets were retrieved via survey and were not part of an experiment. Furthermore, a survey was conducted in the Green Village, the Netherlands, as part of the ST3 work. This survey collected data on energy practices, as well as socio-demographic and technology data from 8 households. Additional information on each individual dataset can be found in the Annex.

Energy consumption flexibility can be evaluated by examining how rigid or adaptable consumption patterns are, including variations in load profiles such as peaks and off-peak periods. This involves comparing the averages, standard deviations, short-term patterns (hourly, daily and weekend variations), and seasonal differences (e.g., summer vs. winter). The analysis began with plotting load curves across different socio-economic categories for all days, seasons, weekdays, and weekends. Seasons were defined meteorologically, such as winter covering the first three months of the year. Peak consumption was defined based on the frequency of peak capacity demands throughout the day, with peak periods varying by sample. For the Austrian datasets, PEAKapp's peak period was set from 4 pm to 9:45 pm. In the Swiss datasets, FLEXI's identified peak hours were from 10 am to 1 pm and from 5 to 9:30 pm, while CREM's were 10 am-12:45 pm and 4 pm-8:45 pm. In a further step, regression analysis was conducted, examining the logarithm of power consumption with relevant variables and their interactions with peak periods. This step assessed the impact of various factors on peak consumption, after verifying assumptions of normality and heteroskedasticity. We also visualized consumption patterns by creating heat maps to compare households with and without sauna and with and without heat pumps. Welch's t-test was used to compare mean consumption profiles between these groups, accounting for variance differences, while Levene's test assessed variance equality during peak times.

Data evaluation and flexibility profiles

Gender

In the PEAKapp dataset on average, men consume more energy than women, showing higher baseline consumption, whereas females experience higher consumption peaks (n=152). This difference is more visible on weekdays and in wintertime. In CREM (Figure 4), similarly to PEAKapp, men have a higher baseline consumption, and we observe higher consumption peaks for women in winter. This difference is visible only in single households.

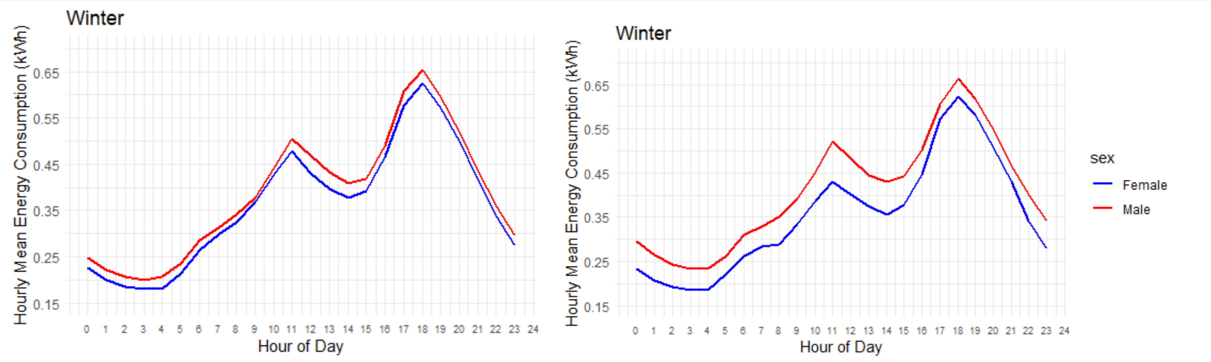

Figure 4: Electricity consumption (kWh) by gender: (a) Multiple-person households with at least one woman (n = 657); (b) Single-person households (n = 197) (CREM data)

Age

The CREM data, due to the homogeneity of the sample in terms of dwelling (multi-family flats) already mentioned, show very small differences in consumption patterns across age categories, making age a less relevant aspect in determining flexibility profiles. While younger households (24-34) have slightly higher consumption peaks in CREM (Figure 5), the opposite is true for the FLEXI data (Figure 6). In this case, households aged 40-64 consume on average almost twice as much (and thus have twice as high peaks) as the 18-29 group in the winter months. However, this may be due to income or household structure rather than an age effect. Indeed, 65% and 57% of households in the oldest (65+) and youngest (24-34) age groups respectively belong to the lowest income group, earning less than CHF 6,000 per month, compared to only 17%, 13% and 19% of households in the 35-44, 45-54 and 55-54 age groups. Most households in the high consumption age groups also have at least one child living at home, while the remaining age groups mostly don't have children living at home.

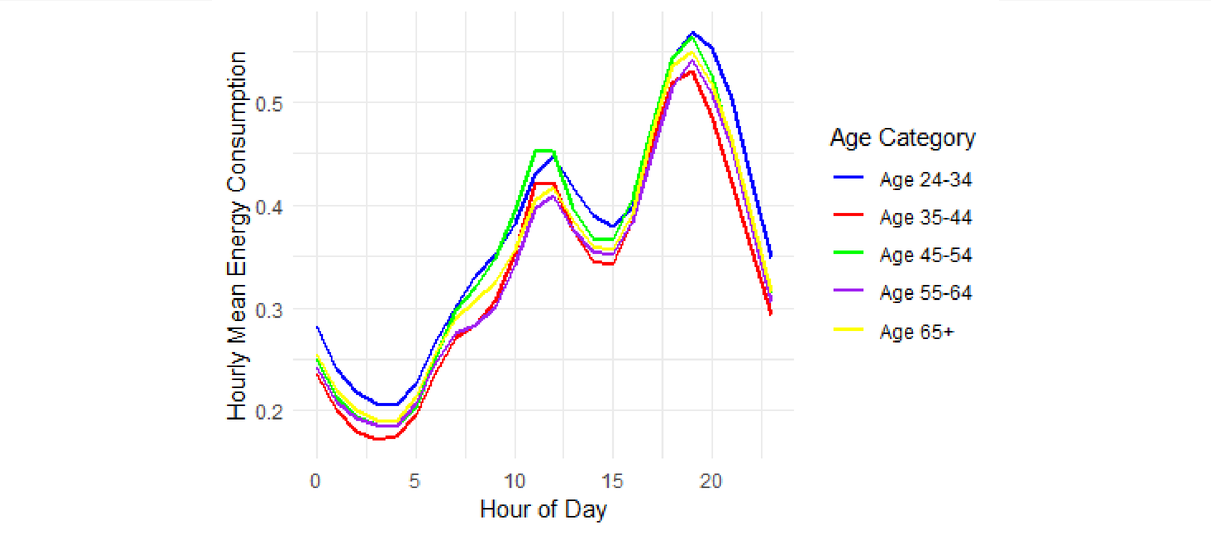

Figure 5: Electricity consumption (kWh) by age category on weekdays across all seasons (n = 657) (CREM data)

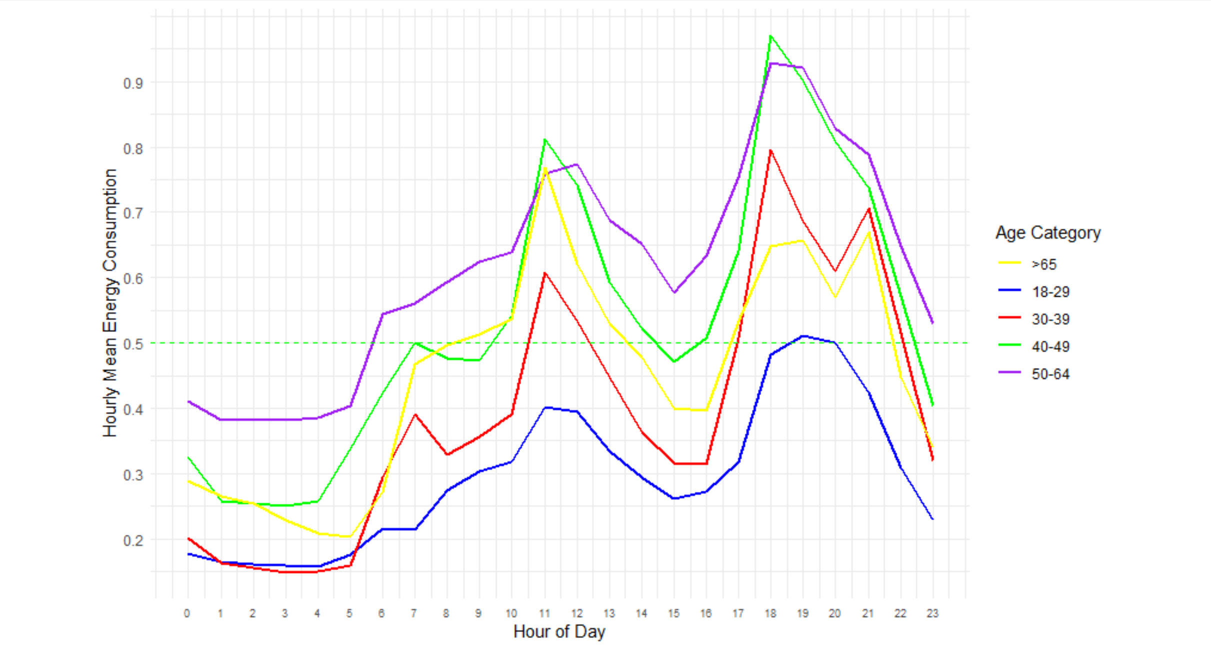

Figure 6: Electricity consumption (kWh) by age category on weekdays during winter (n = 127) (FLEXI data)

Income

As for the income, CREM households don't show significant differences between income categories, even though the lowest income category has a slightly higher peak in the morning hours. This very small difference cannot be explained with the data at hand. In FLEXI, on the contrary, differences are much greater (Figure 7). In winter, the highest-income group has more than twice as high baseline consumption as the lowest income group. Peaks occur at similar times across groups in the evening, during the 17–22-hour range, with clearly much higher consumption values the higher the earning. The morning/noon peak occurs a bit later for the highest income category compared to the other categories. In summer, differences in consumption between groups are not as big.

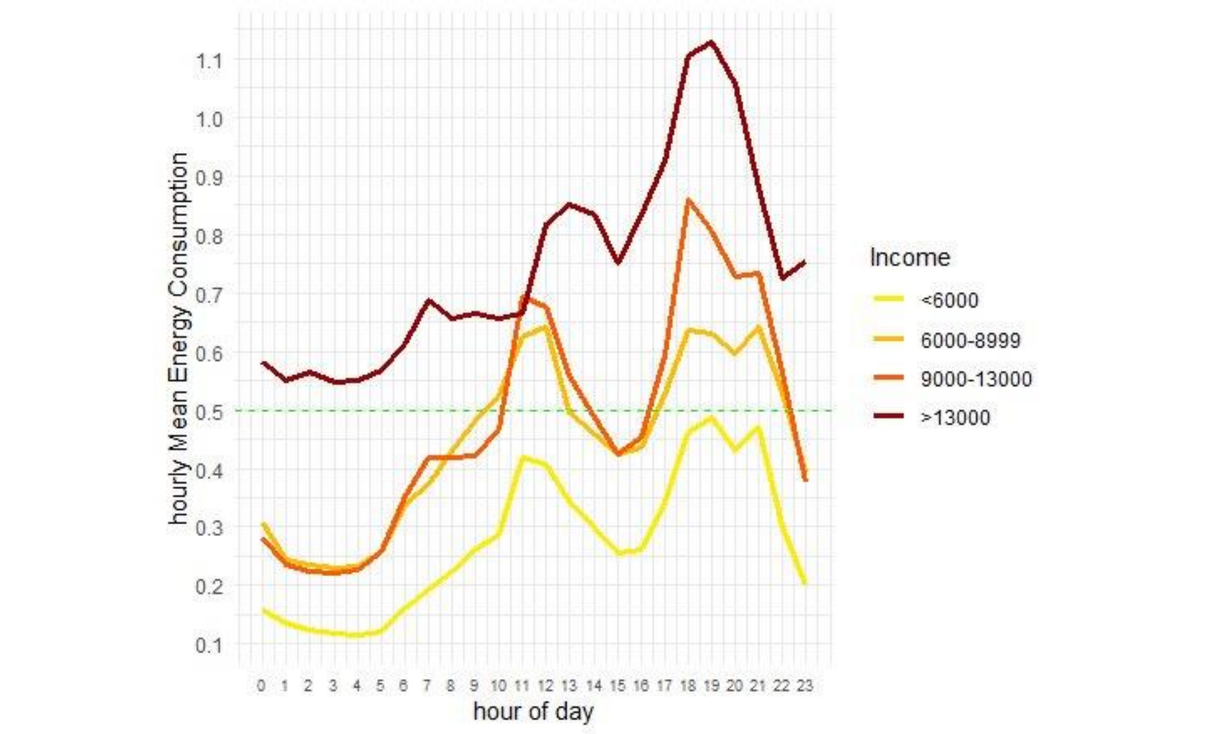

Figure 7: Electricity consumption (kWh) by income level on weekdays during winter (n = 109) (FLEXI data)

Education

In the CREM data, education has a slightly higher impact on consumption than income, but there is no consistent pattern (n = 657). Households with tertiary education (level II) have on average the highest peaks, especially in the morning. However, the difference is very small (<0.1 kWh). In Flexi, the higher the level of education, the higher the peak consumption (n=130). However, the differences in consumption patterns are quite small compared to the other socio-economic categories analysed, especially regarding the morning peak. It is also important to note that education is related to income, as 51% of highly educated households are in the highest income brackets, compared to 12% of low educated households. Also, almost half of the highly educated households (47%) have 2 or more children compared to 25.5% of the low educated households. These factors, which are often related to education, may have a greater influence on the pattern - particularly the evening peaks - than the education factor itself.

Household structure

In terms of household structure in FLEXI (Figure 8), when there are no children at home (or only 2 people present), both the morning and evening peaks are not as high and are shifted 2-3 hours later in the day/night compared to households with children. This suggests that the routines of childless families are different from those of families with children, who tend to go to bed earlier. When there are 2 children in the family, there is an additional peak in the early morning hours (6-8 am). The overall higher energy consumption is intuitively linked to the number of people in the household, but not only. In fact, the majority (75.6%) of households with four or more persons belong to the second highest income group (9,000-13,000 Swiss francs), while a similar proportion (68%) of single households belong to the lowest income group (<6,000 Swiss francs). The majority (58%) of two-person households also belong to the lower income category (<6,000 or 6,000-8,999 Swiss francs). When looking at consumption patterns, it's therefore important to take into account the overlapping effect of children in the household (or number of persons) and income.

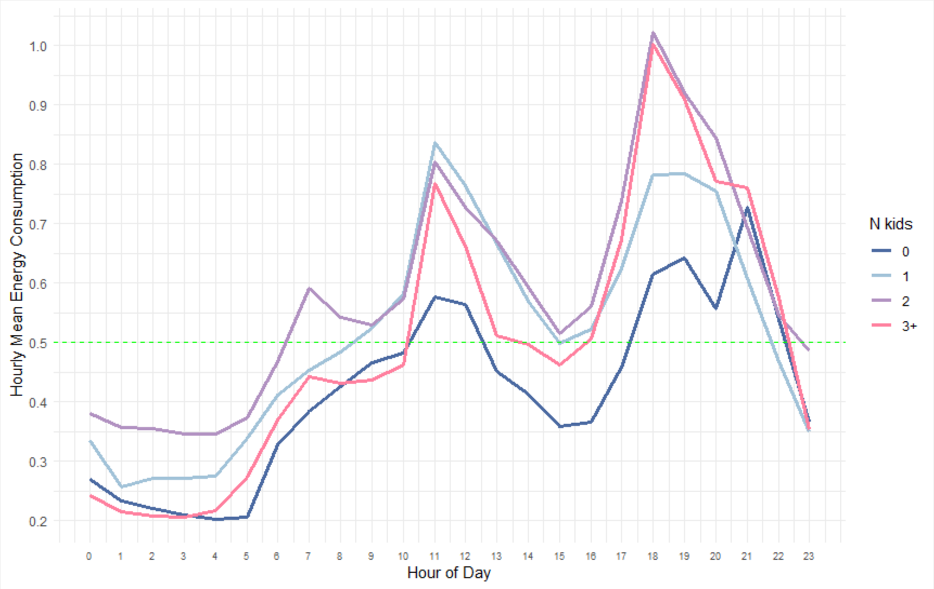

Figure 8: Electricity consumption (kWh) by number of children on weekdays during winter (n = 130) (FLEXI data)

Also, the more retired or unemployed people in the household (1 or 2), the lower the evening peak (Figure 9). The morning peak for these categories is similar to that of households where no retired or unemployed person is present. This suggests not only a different consumption pattern, but also an overall lower consumption of the non-employed compared to the employed. As with the number of children above, this may also be an income-related effect, as households in which at least one person is retired or unemployed tend to be in the lowest income group. Only 10% of households with no retired or unemployed person belong to this income group, compared to 39% of households with one retired or unemployed person and 50% of households with two retired or unemployed persons.

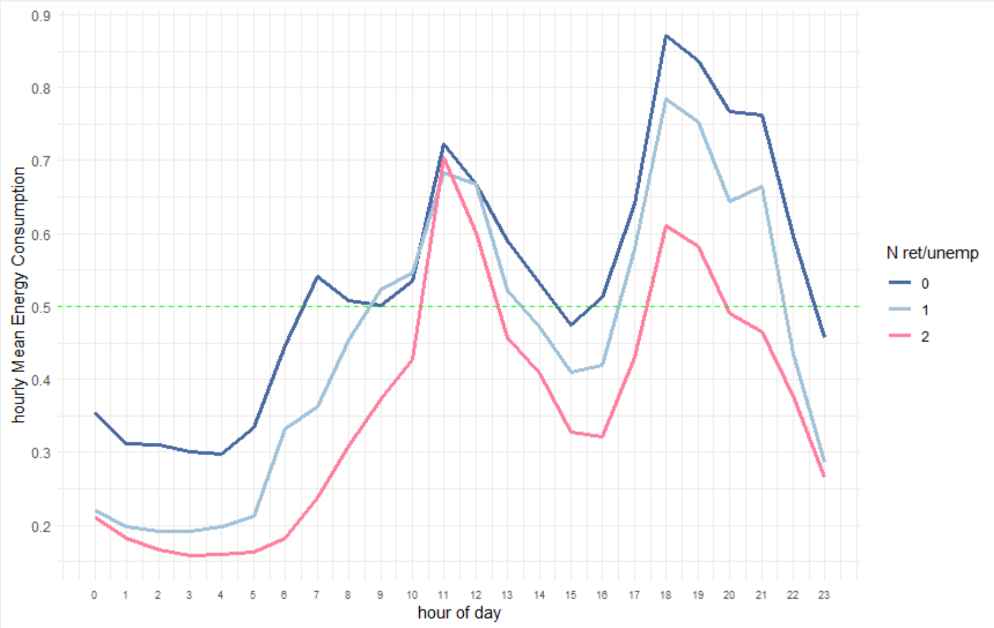

Figure 9: Electricity consumption (kWh) by number of retired/unemployed individuals in the household on weekdays during winter (n = 90) (FLEXI data)

In CREM, the presence of children also influences the load consumption. Couples with children have slightly higher consumption peaks compared to the other categories, especially compared to couples without children in the morning. Also, the energy consumption of families with children in the high-income category is slightly higher than that of families with children in the low- and middle-income categories, especially at weekends (Figure 10). This echoes the results of FLEXI, highlighting the intersection of children in the household and income in energy consumption.

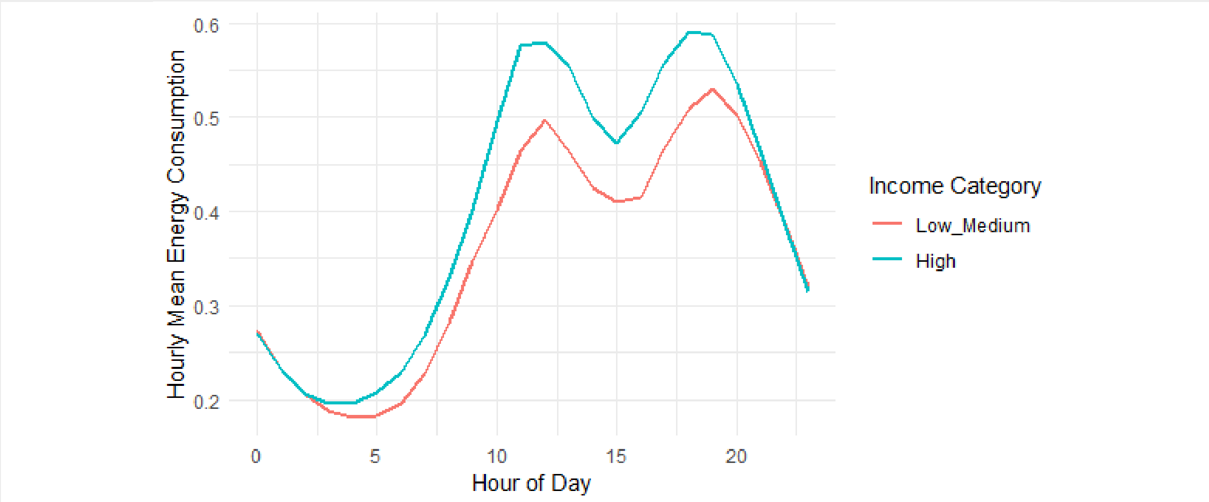

Figure 10: Electricity consumption (kWh) of households with children by income level during weekends (n = 198) (CREM data)

Dwelling & residency type

In Flexi, due to the high heterogeneity of the sample, large differences are observed between households in the ownership (owner/tenant) and living arrangements (house/flat) categories (Figure 11). Households living in flats have much lower baseline consumption (almost half) and peak values than those living in houses. Similarly, tenants consume much less than owners and show an evening peak at slightly later times. Given the similarity of the figures, it can be assumed that house dwellers are most likely to be owners and vice versa, apartment dwellers are most likely to be renters. On the other hand, in the CREM, the type of dwelling doesn't affect the load patterns. This finding is not surprising as all households in this sample live in multi-family flats. However, unlike the Flexi data, ownership status does not affect load patterns at all, and the load patterns of owners (n=346) and tenants (n=311) follow a very similar curve. It can therefore be concluded that the type of dwelling probably plays a more important role in determining the consumption behavior of households than ownership. This is related to the availability of space, which allows the use of a larger number of energy-consuming appliances and requires more energy for heating and cooling, but also to income, as high-income households are more likely to live in larger dwellings and to be able to afford energy-consuming appliances. Ownership may also have an impact on consumption as owners may be more willing to invest in retrofitting and energy saving measures compared to renters who may not have this option and therefore have higher energy savings, but this cannot be determined from the datasets available to this project.

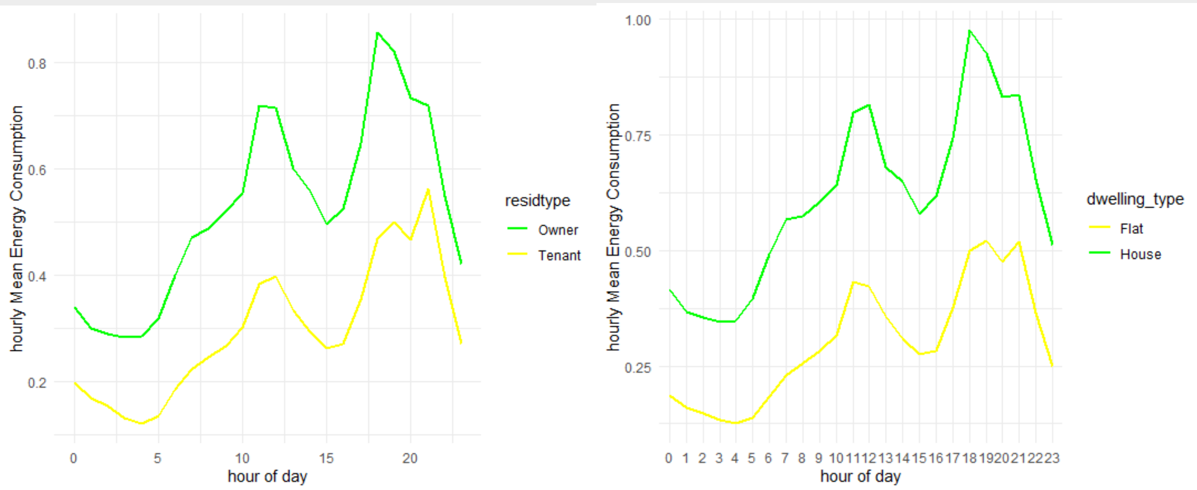

Figure 11: Electricity consumption (kWh) on weekdays during winter by resident type (left) and dwelling type (right) (n = 131) (FLEXI data)

Technology

For heating, households with heat pumps tend to have higher consumption during the night and evening hours. These increases in consumption were visible in Flexi on winter weekdays (n=90), but also in PEAKapp, with a peak around 2 am, similar to those using district heating. Heat pump users have an overall higher baseline consumption, possibly due to income/house size effects. Households with oil and gas heating, on the other hand, have less variability and therefore more constant consumption, with a lower peak at night and a higher peak in the early evening hours. For solar energy, households with PV have a much higher peak in the middle of the day, especially in summer, possibly due to the greater availability of solar energy production (FLEXI data, n = 131). The number of appliances also clearly determines consumption, with much higher peaks for households with 21-29 appliances than for those with 11-20 appliances, and even higher than for those with only 1-10 appliances (FLEXI data, n = 126). Finally, households with saunas have a higher variability of energy consumption compared to those without saunas (Figure 12), i.e. higher standard deviations and hourly means.

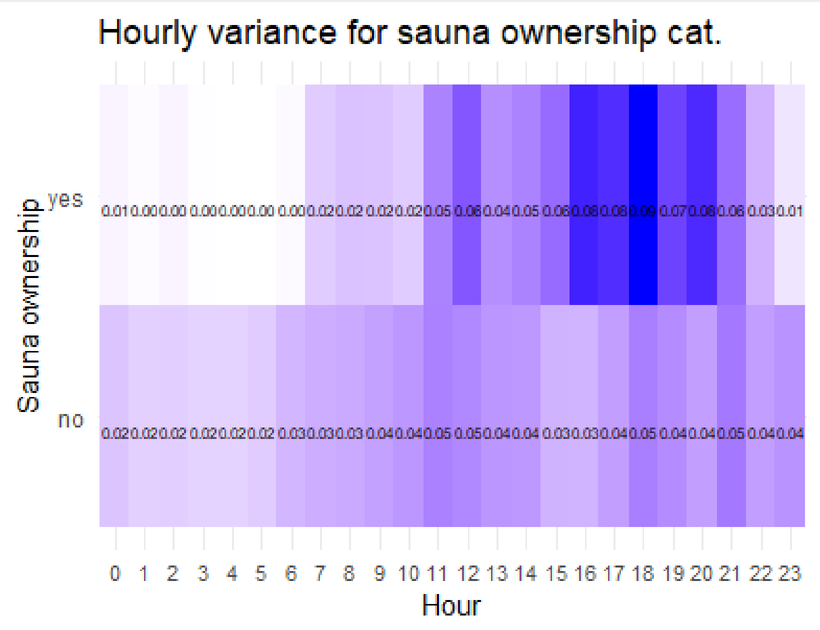

Figure 12: Hourly variation of electricity consumption means (purple palette) and standard deviations (values) (kWh) for sauna owners and non-owners (FLEXI data)

Data quality and availability assessment

Limitations

The analysis presented in this study has several key limitations that affect the robustness of the conclusions drawn. Most notably, the low R^2 in our regression models indicates that the data at hand is insufficient to fully explain the diversity in household flexibility regarding energy consumption. This suggests the presence of unmeasured variables, demonstrating that socio-demographic factors alone are not sufficient to comprehensively understand flexibility patterns. While the current dataset enables differentiation in energy consumption across socio-economic groups, the overall lack of heterogeneity and missing variables hinder our ability to thoroughly assess flexibility profiles.

A significant limitation stems from the inability to establish connections between energy consumption patterns, household demographics, and interactions with energy-related technologies. This aligns with findings from ST1, which similarly struggled to capture the nuances of household interactions with technology and energy use. While daily load profiles may reveal certain peaks and variances, they do not offer substantial insights into the flexibility capacity of households. Consequently, designing Demand-Side Management (DSM) programs solely based on these patterns risks oversimplification. For instance, low-income households may exhibit low energy consumption overall but still experience peak loads, which could unjustly penalize them within DSM schemes.

Specifically, considering the hypothesis we formulated above (see methodology section), it wasn't possible to test hypothesis 2 and 4. In the case of Hypothesis 2, concerning the influence of electric vehicles (EVs) on energy consumption flexibility, our datasets either lacked EV ownership data or had too few households with EVs, preventing meaningful analysis. Similarly, while we could observe the impact of heating systems, such as heat pumps, on consumption patterns, the broader influence of heating and cooling activities relative to other electrical devices remained undetectable due to the absence of specific technology usage data. In the context of Hypothesis 4, it was impossible to assess household responses to price signals by income category, as no income data was collected within the LEAFS and PEAKapp projects. As a result, we could not test the hypothesis that price elasticity varies across income groups.

Another major constraint lies in the incomplete capture of gender-based consumption patterns, particularly in households with multiple members. Although ST1 highlighted the gendered division of labour in energy use, where roles are often divided along gender lines, our data does not allow for the identification of these gender dynamics, especially in shared households. This is problematic as gendered patterns in energy usage and decision-making are well-documented but remain underexplored in our analysis.

Data collection exercise

In order to address the shortcomings of the existing data information that we have in the collected datasets, we developed a survey designed to more accurately reflect the insights generated during the analysis. For this purpose, we chose the Green Village in the Netherlands as a case study. More information on this data set and the survey design is found in the Annex. The data was collected in a scientifically sound manner, adhering to data privacy regulations. Although the data is not representative, it served as an exercise to put into practice the lessons learned from the initial phase of data analysis. To improve the understanding of energy consumption patterns within households, the survey included not only socio-demographic data and information on appliances or energy systems, such as heating type, but also detailed information on energy practices, such as teleworking. Understanding the frequency of consumption habits is essential for interpreting electricity load patterns. Indeed, the survey revealed that energy practices vary significantly between households in terms of the intensity and frequency of appliance or system use. Among the energy practices that account for significant variability in consumption and that have gained prominence in recent years, teleworking was identified as particularly influential. Questions were therefore included to assess its impact on energy consumption. Specifically, participants were asked how often members of their household worked or studied from home, and the responses showed considerable variation. Some households reported no remote work, others reported teleworking several days a week, while some households worked remotely all the time, highlighting the varied impact of teleworking on household energy use.

For energy-intensive appliances such as washing machines, dishwashers and tumble dryers, participants were asked about the time slots and periods during which wet appliances were typically used, distinguishing between weekdays and weekends or holidays. Analysis of appliance use patterns across households revealed considerable variability in behaviour. Some households exhibited highly regular and predictable patterns, possibly indicative of automated appliance settings. For example, one respondent consistently operated all wet appliances, including the dishwasher, washing machine and tumble dryer, at 1:00 a.m., regardless of the day of the week.

In contrast, other households showed a more variable use of appliances. For example, one respondent operated their wet appliances at different times throughout the day, with usage distributed over the morning, afternoon and evening hours, indicating a more flexible or less structured approach. Another household operated a more repetitive pattern of use during the working week, using appliances at the same times each day, whereas at weekends they were more flexible, using appliances over a larger time span. These different behaviours highlight the diversity of energy consumption habits and suggest that some households may optimise appliance use based on convenience or energy saving strategies, while others may adhere to more variable routines.

In the context of heating and cooling practices, seasonal variations must be taken into account. During the winter, the type of heating and heating usage habits are key factors in explaining consumption loads. In contrast, in the summer, cooling habits and cooling system type become more relevant. The survey revealed clear differences between households. Approximately 33% of households reported never using cooling systems during hot months, and 50% indicated that they only used a ventilator, which consumes significantly less energy than air conditioning. This meant that cooling could be excluded as a potential explanatory variable for consumption peaks in these households. Conversely, for heating, several households reported using it at various times throughout the day, which positioned heating type as a potential explaining variable in winter consumption patterns, particularly for those utilising heat pumps or electric heating systems. These varying routines demonstrate the importance of considering both household behaviour and technological factors in energy consumption analysis.

In future research, data collection efforts should also factor in other electricity-intensive activities to gain a deeper understanding of energy loads, such as electric vehicle (EV) charging. While this data was not included in the current survey, given that the EV-charging station was located on campus and not reflected in the household metering data, it is crucial to include this data, especially in contexts of high EV penetration. The more comprehensive the information on energy practices, the more comprehensive the picture of energy use will be, further improving the interpretation of consumption peaks within households.

Furthermore, to account for diversity in household dynamics and the interaction with appliances, the survey included questions on task allocation. This included, for example, which household member typically loads and operates wet appliances. This approach could be especially useful in research aiming to identify potential gender differences in energy practices, providing additional insight into how household roles and responsibilities influence energy consumption patterns. By linking specific responsibilities to energy use, we can gain deeper insights into how individual household members influence overall energy consumption, thereby refining our understanding of flexibility profiles and energy management strategies within a community.

Recommendations for future data collection and analysis

Based on the limitations and the data collection exercise outlined above, we propose the following recommendations for improving future data collection efforts.

1. **Cover Relevant Demographics**: In the context of the analysis of flexibility profiles, future data collection efforts should comprehensively cover all relevant socio-demographic variables, including age, gender, income, household composition, ownership, and education level. Omitting any significant socio-demographic category can impede the accuracy and depth of the analysis. Equally important are technology-related variables, which play a key role in understanding flexibility. For example, electric vehicle (EV) and heat pump ownership are critical factors but may have limited representativity in samples due to low adoption rates in certain regions or populations. In such cases, targeted sampling methods, such as quota sampling, should be used to ensure these groups are adequately represented. Income data, while crucial, may be perceived as sensitive and difficult to collect. To overcome this challenge and ensure robust participation, an income proxy, such as self-reported socio-economic status, should be employed. This approach is particularly relevant for field experiments investigating income elasticity in the context of electricity tariffs, where capturing a reliable measure of income is essential for analysing consumption responses across different income groups.

2. **Incorporate Consumption Patterns Beyond Demographics**: In addition to basic socio-demographic data, future surveys should include detailed information on household consumption behaviours, such as teleworking habits, cooking routines, and other daily activities. Social-psychological factors, which

often influence decision-making at a subconscious level, as many routine behaviors are performed with minimal conscious deliberation (Jackson, 2005), are frequently overlooked in traditional energy behavior models. The predominant focus on intention in energy behavior models frequently leads to the assumption that stated intentions in surveys accurately reflect actual behavior (Labrecque et al., 2017), thus neglecting the significant influence of entrenched habits. These habitual behaviors play a critical role in shaping behavioral change (Gärling, 1992). Consequently, it is essential to develop a more nuanced understanding and modelling approach that captures how existing habits, routines, and everyday actions influence energy consumption. Such habits may act as behavioral "lock-ins," potentially impeding the transition toward greener or DSM-compliant behaviors.

3. **Collect Time-Use Data:** To address the data gap regarding household roles and technology interactions, time-use survey diaries should be employed to track when and how different household members use various appliances. Studies such as Palm et al. (2018) in the Swedish context have successfully demonstrated how time-use data can reveal patterns of energy-intensive activities, varying by socio-demographic characteristics. For example, younger respondents tend to use more energy in the evenings (Lo Piano & Smith, 2022). Other studies investigating time schedules across income categories found that lower-income households showed a more constant energy demand throughout the day (Xu & Chen, 2019). Such data would also facilitate a more accurate assessment of gender differences in household energy use, which is often difficult to capture in multi-member households.

4. **Collect Appliance-Specific Data:** Tracking appliance-specific energy use, alongside gender and demographic data, would yield insights into how different household members influence overall energy consumption. However, the collection of such data is constrained by the high costs associated with appliance-level monitoring campaigns. Consequently, these datasets are typically limited in availability and derived from localized samples, which reduces their representativeness for broader regional or national contexts. Despite these challenges, obtaining appliance-specific data is crucial for understanding energy consumption behaviors across different socio-demographic categories. Such insights can inform the design of more targeted and effective energy management programs, thereby contributing to enhanced energy efficiency and demand-side management strategies.

5. **Explore Gendered Patterns of Energy Use:** Given that women are often responsible for more energy-demanding household chores, while also engaging in more energy-saving behaviours, it is crucial to examine gender differences in energy consumption and technology interactions. Understanding how women engage with technologies and make energy-saving decisions could significantly enable women’s participation and enhance the design and effectiveness of DSM programs. Also, investigating household roles with respect to influence on energy-related decisions (e.g., who has the app to

monitor household consumption or to set devices starting times/modes) would also be relevant in this respect. Additionally, investigating the gendered division of labour in household energy use could shed light on broader issues of inequality in domestic responsibilities, contributing to both energy-saving goals and social equity.

6. **Investigate Intersectional Factors**: The influence of intersectional factors—such as the interaction between age, gender, and income—on energy consumption and flexibility should be explored further, as in line with ST1 results. In the results we showed how income in relation to household structure (presence of children in the household) influences flexibility. Investigating the intersection between age and gender in consumption flexibility could also be a potential avenue for research. Palm_et al., for instance, find that gender in relation age is relevant for determining the times at which energy-intensive activities are performed, as older female respondents tended to perform them during the daytime. Understanding these intersections is essential for identifying which households are most likely to exhibit flexibility and how DSM programs can be tailored to meet diverse needs.

Conclusions

Subtask 3 showed that household energy consumption exhibits significant variability, even when accounting for other factors. These may include consistent weather conditions, system technical characteristics, and socio-demographic and economic factors, as well as historical consumption data and energy prices (Zhao & Magoulès, 2012). This residual variability, which is non-negligible, has been attributed to the specific manner in which technologies or services are utilized within the home, including the intensity and timing of their use (Piano & Smith, 2022). These usage patterns are often underrepresented in energy demand models (Huckebrink & Bertsch, 2021). When included, they are typically averaged across a limited number of socio-demographic categories. Consequently, this approach can lead to inaccurate estimates of individual and population-level flexibility potential, potentially misguiding policy design and failing to adequately identify and address target groups.

Annual energy consumption statistics, while useful, do not adequately capture the temporal and volumetric heterogeneity of energy consumption across households. In this respect, high resolution data at the appliance level would provide a more accurate basis for analysis. The collection of detailed information on household consumption patterns, such as time-of-use data collection methods, could further improve the models. Future data collection efforts are also encouraged to further explore the gender dimension of energy flexibility as well as intersectional aspects.

Flexibility Readiness and the extension of Social License Concept

Flexibility Dimensions, Factors and Readiness in Relation to Diversity

Assessing residential energy load flexibility for demand response (DR) involves accounting for various factors. Afzalan and Jazizadeh (2019) highlight that diversity in appliance types and user behaviors causes significant variability in load profiles, complicating flexibility estimates. Even identical appliances can yield different flexibility potentials based on how users interact with them, making both load and user flexibility key factors in energy demand characterization. Powells and Fell (2019) introduce "flexibility capital," which reflects an individual's ability to adapt energy consumption based on social, cultural, and economic resources. Flexibility is shaped by factors like working patterns, household composition, and access to technology. Wealthier individuals typically have greater flexibility, and energy policies promoting flexibility could exacerbate social inequalities if they overlook these disparities.

Libertson (2022) expands on this, emphasizing that flexibility capital is not just about energy use but also social status. He critiques demand-side technologies (DSTs) that assume users are rational agents, overlooking the social and temporal factors that affect their capacity to adapt. This commodification of behavior may disadvantage lower-income households, forcing them to adapt out of necessity rather than choice. At a broader system level, flexibility is essential for managing imbalances in energy generation and demand. Cruz et al. (2018) explain that energy systems need to adapt to changes in network configurations, user needs, and climate conditions to maintain stability. D'Ettorre et al. (2019) further categorize flexibility potential into theoretical, technical, economic, and market levels, helping to understand how buildings and systems can adjust energy demand profiles in response to signals like energy prices or emissions.

Flexibility types, targets, direction, and implementation

Energy flexibility manifests in different ways, such as load shifting, where energy usage is moved to different times of the day, or load reduction, where the total consumption is decreased. Sub-forms include peak shifting, which reduces the demand during peak hours, and valley filling, where energy usage is increased during periods of low demand to balance grid requirements. Flexibility can have different optimization goals. Grid-oriented optimization focuses on adjusting household energy usage to stabilize and benefit the larger energy grid. In contrast, household-oriented optimization aims to maximize benefits at the individual household level, such as reducing energy bills or enhancing comfort. The direction of flexibility is equally important. Positive flexibility refers to the ability of households to feed energy back into the grid, such as when solar panels generate excess electricity. On the other hand, negative flexibility involves drawing power from the grid, particularly when energy is needed, or prices are favourable.

Flexibility can be implemented manually or through different degrees of automation which go from automated reminders to shift to active programming, to active agreement or withholding of a veto for direct load control to direct load control without contacting consumers about specific automation incidents.

Dimensions and factors of flexibility readiness

Based on insights from the literature and expert knowledge, 3 core dimensions of flexibility were defined, impacting the “flexibility readiness” of a consumer:

- **Flexibility Capacity**: Involves the physical potential for flexibility, including prosumer technologies (e.g., solar panels) and household loads (e.g., appliances).
- **Flexibility Ability:** Considers the awareness, knowledge, and enabling technologies that allow users to make informed decisions about energy use. It includes awareness of energy practices and constraints based on lifestyle factors such as working hours and family life.
- **Flexibility Willingness:** This refers to the user's motivation to engage in flexibility, influenced by perceived benefits, technology affinity, and social norms.

These three dimensions are seen as shaping together the **Flexibility Readiness** of a consumer, defined as “readiness modify one's energy use in time, space, or intensity to accommodate needs regarding power consumption by moving the activity to another time of the day, relocating it to another place, or changing the intensity at which the activity is performed” (based on Libertson, 2022) but extended to include increase of consumption and personal needs as well)

Looking closer at factors determining the level of flexibility within these dimensions, the following can be emphasized:

- **Flexibility capacity factors** include the number and size of energy-consuming devices, the availability of smart appliances, and system-level automation. Households with access to prosumer technologies (like solar panels and energy storage) and feedback mechanisms have greater potential for managing energy usage independently.
- **Flexibility ability factors** include personal and situational factors that enable energy flexibility such as time availability, flexible routines (e.g., remote work), awareness of energy issues, and digital literacy are critical factors. Access to smart devices, technical knowledge, and financial means to invest in energy-efficient upgrades also influence a household’s ability. Additionally, home ownership enhances flexibility potential.
- **Flexibility willingness factors** include the motivation to engage in energy flexibility, driven by perceived benefits (environmental, social, or financial) and affinity for technology. Barriers such as comfort and convenience can hinder motivation, while social norms and energy tariff structures that reward flexible energy use can increase it.

Regarding the role of diversity dimensions in the context of flexibility readiness, the following insights could be gained from the project results.

Positive impact on flexibility readiness:

- **Diversity-specific Flexibility Capacity:** Men show an increased technical flexibility capacity due to their association with enabling technologies, prosumer technologies, and household loads. Women show this through their higher temporal capacity. Households with younger children demonstrate more capacity linked to household loads. Homeownership impacts capacity through enabling technologies, prosumer technologies, and household loads. High-income households exhibited capacity through prosumer technologies, household loads, and enabling technologies while medium income provide capacity through household loads.
- **Diversity-specific Flexibility Ability:** Middle-aged individuals exhibit enhanced flexibility ability through their strong control and knowledge of energy usage. Young people show readiness due to their awareness, flexibility, and knowledge, which contribute to their adaptability. Women demonstrate higher flexibility ability through their control, awareness, and practices, supported by access to information and knowledge. Men display flexibility ability across several dimensions, including control, awareness, information, knowledge, skills, an ability to transform due to more often being in charge of large investments. Homeownership plays a crucial role in enhancing flexibility ability, contributing to control, flexibility of energy practices, knowledge, and increased ability to transform. High-income households also show increased flexibility ability through access to information and knowledge, enabling them to transform their energy practices effectively, and financial means enabling them to transform their capacity.
- **Diversity-specific Flexibility Willingness**: Men demonstrate a higher willingness to engage in energy flexibility, largely due to their technology affinity but also higher interest in financial incentivization, while women respond to motivations that are environmentally and socially oriented. High-income and medium income households also exhibit this willingness, benefiting from a favourable disposition towards adopting new technologies while low-income households can respond strongly to sufficient monetary incentivization. Young people are characterized by their technology affinity as well, which enhances their willingness to adapt. Homeownership significantly contributes to willingness through both technology affinity and access to incentives, allowing homeowners to make decisions that promote energy flexibility.

Negative impact on flexibility readiness:

- **Diversity-specific Flexibility Capacity:** Low-income households struggle with prosumer technologies, household loads, enabling technologies, and temporal capacity. Tenancy negatively affects technology capacity concerning prosumer and enabling technologies, while households with young children face challenges with temporal capacity. Younger consumers also experience negative capacity due to limited possibility of prosumer technology instalment.

- **Diversity-specific Flexibility Ability**: Conversely, tenancy negatively impacts flexibility ability, particularly in terms of control and restricting the development of essential skills. Low-income households face challenges related to information availability, limiting their overall flexibility ability. This demographic also struggles more often with awareness and skills necessary for effective energy management. Older individuals experience difficulties due to a lack of skills, while households with children find their flexibility ability constrained by various factors including flexibility of energy practices and their ability to control.
- **Diversity-specific Flexibility Willingness:** Older individuals show a reduced willingness due to their low technology affinity, hampering their adoption of required technology for flexibility. Further, low-income households show reduces willingness due to limited benefits.

Flexibility Readiness can therefore be categorized into three levels:

- **High flexibility readiness:** Typically seen in tech-savvy, higher-income households with flexible schedules and access to advanced energy technologies. Both men and women can show high flexibility due it is often different types of flexibility with different motives behind (women with manual flexibility and interest in environmental and community benefits, men more inclined to the use of enabling technologies and interest in financial benefits and technological innovativeness. Homeownership increases readiness as both options and potential benefits increase noticeably.
- **Medium flexibility readiness:** Medium readiness is characterized with potential but in need of support and targeted programs to fully engage in demand-side management (DSM) programs. Younger consumers are often already engaged and more technology-affine but lack opportunities and capital. Households with children are interested but struggle with temporal flexibility. Tenancy is another restricting factor which also requires better options for participation.
- **Low flexibility readiness**: Often lower-income households, facing barriers like financial constraints, limited knowledge, inflexible routines and limited benefits. Older consumers also struggle due to limited knowledge of possibilities, low technology and, as a specifically vulnerable intersection, poverty in old age which specifically affects women. Language barriers can lead to lack of access to information and also often intersect with low-income groups and associated barriers.

These profiles highlight how diverse user characteristics influence flexibility readiness, with high readiness linked to high-income, homeownership and, regarding automated flexibility, men, while medium flexibility can be observed with young consumers, households with children and tendency, and low readiness more often with low-income households and older consumers. It is important to be aware, that intersection of these dimensions can impact readiness greatly and shift one consumer group up or down with regards to flexibility.

A More Inclusive and Community-Oriented Social Licence to Automate

SLA guides various stakeholders in identifying the key factors necessary to achieve a social license. It is therefore important to assess what discourses, needs, beliefs, and actors may be missing from the conversation, as well as to encourage a deep dive into the cultural and social frameworks at play—asking how often diversity is considered and what local agents are involved in shaping outcomes.

Background to the Social License (to Automate) Concept

The concept of Social License to Operate (SLO) emerged from the mining sector in the 1990s, highlighting the social conditions necessary for the success of a resource project (Boutilier & Thomson, 2011). Early literature on SLO explored how various issues affect different groups, with a focus on key operating factors. These include economic legitimacy, where end-users perceive that they benefit from the project or company, and socio-political legitimacy, where end-users believe the project or company contributes to well-being, meets the expectations of its role, and acts fairly—originally, this applied to the region and way of life. Other factors include interactional trust, where end-users perceive that responsible parties listen, respond, keep promises, engage in mutual dialogue, and demonstrate reciprocity; and institutionalized trust, where stakeholders are perceived to maintain trustful relations and uphold each other’s interests. SLO is viewed as an intangible and non-permanent indicator of a community’s ongoing approval and can serve as a means to account for resistance if this license is lost or absent. It exists on a continuum and is recognized as a contextual, multifaceted, and contingent concept.

As part of the first “Social Licence to Automate” Task of the UsersTCP, this concept of the social license to operate was reflected upon within the context of automated DSM. Adams et al. (Adams et al., 2021) highlight key aspects of Social License to Operate (SLO), stressing that it extends beyond regulatory approval to include the broader public, which can influence a project's success. SLO exists on a continuum, ranging from rejection to full psychological identification with a project’s goals. They also note that the boundary between local communities and wider stakeholders is fragile, as nearby groups may become activists under certain conditions. The authors argue that SLO must consider potential misalignments between various actors' roles and stakes. While traditionally linked to global supply chains, in contexts like electricity grids, the focus shifts to users' flexibility as the key commodity. "Grid sensitivity," shaped by experiences like service disruptions, plays a role in how Demand-Side Management (DSM) projects are received. DSM can create winners and losers, with certain groups disproportionately impacted. In DSM, three key factors need attention: households' capacity to alter energy use, their sense of control and trust in providers, and their stake in grid management. Resistance to DSM often stems from a mismatch between household flexibility and the demands of automation, as well as the lack of agency in these programs. Adams et al. recommend modifying the SLO concept in DSM to amplify the voices of affected actors, fostering a more collaborative and fair approach.

Extension of the concept

Within SLA2.0, we aimed to further expand the social license concept, incorporating a consideration of social aspects and a contextualization in order to enrich it's understanding and application with a multi-lens perspective that supports the development of inclusive and socially just solutions. The concept of social licenses to automate outlines three key pillars: legitimacy for gaining acceptance, credibility for securing approval, and trust for achieving psychological identification with DSM. These aspects are not simply a matter of personal choice but are shaped by the social conditions set by community stakeholders to overcome these barriers and achieve broader acceptance (Boutilier & Thomson, 2011).

- Legitimacy is built by demonstrating a perceived benefit, not only for the individual user but also for the community as a whole, contributing to overall wellbeing while maintaining fairness.
- Credibility arises from transparent communication, the availability of clear information, and ensuring accessibility.
- Trust is established through shared experiences that foster rapport, a sense of reliability, accountability, and a perception of shared goals and collaboration toward achieving them.

Building a diverse social license

Mapping the dimension of the social license onto insights gained regarding the role of gender and diversity factors in the ability, willingness and capacity for demand side management, the following insights and implications emerge for building a diverse social license:

Gender significantly shapes perceptions of legitimacy, credibility, and trust in energy management systems. Men and women tend to prioritize different aspects, with men focusing on financial and technological incentives, while women emphasize environmental and social benefits. These divergent priorities affect how each group perceives the legitimacy of energy management initiatives, as their perceived benefits vary. Moreover, women often face barriers to technology access, which limits their ability to fully engage with energy programs. This reduced access restricts the flow of information and diminishes the credibility of the system from their perspective. Without direct involvement, women may feel excluded from meaningful participation, particularly if their engagement is mediated through a partner, leaving them with a secondary role. This, in turn, hampers the trust-building process, as trust is often rooted in interaction and communication. The masculinity bias stemming from more direct involvement and information access leads to a closer alignment of motivations and opportunities with male priorities, thus enhancing both legitimacy and credibility for men, while women's perspectives may be underrepresented or overlooked. The differing levels of access and involvement between genders highlight the need for inclusive strategies that account for these disparities in energy management systems.

Income and class dynamics also play a critical role in shaping the legitimacy, credibility, and trust to support a social license for flexibility and automation. Low-income households often lack access to the necessary technology for energy-shifting programs, which undermines their ability to participate meaningfully. This lack of access diminishes perceived benefits while the required effort to participate increases, leading to a failure of communication of legitimacy for these groups. Additionally, the concept of "flexibility capital" highlights how low-income users often have limited options for flexibility in energy use, further restricting their ability to derive benefits from energy-shifting programs. This lack of flexibility contributes to the challenges in establishing legitimacy, as the programs fail to provide meaningful advantages for these households. Furthermore, individuals with low energy literacy can face difficulties in understanding the information presented, further hampering the crossing of the legitimacy- and credibility-boundaries. Trust is also affected by these dynamics. Without access to affordable technology or relevant information, low-income households may feel disconnected from the process. Economic constraints exacerbate this disconnect, leading to a sense of exclusion and a lack of trust in the system. To address these challenges, energy management programs must offer tailored solutions that accommodate the financial and informational needs of low-income participants, ensuring their inclusion and the realization of tangible benefits. Without it, these groups will not be reached and will not grant a social license.

Age introduces specific challenges in establishing legitimacy, credibility, and trust as well. Elderly individuals, often facing health issues and lower technological literacy and digital skills, often struggle with the adoption of new technologies, and, although typically they have more time available, are often less open towards changes in routines. While they are typically motivated by a strong sense of communal responsibility and ecological benefits, their hesitation toward technology and potential rigidity of daily structures makes it difficult to realize the full advantages of energy-saving initiatives. Both aspects can limit the perceived legitimacy of such programs for older adults. Limited digital skills also challenge credibility as they pose a communication barrier. Complex energy and technology concepts may be harder to grasp and lead to a feeling of disconnection from the process. Crossing the credibility boundary can therefore be challenging due to difficulties in reaching these users and establishing trusted communication. Establishing credibility requires addressing these specific needs and ensuring that the information is presented in an accessible and trustworthy manner through appropriate channels, potentially accompanied by additional explanations and training offers. This can also support the building of trust as it supports the experience of being included, sharing of experiences and opportunities to participate. Among younger users, while they tend to be more tech-savvy and their daily routines can be more flexible, they often face financial and social constraints, limiting their actual ability to engage with energy-saving programs. In such cases, the legitimacy of these programs is compromised if they fail to provide meaningful benefits that address the financial and living situation challenges faced by this group. Thus, age-specific approaches are necessary to ensure both younger and older participants can experience the advantages of energy management initiatives in a way that resonates with their unique needs.

Intersectionality further complicates these dimensions. Women in low-income households often bear more of the burden when it comes to energy-related tasks, and energy poverty disproportionately affects women. Additionally, women, particularly older ones, tend to have lower technological affinity, which creates further barriers to both credibility and trust. The elderly are also more frequently affected by (energy) poverty, which reduces their ability to participate effectively in energy management programs. Addressing these intersectional challenges is essential for building legitimacy, credibility, and trust across diverse groups.

Levers of energy community initiatives to support social license building

Community approaches can ideally contribute to developing legitimacy and acceptance as the ownership of the provision belongs to the community. Therefore, the costs/risks and benefits of projects are distributed more equitably, community receiving the immediate and direct benefits. Democratic decision making as part of the community model can be a driver for developing legitimacy where community is engaged in the problem definition of the flexibility, energy provision etc. Similarly, in community approaches, it is collective decision-making and the encouragement of cooperation that helps to recognise the diverse needs, expectations and values. For credibility to be established, significant efforts must be made by third parties to communicate transparently with the community, ensuring reliable and accurate information is shared. The inclusion of community actors and leaders in these processes strengthens credibility by promoting transparency and enhancing trust in the solutions being implemented. Building or leveraging existing social capital within energy communities can greatly enhance trust in projects like PV installation, flexibility, and automation initiatives. Shared responsibility within the community further strengthens this trust, as members feel they are working together toward a common goal. Regular engagement, cooperation, reciprocity, and a sense of shared responsibility all contribute to building long-term trust, ensuring the success and fairness of energy projects while solidifying community ties.

The Role of Data Collection and Analysis in a Social License for Flexibility

From a data collection and communication perspective, the importance of collecting and analysing load profile data, as well as data on user characteristics and contextual information is underlined. Only if it is understood who has access to provided data and recommendations, their success or failure in supporting flexibility can be properly understood and tailoring of the presentation to the everyday context of users can be enabled, affecting both legitimacy and credibility. Further, provision of feedback and device-specific data is crucial to enable impact evaluation, providing the evidence needed for households to cross the legitimacy threshold and accept manual or automated load management as a viable way to balance their energy demand over time. Additionally, analysing load profiles can help build legitimacy and credibility by simulating the impact of shifting, showing that even small load shifts have a measurable effect on the energy system.

As communication of benefits should be tailored to user motives, data on user characteristics will further support legitimacy building. If the concept of load shifting aligns with a household's value system (e.g., eco-orientation), it is more likely to be actively approved and a higher level of approval and identification communicated motives behind load shifting increases the likelihood that households will engage in it, either manually or automatically, without external incentives. Finally, analysing load profiles can also foster trust through providing a base for the emphasis of shared experiences, goals, decisions, and collaboration. Transparent access to information allows users to feel involved in decision-making, understanding the rationale behind

DSM strategies, and empowering them to participate. Additionally, it makes it possible to present the users involved as a community, show shared motives and patterns and support collaboration towards shared stated goals. Providing awareness about the variety of members can show that diverse needs are acknowledged and valued, and diverse user groups are welcome and can be involved. This inclusion strengthens trust by making users feel like active partners in managing energy effectively.

Conclusions

The results of this Task highlight the importance of considering intersectionality in the design of Demand-Side Management (DSM) programs. Demographic factors and individual interests, such as technology use, influence both participation and flexibility in these programs. If DSM systems are not designed inclusively, they risk disproportionately benefiting privileged users while disadvantaging others, especially those already facing energy poverty. Many groups are willing to shift energy use for community and environmental benefit, provided the conditions are just, accessible, and economically fair. Programs should engage entire households, considering diverse motivations and needs. Further, energy communities (EC) have potential to contribute to socially equitable, democratic energy consumption models, but a social license to automate is not guaranteed. ECs' success depends on factors like governance, financing, and local context. Addressing social dimensions like energy justice, community empowerment, and social capital is crucial to building legitimacy and trust. Finally, household energy consumption varies significantly due to factors like usage timing and intensity, which are often underrepresented in models. High-resolution appliance-level data and time-of-use information could improve energy demand modelling. Future efforts should also explore the gender and intersectional aspects of energy flexibility to ensure more accurate and inclusive policy design.

Flexibility readiness in Demand Response (DR) is shaped by three dimensions: capacity, ability, and willingness. Capacity refers to the physical potential for flexibility, with higher capacity in men, high-income households, and homeowners due to access to technologies. Ability involves knowledge and control over energy use, with stronger ability in middle-aged individuals and homeowners, while low-income households and older individuals' struggle. Willingness is motivated by interest in technology, with higher willingness in younger, tech-savvy consumers and homeowners, and lower willingness in low-income and older individuals due to limited technology affinity. High flexibility readiness is seen in tech-savvy, higher-income households. Low readiness is common in low-income households, tenants, and older consumers due to financial and technological barriers.

Incorporating user group diversity into the Social License (SL) concept enriches the understanding of household needs and ensures that overlooked voices are heard. Community-based energy initiatives can foster legitimacy through equitable distribution of risks and benefits, democratic decision-making, and transparent communication. Effective data collection, such as load profiles and user characteristics, can help design tailored energy programs, enhancing legitimacy and trust by aligning initiatives with household values and involving users in decision-making.

Recommendations

Following, specific recommendations that were developed based on the Subtask results are presented.

Furthering inclusive participation in demand side management

- **Participation without Financial or Technology Barriers:** Ensure that there are ways of participation in DSM programs (and/or energy communities) that do not require financial investments or new technology purchases (e.g. participation via app) and that basic requirements such as smart meter instalment are fulfilled.
- **Tailored Support for Low-income Households:** Implement subsidizing programs and financial incentives to help low-income groups access energy-saving technologies and provide participation opportunities through housing cooperatives or social housing to ensure low-income households can engage.
- **Reduction of Cost Burdens for Low-income People:** Policymakers and energy projects should prioritize reducing the cost burdens for low-income people, ensuring that the benefits and costs of energy projects are justly distributed.
- **Low-tech Solutions for Limited Digital Skills:** Offer low-technology solutions for people with limited digital skills or low technology affinity, ensuring that technological advancements do not exclude users who may not be comfortable with or able to use advanced technology.
- **Accessible Solutions Integrated with Everyday Activities:** Design solutions that are multilingual and barrier-free and reference everyday activities, making them more intuitive and accessible to people with different levels of technological familiarity and from diverse socio-economic backgrounds.
- **Support for Digital and Energy Literacy:** Increase support for digital and energy literacy through accessible information materials, workshops, and community engagement efforts, helping users from diverse backgrounds better understand and engage with energy-saving technologies.
- **Reach out to hard-to-reach Groups**: Use targeted communication strategies to engage underrepresented or hard-to-reach groups, such as women, elderly people, and low-income households, in energy-saving initiatives.

Supporting a social license though energy community initiatives

- **Continued engagement and trust building:** Establish and maintain relationships with local communities through continued engagement and relationship building, ensuring meaningful, open and transparent communication and involvement to build trust.
- **Reduction of Cost Burdens and Benefit Sharing:** Implement financial mechanisms within ECs to reduce cost burdens and fairly distribute benefits and costs for low-income members, ensuring sufficient benefits of participation.
- **Local Actors Engaging Citizens:** Local actors should be directly involved with informing citizens about energy community participation options.
- **Strengthen Engagement of Energy Cooperatives in Energy Communities (ECs):** Energy suppliers such as energy cooperatives should expand their service portfolios to support and actively engage with Energy Communities (ECs), as well as train their staff to handle inquiries and requests effectively.

- **Equity-focused Approaches:** Adopt equity-focused approaches to energy community participation with participation opportunities tailored to specific groups and tailored support to different communities with different needs.
- **Simplify participation in ECs:** Reduce bureaucratic complexity including required contractual agreements, enable participation without technical infrastructure and limited investment of time and cognitive resources, and consolidate billing procedures to enhancing accessibility of founding and participating in energy communities.

Supporting Tailored Participation and Social License Building through Social, Demographic, and Behavioral Insights

- **Ask About Household Roles:** Include questions about individual roles in household energy use, such as who uses which appliances or who makes energy-related decisions, to single out gender or role-based differences in energy consumption.
- **Habits and Routines in Energy Use:** Investigate how habits, routines, and everyday actions (not just demographics) influence energy consumption, identifying patterns among different user groups that can support targeted involvement.
- **Collect granular and device-specific data:** Collect detailed data to enable meaningful feedback and targeted advice.
- **Support Intersectional Understanding:** Apply intersectional perspectives in order to better understand the particular circumstances and needs at intersections of diversity dimensions.
- **Greater Research into Social Dimensions of ECs:** Investigate social dimensions such as gender, income level, and cultural practices in energy communities, ensuring that ECs cater to the needs of diverse groups.
- **Research on Financial Incentives for Diverse Groups:** Investigate the types of financial incentives that effectively influence energy-saving behaviors across diverse demographic groups, ensuring that policies and programs are designed inclusively.
- **Study the Impact of Energy Prices and Inflation**: Examine how factors like energy prices and inflation disproportionately affect energy-saving behaviors.

Summarizing recommendations from a stakeholder-group perspectives, the following points can be highlighted:

- **Organizational Stakeholders (e.g. energy providers, aggregators, energy cooperatives):** Focus on diverse and easily accessible, low-investment participation opportunities, ensure procedural justice, transparent communication and fair distribution of benefits, carry out continued (community) engagement, ensure involvement of relevant stakeholders and open communication between stakeholders
- **Technical Stakeholders (e.g. providers of enabling technologies, network companies, grid operators):** Prioritize accessibility and usability, develop

multilingual of solutions that only require basic technology (smart meter, smart phone), connect content with everyday activities of users, offer household-level solutions.

- **Financial Stakeholders (e.g. financing institutions, government subsidy programs, providers of grants and funding)**: Focus on equitable financing mechanisms, subsidies, and cost reduction for low-income participants, incorporate risk-sharing mechanisms, standardize evaluation.
- **Regulatory Stakeholders (e.g. policy makers, government agencies, energy regulators)**: Emphasize fair participation, develop targeted support programs, ensure fair sharing of costs and benefits, enable fast legislative changes.
- **Scientific Stakeholders (e.g. academia, applied research institutions, corporate research, NGOs, etc.)**: Investigate social dimensions and intersectional aspects, energy behaviors and household roles, and the effectiveness of financial incentives and community participation processes.

Directions for future research

The results of the SLA2.0 Task have highlighted that households and energy communities are 'collectives' rather than single or dichotomic entities. Within these collectives, multiple agencies, and negotiations, and (in)capacities exist, and dimensions are interconnected. Engagement and participation in flexibility (both production and consumption) are inherently emergent and co-produced phenomena, rather than specific and fixed, and can therefore not be addressed sufficiently though normative and pre-given models of participation.

Future research is warranted with a constructivist perspective and research that puts an analytical focus on the collectives of engagements ‘in the making’ and pay particular attention to the circumstances of its construction and processes of social licenses to automate. De-centring from the main focus only: who says ‘yes’ or ‘no’ (SLA V2), but more examination and understanding of processes: activities (what activities are involved and how they are linked), governance (who is involved and how) and collective outcomes (naturally depends on the activities and governance).

Research building on our insights should focus on:

- How are flexibility decisions negotiated within households and how do these negotiations interact with household roles of household members?
- What type of processes, dialogues, organizational, and governance structures and participatory approaches should be there to build social license with multiple actors with diverse profiles & capacities?
- What types of collective benefits and social sustainability outcomes are co-created and can be measure which underpins the social license to automate.

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Appendix 1: Country Profiles

Austria

Composition of population

By January 2024, Austria's population was about 9.16 million people, 50.70% female, 49.30% male. Currently the life expectancy for women is 83.78 years, for men 79.05 years. In general Austria's population is aging: 19.3% of under-19s compared to 43.4% of over-65s. The average is in Austria is 43.4 years. Austrias fertility rate is 1.41, so Austria's increase of population is caused by immigration. 49.1% of people over 15 years are married or in a civil union, 36.2% are unmarried, 8.5% are divorced. This leads to 1.57 million single-person households and an average of 2.18 persons per household. In 2023 there were 4,119,100 households in Austria.

Regarding highest completed education, 17.1% finished compulsory schooling, 32.0% finished apprenticeship, 30.4% hold a middle- or high school certificate and 20.4% hold a university degree. Austria's labour force participation rate in 2023 was 74.1%, the average net monthly income in Austria is 2,330 Euro. Households with an income of <60 of the median income are considered as at poverty risk. 17,7% are in poverty risk, 3.7% live at poverty. Single parenting households – mainly women with their children – have the highest risk of poverty (36%) and this effect is rising. In 2022 45.4% of single parents stated that they face payment difficulties in the upcoming months, compared to 21.2% one year earlier.

Austria's rental rate is 43.7%. 36.2% own the house they live in, 11.8% own a flat, 23.6 live in communal or cooperative flats, 19.3% live on rent on various kinds of contracts. In 2022 there were 4.97 million residential units, 1.54 million of which were single-family houses. A higher percentage than in most European countries lives in rural areas in Austria (39%), 35% live in urban areas and 26% live in urbanized rural areas.

95% of Austria's population uses the internet, 76% are e-government-users. Grid operators are legally obliged to equip at least 95% of their metering points with new electricity meters by the end of 2024.

Tariff structures

The most common tariff system for electricity in Austria is flat-rate. Time-dependent tariffs with flexible, often monthly prices, such as Time-of-Use or Demand-based, which allow consumption to be adjusted to the electricity price are still quite niche, also due to the slow penetration of smart meters, which are a prerequisite for such tariffs. For example, the company aWATTar offers an hourly tariff based on hourly spot prices to customers with smart meters. Moreover, suppliers are quite restrictive and there is currently no option to take two different suppliers and for instance a flexible tariff for the flexibility and another tariff for non-flexible loads. Two tariffs and two meters are possible regarding some suppliers. At the end of 2022, only 68 per cent of all smart meters had been rolled out in this country. The target that Austria set itself was therefore also missed - according to this, a total of 95 per cent of all electricity meters should have been smart meters by 2019.

Electricity prices for households were EUR 0.27 per kilowatt-hour in December 2023 (EUROSTAT). It is important to note that the electricity cost subsidy (known as "Strompreisbremse") applies in Austria from 1 December 2022 to 31 December 2024. It caps electricity costs at 30 cents per kilowatt hour up to a consumption of 2,900 kWh per year. From 1 January 2023, the grid cost subsidy also came into force. This is intended to reduce the effects of the sharp rise in electricity and energy costs.

Also, it is important to mention that the Electricity Industry Act (Elektrizitätswirtschaftsgesetz, ElWG), which is currently in draft form, would give end customers whose consumption is measured using a smart meter the right to a supply contract with dynamic energy prices. Suppliers supplying more than 50,000 metering points under this regulation would be obliged to offer supply contracts with dynamic energy prices. The future of the law will be decided after the Austrian parliamentary elections at the end of September 2024.

Energy Communities

ECs as per the Clean Energy for All Europeans Package (CEP) of 2019 have been legally enabled since mid-2021, as part of the establishment of the Renewable Energies Expansion Act (Erneuerbaren-Ausbau-Gesetz) and a recast of the Electricity Industry and Organisation Act (Elektrizitätswirtschafts- und Organisationsgesetz). At first, only Renewable Energy Communities (RECs) could be implemented since DSOs needed some time to implement according to processes continuously. From April 2022 onwards, also Citizen Energy Communities (CECs) could be established – at first, constrained to the concession are of one DSO; a few months later without geographical constraints within whole Austria.

When it comes to RECs and CECs, the DSO plays an essential role. The DSO is not only responsible for data measurement, but they are also responsible for allocating energy within the EC between participants based on either a static or dynamic allocation key (which the EC is free to choose). Based on the measured and allocated energy data – which the DSO provides to the EC – the EC can perform the billing (determine how much has to be paid by individual participants due to purchasing from the EC and determine how much revenues are generated by individual participants due to selling to EC peers). The energy price within the EC can be freely chosen by the EC. The residual load of the different participants is covered by a conventional energy supplier (can be different for each participant!), and the surplus generation can be sold to e.g. a supplier for a certain feed-in-tariff.

RECs are subject to reduced grid tariffs and exempt from certain levies such as the electricity surcharge and the renewable energy surcharge. CECs do not receive direct additional financial support. However, it needs to be kept in mind that the biggest lever for the profitability of ECs is still an appropriate energy price within the EC. Currently, according to the official body for ECs in Austria – the Österreichische Koordinationsstelle für Energiegemeinschaften – more than 1000 ECs have already existed as of February 2024. These are RECs to the largest part, only a small percentage is CECs.

The set-up of the individual ECs differs significantly. The number of participants ranges between the minimum of 2 and a couple hundred. ECs with a small number of participants are oftentimes those that are established for energy sharing between family members. Larger ECs are oftentimes those being organised by a whole municipality or other officials, such as climate and energy model regions (Klima- und Energiemodellregionen – KEM). Most EC members are households, some ECs also integrate small- to medium-sized enterprises. Big interest in EC engagement is expressed by social housing developers, who mostly have the issue to be classified as large enterprise, and thus excluded from participation in RECs, and subject to participation with limited control function in CECs. ECs within the borders of one multi-apartment building, or, more generally formulated, ECs with participants behind the same grid connection point have already been legally allowed since 2017 with regulatory guidelines laid down in the Electricity Industry and Organisation Act §16a. (However, these small-scale communities do not classify as the two forms of ECs as per the CEP.

Ireland

Composition of population

The Republic of Ireland has a population of about 5.1 million on 83 percent of the total area of Ireland, which is 84,421 km2[2]. The population includes 2,544,549 males and 2,604,590 females. The average age is 38.8. The population is aging, with the highest increase seen among the over-70s. The proportion of people married, including same sex civil partnerships, was 46%. Among single people, there were more men (52%) than women (48%). 8% of the population reported experiencing at least one long-lasting condition or difficulty to a great extent or a lot. The labour force participation rate remained at 61% in 2022. The proportion of owner-occupied dwellings was 66% at the same time. Nearly a quarter (23%) of households reported that they used renewable energy sources. The use of solar panels was reported by 6% of households, ranging from 3% of households in Dublin City to 11% of households in Meath. Over 70% of the dwellings built since 2016 used at least one renewable energy source. Over 40% of this same cohort had heat pumps. Approximately 30% had solar panels. Almost 80% of dwellings had a broadband connection. According to the Commission for the regulation of utilities every home and business in Ireland will have a smart meter by the end of 2025.

Tariff Structures

In Ireland, energy tariffs are structured in various ways depending on the type of customer (residential, commercial, or industrial) and the energy provider. Residential customers can choose between: (1) a flat rate tariff where customers are charged a fixed price per unit of energy consumed, regardless of the time of day; (2) a time-of-use (TOU) tariff where the price per unit of electricity varies depending on the time of

[2] Census of population 2022, Central Statistics Office, Ireland. See Census of Population 2022 - CSO - Central Statistics Office

day[3] for example day/night tariffs; (3) a more dynamic rate through smart meters providing real time information on energy use enabling accurate billing and assisting consumers in monitoring their consumption to allow them to avail of lower off peak rates; or (4) a pay as you go meter where customers pay for their electricity in advance. There are also other tariffs where customers pay a fixed standing charge (a daily or monthly fee for connection to the energy grid) and a per-unit consumption rate for electricity or gas and also renewable/green tariffs (aimed at consumers who prefer to use green energy) and electric vehicle (EV) tariffs for customers who own electric vehicles, often incorporating reduced night rates to encourage EV charging during off-peak hours. On average, rates are around:

- **Peak Rate**: 29.11 cents per kWh
- **Day Rate**: 27.28 cents per kWh
- **Night Rate**: 14.34 cents per kWh

Each of these structures can differ slightly between energy providers, and customers are encouraged to compare tariff options to find the best one for their usage pattern. Additionally, Ireland has implemented a Public Service Obligation (PSO) Levy on electricity bills, which funds renewable energy and other government energy initiatives, though it is being phased out.

Energy communities

Energy communities in Ireland are collaborative groups of citizens, businesses, and local organizations that come together to generate, use, and manage energy in a more sustainable, locally-driven manner. These communities are designed to foster local energy independence, reduce carbon emissions, and share benefits from renewable energy generation. Ireland's government, through its Sustainable Energy Authority of Ireland (SEAI), supports energy communities under initiatives like the Sustainable Energy Communities (SEC) network. Grants, expertise, and technical assistance are provided to help communities plan and implement projects (e.g., renewable energy projects such as wind, solar, bioenergy projects). These projects also include energy efficiency initiatives, such as retrofitting homes, installing smart meters, or promotion of the adoption of electric vehicles.

Energy communities in Ireland are regulated under a mix of EU-driven directives (e.g., Renewable Energy Directive (RED II) (EU Directive 2018/2001 and the revised directive 2023/2413) and the Electricity Market Directive (EU Directive 2019/944)) and national policies that support community participation in renewable energy production and the broader energy market. Key regulatory frameworks like RED II, the Renewable Electricity Support Scheme (RESS), and the Microgeneration Support Scheme (MSS) provide the legal, financial, and operational backing necessary for community-led energy projects, aiming to decentralize energy production and enhance local engagement in the energy transition.

[3] Higher rates are charged during peak demand hours, and lower rates are offered during off-peak periods (such as at night or weekends).

Introduced in 2021, the MSS allows individuals and communities to generate renewable electricity and sell excess power back to the grid, supporting smaller, localized projects.

The Commission for Regulation of Utilities (CRU) oversees the implementation of energy regulations, ensuring that energy communities have fair and non-discriminatory access to the market. Launched in 2020, RESS is a financial support mechanism to promote the development of renewable energy projects. Under RESS, community participation is prioritized, with provisions for Community-led RESS Projects and Community Benefit Funds. These funds ensure that a portion of revenue from large-scale renewable projects is invested back into the community. Ireland's National Energy and Climate Plan (NECP) 2021-2030 incorporates the goals of empowering citizens to participate in the energy transition, largely through the development of energy communities. In addition, the Climate Action Plan 2023 provides an ambitious roadmap for transitioning to a low-carbon economy, which includes specific targets for community energy projects, aiming for widespread participation in renewable energy generation.

The Netherlands

Composition of Population

The Netherlands has a population of approximately 17.5 million people, with an area of about 41,850 km². Around 93% of the population lives in urban areas. Major cities like Amsterdam, Rotterdam, The Hague, and Utrecht dominate the urban landscape forming area known as Randstad. The typical Dutch household lives in a terraced house, apartment, or detached house. Single-family homes are common in the suburbs, while multi-family apartments are more common in city centres. The Netherlands is known for its dense infrastructure, with a high population density of about 420 people per square kilometre.

The Dutch population is aging, with about 20% of the population aged 65 and over. This demographic shift affects the country's energy needs, particularly in housing and transportation sectors.

Energy Sector Overview

The Netherlands has a well-developed and diversified energy sector, traditionally dependent on natural gas due to its large Groningen gas field, though gas extraction has been scaled back due to environmental concerns (earthquakes). The country is transitioning to renewable energy, with a significant focus on wind, solar, and biomass. As of 2023, around 35% of electricity is generated from renewable sources, with a goal of 100% renewable energy by 2050.

Wind energy, both onshore and offshore, is a major component of the Dutch renewable strategy. Offshore wind farms are a particular focus due to the country's geographical location. Solar power is also rapidly growing, especially in urban areas, where rooftop solar panels are very common.

Tariff Structures

The Dutch electricity market is liberalized, allowing consumers to choose from a variety of energy providers and types of contracts. The most common types of contracts include:

- **Fixed-price contracts**: These offer a stable rate for a certain period (usually 1-3 years).
- **Variable-price contracts**: The price fluctuates with the energy market.
- **Dynamic pricing contracts**: Based on real-time market conditions.

Energy tariffs consist of two parts:

1. **Energy supply costs**: This includes the cost of electricity or gas consumed, paid to the energy provider.
2. **Network fee**: Paid to the Distribution System Operator (DSO) for maintaining the grid and transporting energy. The fee is usually fixed but may also have a consumption-based component.

Smart meters have been rolled out widely, with over 90% of households expected to have them by 2024. These meters enable better monitoring of energy usage and allow consumers to take advantage of dynamic pricing.

Energy Communities in the Netherlands

The Netherlands has adopted European Union directives for Renewable Energy Communities (RECs) and Citizen Energy Communities (CECs). These allow communities, businesses, and individuals to collaboratively generate and share energy. The Energy Agreement of 2013 and subsequent policies have facilitated the growth of local energy cooperatives, which now number over 700 across the country. These cooperatives typically focus on local solar or wind projects.

Pilot projects for energy communities include initiatives where apartment buildings or neighbourhoods share locally generated renewable energy. These projects are supported by subsidies and regulations that promote community energy sharing, allowing participants to sell excess energy to the grid.

The Dutch government supports the development of energy communities through various incentives, including the **SDE++ subsidy** (Stimulering Duurzame Energieproductie en Klimaattransitie), which encourages investment in renewable energy projects. Additionally, the "Postcoderoosregeling" (Postal Code Rose scheme) allows residents in certain postal code areas to collectively invest in solar panels and benefit from tax exemptions.

Norway

Composition of population

Norway has a population of about 5.4 million people, in an area of 323,802 km2. 82% of Norwegian inhabitants live in urban settlements according to Statistical research at Statistics Norway. The most common forms of dwellings are single houses and detached houses, although the dwelling type increasing the most is the multi-dwelling building. Norway has a large, state-owned oil and gas sector and almost all the petroleum produced on the Norwegian continental shelf is exported. In 2020 Norway banned oil-fired heating in buildings. Energy use in homes in Norway amounts to 47-48 TWh per year. Two-thirds of this goes to space heating, while around 12 percent is used for heating tap water, 5 percent for lighting, and around 15 percent is used for electricity-specific equipment.

About 88 % of the Norwegian energy production capacity comes from hydropower plants, while 11 % comes from wind farms. Norway has about 1240 storage reservoirs meaning that about 75 % of the Norwegian electricity production capacity is flexible according to energy facts Norway.

Tariff Structures

Norway has had a deregulated marked-based power system since 1991. The Norwegian grid is a part of a joint Nordic power exchange Nord Pool with Sweden, Denmark and Finland and also interconnected to the Netherlands, Germany, the Baltic states and Poland. The network company (TSO) Statnett has a monopoly on building and operating the infrastructure in its local area and is overseen by the regulation authority (RME) within NVE. The utilities' roles are to be the link between the energy market and the consumers.

In Norway, it is common to distinguish between the grid fee for the DSO and the electricity company bill. These two bills can be received separately. The grid fee (DSO bill) is divided into three components.

- ***Capacity part*:** This charge is based on the average of your three highest daily maxes per hour within one calendar month. The charge is divided into different levels.
- ***Variable part:*** This charge depends on the total energy consumed in kWh. The time of day and seasons influences this cost.
- ***Taxes and Other Charges:*** This includes public fees such as VAT, the electricity tax, and certificates. These fees are set by the government.

The electricity bill covers the price per kWh, including the spot price and a markup (which includes VAT, profit margin, and certification fees). The Norwegian household end-user can choose between various types of contracts for electricity bill. Like fixed-price, standard variable price, and spot price. 93 % of households in Norway are on spot price contract. About 98,8 % of the households have in 2024 a smart meter with features that make it possible for installed automated solutions to extract data on electricity use. The Norwegian electricity market is also divided into five pricing zones, meaning that e.g the north of the country can have low prices when the south has high prices. The combination of a hot year in 2020, and a cold winter of 2021 did set new records for the power consumption and the prices in the winter of 2022. Resulting in a lot of media on electricity prices and a decrease in electricity use by 12 per cent from 2021 to 2022. From august 2023 the aggregate electricity use did increase again, which has supported interpretations that the response at household level is in relation to the relatively perceived price, e.g. there is a stronger response in periods with a lot of media coverage of high prices according to Norwegian water resources and energy directorate (NVE).

Energy communities

Concepts such as Citizen Energy Communities (CECs) and Renewable Energy Communities (RECs) have yet to be integrated into national law of Norway or practice according to the definitions outlined in the EU Electricity Market Directive (EMD) (2019/944) and the Renewable Energy Directive (REDII) (2018/2001) according to Nordic energy research. Since Norway is not an EU member state, the implementation of CECs and RECs remains pending, meaning that Norway is still in its early stage of implementing energy communities (ECs) according to the EU definition. However, pilot projects of energy communities exist in Norway, mostly driven forward by local DSOs.

The Norwegian Energy Act has been a barrier to local production and sharing electricity, but as of October 1, 2023, customers sharing a common farm and utility number can collaborate to invest in renewable electricity production and distribute this electricity among users on the same property.

Sweden

Composition of population

Sweden has a population of about 10,5 million on an area of 447 424 km^2. 88% of the population live in densely populated areas mostly in the southern part of the country, with 2,5 million concentrated in the 3 biggest cities. The population is quite evenly distributed across age; 22,3% under 20, 25,7% between 20 and 40, 25% between 40 and 60, 20,6% between 60 and 80, and 6,4% over 80. The gender split is almost equal (men 50,3%, women 49,7%). The largest share of Swedes lives in single-person households (41%) followed by 30% in two-person households, 11,3% for both 3- and 4- person households, and the final 5,9% in 5+ person households. Of the approximately 5 million households, 50% (2,5M households) live in an apartment in a multi-household building (compared to 42,2% (2,1M households) in single-family houses), but more individual people live in single family houses (51% (5,4M), compared to 43,1% (4,5M) in multi-family houses).

Electricity (163 TWh yearly) is produced using hydropower (40%), and wind and solar (23% with solar growing significantly). 30% of electricity is produced in nuclear power plants, despite Sweden voting in 1980 to phase out nuclear by 2010. New investments in nuclear power are being discussed, to create a stable supply and facilitate electrification of transport and industry. Energy production should be completely fossil free by 2040.

Sweden uses 135 TWh electricity per year, more in winter than in summer because of the need for heating. The biggest peaks are cold winter evenings. Single-family houses are often heated with electricity as the main source (30% either directly or using air-source heat pumps, and 18% in combination with biofuel). Such houses generating an average consumption of 20000 kWh/year, while houses heated with other forms of heating (e.g. geothermal heat pumps 13%, district heating 12%) use approx. 5000 kWh/year. Apartments in Sweden are often heated with district heating, so electricity is only used for household practices, usually 2000kWh/year up to 5000 for bigger apartments.

Tariff structures

Swedish electricity tariffs for households are divided into two main parts:

1. Energy supply tariff paid to the electricity supplier for the consumption of electricity, per kWh. Households can choose between about 120 different companies (ei.se). Households can also choose type of contract: Fixed price for the duration of contract (usually 1-3 years, 11,5% of customers), Variable price which varies monthly in relation to spot price on the Nord Pool exchange (57,3% of customers), and Hourly price (Time-of-Use) where price varies hour to hour based on the Nord Pool market (12,6% of customers). Hourly rates are expected to be replaced by prices based on quarter of an hour in 2025, when smart meter roll outs are supposed to be completed (January 1st 2025). With the energy supply tariff comes a certificate fee which aims to stimulate renewable energy production and VAT.
2. Network fee paid to DSO. Households cannot choose DSO (local monopoly), and there are 170 different DSO companies in Sweden. The network fee consists of 1) fixed monthly cost based on the capacity of the household's connection, 2) variable transmission fee based on monthly electricity consumption (kWh), and 3) power tariff**.** Sweden's DSOs are in the process of introducing power tariffs (deadline January 1st, 2027) and have chosen to design them differently. The guideline is that it should be a time-differentiated fee based on the individual consumer power demand and the combined demand on the grid. Usually, this fee is set based on the maximum load during peak times for the month. The network fee also includes energy tax, VAT, and additional fees for surveillance, preparedness, and safety.

Energy communities

Energy communities became possible in Sweden January 1st, 2022, when regulations were changed to allow the sharing of energy between residential buildings on the same or neighbouring properties. Both Renewable Energy Communities (electricity, heating and cooling) and Citizen Energy Communities (only electricity) were made possible at the same time. There are however few examples of existing energy communities, but a growing number of pilots and initiatives (e.g. Hammarby Sjöstad, Tamarinden, Gotland). The Swedish energy agency (on behalf of the government) is currently investigating existing obstacles to, and the potential for, developing renewable energy communities and citizen energy communities and whether Sweden can do more to improve the conditions for energy communities through promotional efforts (not including tax).

Switzerland

Composition of population

Switzerland, officially the Swiss Confederation, is a landlocked country situated at the confluence of Western, Central, and Southern Europe. It is a federal republic composed of 26 cantons, with federal authorities based in Bern. The population of Switzerland is 8.5 million concentrated mostly on the plateau, where the largest cities and economic centres are located, among them Zürich, Geneva, and Basel.

Switzerland's population is distributed across gender, age and house type groups as follows: 50.4% female and 49.6%; approximately 15% are aged 0-14 years, 65-66% are aged 15-64 years, and 19-20% are 65 years or older. There are 4.6 million private households in Switzerland comprised of 1.1 million of single-family houses and 3.5 millions of multi-family flats.

Tariff structures

In Switzerland, electricity tariffs vary depending on the supplier, the canton, and the type of consumer (residential, commercial, or industrial). The tariffs typically consist of three main components: energy costs, grid fees, and taxes or surcharges.

Energy Tariff: This is the price for the actual electricity consumed. It can either be a flat rate or a time-of-use rate, where the price fluctuates based on the time of day (more expensive during peak hours and cheaper during off-peak hours). These are the most common tariffs that are deployed in Switzerland. Recently, in Canton Fribourg and Neuchâtel, a dynamic tariff option has been offered with a price varying at every 15 minutes, depending on the expected load on the electricity grid. This is a solution that aims to make efficient use of the grid and benefits all customers. The average per kWh also changes from one canton to another between 9 ct./kWh to 45.86 ct./kWh.

Grid Fee: This is the fee for using the electricity grid, covering the costs of transmission and distribution infrastructure. It is usually based on the amount of electricity consumed (per kWh) and the capacity of the connection. Although less frequently encountered, power tariffs are also present. The bill is formulated on CHF/kW basis that is calculated based on the maximum average power of the month or year.

The extent of smart meter adoption coverage is low. According to the latest statistics from the Swiss Household Energy Demand Survey (SHEDS) this share is roughly 10% in 2018. The Swiss government has nevertheless planned a general roll-out with a law stating that the proportion of equipped consumers from all sectors (residential, service, industry) must reach 80% by 2027. The narratives are to enable the grid security and system voltage stability in distribution networks and give value to flexibility.

Energy Communities

In order to create better framework conditions for clean consumption, the Swiss energy legislation has been providing for regulations since 2018, particularly with regard to the bundling of several end consumers for clean consumption, that is, for energy communities. Indeed, individual and collective self-consumption are explicitly defined by the regulations in force as of 1 January 2018, (the Energy Law (LEne)4 of 30 September 2016 and the Energy Ordinance of 1 November 2017 (OEne)5). Swiss provisions define community energy according to their factual elements, that is, according to the activities they could perform. They allow the formation of self-consumption communities (SCC), *communautés d'autoconsommation,* which gives electricity producers the right to consumption and to trade self-generated electricity entirely or partially at the place of production (LEne, Art. 16). According to the LEne, own or self-consumption (*consommation propre)* means the direct consumption of electricity simultaneously with production at the place of production or simultaneous storage and future consumption at the place of production. In addition to the self-consumption of energy produced for one's own needs, the law also provides for the extension of self-consumption to multiple consumers, which allow to create a cluster of prosumers and consumers called *regroupement dans le cadre de la consommation propre* (RCP) (LEne, Art. 17), that are self-consumption communities (SCC). The current Swiss regulation allows forming SCCs on adjacent plots of land (requirement of proximity stated in OEne, Art. 14), if all community members are connected to the same grid connection point, since the grid operator shall regard such a community as a single consumer (LEne, Art. 17). In order to be authorized, the SCC must have one or more installations with a production capacity of at least 10% of their connection capacity (OEne, Art. 15).

With the federal law on a secure electricity supply based on renewable energies (accepted by the 9th of June 2024 referendum with 66%) and the amendment to the Electricity Supply Ordinance, local electricity communities (LECs) are legalised which makes it possible to market self-generated electricity locally, within a district or municipality, via the public grid. Prosumers, storage facility operators, 'ordinary' end consumers and generators can participate in an LEC if they are locally close to each other and if they are connected to the same network level with a distribution system operator (participation in several LECs is therefore excluded). A LEC may also include one or more self-consumption communities (SCC). In addition, electricity supply companies can also include production or storage facilities in a CEL and participate in the community in this way. Each participant must be equipped with an intelligent metering system.

Appendix 2: Case Studies

Case Studies Subtask 1

Austria

Biscuit4all - Sustainable Behaviour Benefit Communication for All

Context and Objectives

Biscuit4all was a 21-months project that explored motivations, barriers for sustainable behaviour in the energy, mobility, and food sector with a gender- and diversity-sensitive perspective. Based on the results design examples for behaviour change support tools, integrating a number of different individual and collective engagement strategies, were developed and target groups were identified through a representative questionnaire study. A handbook with a framework for practitioners was developed to support the future development of engaging, gender- and diversity-sensitive digital solutions to support behaviour change. Automation elements were not a focus of this case study, and no trial was carried out.

Participation

Participants ranged widely throughout the different studies carried out and involved all age groups, educational levels, sexes, income levels, and geographical and housing backgrounds. The project didn't involve a field trial.

Methods

The project involved a cultural probing study with interviews with 13 participants that explored motivations and barriers for sustainable behaviour, as well as the role sustainable behaviour played in participant's identities. Further, four co-creation workshops for behaviour change support tools for the domains energy, mobility and food were carried out, including one with an energy focus that involved energy advisors for households affected by poverty. Finally, a questionnaire study with 501 participants was carried out to identify which user groups favour which behaviour change goals, which motivations and barriers are prominent for them and how they respond to different design solutions. Based on these results, target clusters for behaviour change were identified.

Results

The results show that identity and community play a crucial role in climate-related behaviors. A "green" identity is often linked to personal values, with shared activities like cycling or cooking playing a key role. Practices like waste reduction and cutting back on unsustainable products are also important, influenced by factors such as gender, role, and social class, and should be understood in context. Motivations for sustainability vary across areas. In mobility, health, environmental protection, and cost savings are key drivers, while barriers include flexibility and infrastructure. Women are motivated by health, men by cost savings, younger individuals by cost, and older individuals by environmental protection. In food, reducing waste and choosing local products are important, while cost and limited choice are barriers. For energy, saving money and environmental protection are top priorities, with cost and lack of control being barriers. Families and older people emphasize responsibility for future generations, while younger and urban participants focus on cost and comfort. Target groups were classified into four main types: Motivated-Relaxed (high motivation, few barriers), Motivated-Struggling (high motivation, many barriers), Neutral (low motivation, few barriers), and Rejected (little interest in sustainability). This classification helps tailor strategies to address different motivations and barriers.

Link: https://projekte.ffg.at/projekt/4387869, https://biscuit4all.info/

Serve-U – Forschungsprojekt zur Prognose und Verbrauchsoptimierung in Energiegemeinschaften

Context and Objectives

The project Serve-U aimed at the development and validation of an energy use optimization platform (EOP), which supports energy communities (EC) in terms of energy flow visualization and communication and enables EC members to optimally control the utilization of their renewable energy sources in a manner that accentuates flexibility and demand optimization with minimal technical and financial effort. The overall aim of the project was to determine the economic and ecological potential of such a low-cost optimization approach for energy communities, taking user-specific aspects as pre-condition for acceptance and market uptake into account.

Participation

The sample consisted of 37 participants (34 male, 3 female). Their birth years ranged from 1951 until 1997 (most were born in the 1960s: 14 of 37 participants). Regarding household size, the majority of participants were 2 person households without kids (17). There were in sum 9 households with kids and parents (one of them a single parent household) and two participants that lived with more than one other adult in their home (in sum 3 or 4 adults).

Methods

A pre-post survey setup accompanied the functional validation, yielding longitudinal data for comparing users' acceptance, perspectives on DSM measures, willingness to adopt such actions, insights into household energy practices, and attitudes.

Two online workshops (before and after testing the app in real life in their household) where held to gather qualitative insights into users' expectations before and experiences after using the app in real life context.

Results

The gender-gap in energy technology projects does also hold true in this project. Generally, we could see that households' chores in relation to appliances (switching dishwasher, washing machine etc. on) were more often shared tasks among household or responsibilities of spouses (majority of participants were male), and less conducted by the persons involved in the project. On the other hand, the persons

involved in the project stated to be responsible in their households for choosing the energy provider, paying energy bills and take over communications with the energy provider.
Here, a typical pattern is given evidence: the mainly male participants hold the energy contract and have main responsibilities towards energy provider. Yet, the responsibilities for household devices are partially shared with others or are even in the responsibility of someone else from the household – therefore, it is questionable whether the person interested and involved in energy-related projects is actually the person in charge of the potential actions. It highlights the necessity to include the household members as well and underlines gender-related distinction of roles and responsibilities.

Link: https://serve-u.at/

Ireland

Co–Wind project - Community Engagement in Wind Energy - Innovative approaches to achieving a social license

Context and Objectives

Social Acceptance is one of the key barriers to scaling up on-shore wind installation in Ireland and many other countries. The Community Engagement in Wind Energy, ‘Co-Wind’ project, funded by the 2018 SEAI National Energy Research, Development & Demonstration (RDD) aimed to better understand ways community engagement in wind energy can be improved to gain a better appreciation of the issues that underpin acceptance of wind energy developments and identify innovative approaches to achieving a social license including engagement strategies, benefit sharing mechanisms and community co-ownerships structures for financial participation in projects.

Participation

The national survey was on online national representative survey of all citizens in Ireland. Most of the respondents in this survey did not have first-hand lived experience of living near a wind farm; 1,170 (58%) respondents lived over 10km from an existing wind farm. The community survey surveyed those with lived experience of a wind farm including 409 respondents in the operational stage and 132 respondents in the construction stage and the pre-construction included participants with lived experience of wind farms in pre-planning site investigation and design (103 respondents), those in the planning stage when proposals had been submitted to the planning authorities (144 respondents) and 38 respondents that were unsure if planning proposals had been submitted or not. Developers included nine senior managers in the wind energy industry.

Methods

A national survey examined broad societal acceptance of wind farms (N=2,023). A wind farm community survey examined local community acceptance of wind farms

(N=826). Field work included community interviews to validate survey findings. Developer interviews (interviews with actors in the wind energy sector) were conducted to discover their opinions on the three themes (N=9). Discrete choice experiments were used to decipher: (1) trade-offs between engagement, benefit sharing and co-investment attributes when deciding to accept a local wind farm (N=1,014); and (2) trade-offs between investment attributes when deciding whether to invest in a wind farm (1,009).

Results

We find that males and younger age groups were more likely to accept compared to females and older age groups when asked about their level of support for the local wind farm with ‘1’ being very opposed and ‘4’ being very supportive in the community survey (e.g. those with lived experience). The experience of respondents during the planning process was found to have an ongoing impact on respondents’ acceptance of the local wind farm, demonstrating the importance of engagement and fair process during the pre-planning/planning stage. The respondents’ who ‘agree’ or ‘strongly agree’ with the statements ‘The wind farm developer acted openly throughout the planning process’ and ‘The planning process was fair’ were significantly more likely to accept their local wind farm than those that ‘disagree’ or ‘strongly disagree’ with those statements. Respondents’ who ‘agree’ with the statement ‘The community was able to influence the project’ were significantly more likely to accept their local wind farm compared to those that ‘strongly disagree’ with this statement. Respondents’ who ‘strongly disagree’, ‘disagree’ and ‘neither agree nor disagree’ with the statement ‘The wind farm developer was going to do what they liked anyway’ were more likely to accept their local wind farm than respondents who agree with the statement. Respondents’ who ‘agree’ with the statement ‘The wind farm developer was going to do what they liked anyway’ were more likely to accept their local wind farm than respondents who ‘strongly agree’ with the statement. In the same analysis, it was found that respondents in the construction stage were more likely to accept their local wind farm compared to respondents in the pre-planning/planning stage. Respondents living over 2km from an existing or planned wind farm were more likely to accept compared to those living further away.

In the national survey, we find that males were more willing to invest (and invest higher amounts) in wind development projects (local, non-local and portfolio projects) compared to females. Landowners were also more likely to invest in each of the project types, relative to non-landowners. This could be due to a wealth effect, or the financial benefits that landowners receive from local wind farms. People with financial investment experience were more willing to invest in each of the project types, compared to people without such experience. People in higher income households were more willing to invest in each of the project types, compared to people in lower income households. City residents were more willing than rural dwellers to invest in each of the project types, a finding possibly attributable to their higher incomes and their greater concern about climate change, relative to rural dwellers. People living within 10 km of a large wind turbine/farm were also more likely to invest in each of the project types, compared to people living more than 50 km away. People living in communities with a strong spirit were also more willing to invest in each of the project types, compared to people living in other communities. Concern about climate change was also found to increase citizens' willingness to invest in each of the project types, which is in line with evidence that people who are concerned about climate change tend to be more supportive of wind energy projects. Attitudes towards wind energy also impacted citizens' investment decisions. In this regard, people who agreed there was a role for both on-shore and off-shore wind energy were more willing to invest in each of the project types, compared to people who disagree.

For greater information see Power et al. (2023)[4] and Sirr et al. (2023).[5]

Link: https://www.ucc.ie/en/eri/projects/community-engagement-in-wind-energy---innovative-approaches-to-achieving-a-social-license.html

Norway

JustFlex

Context and Objectives

In the JustFlex project, funded by the DSO Elvia in Norway, the primary objective was to better understand various customer groups and learn how to maximize their flexibility potential. Additionally, the project aimed to explore how Elvia could be mobilized as a resource for a transition that offers both a better energy system and a just energy transition. The JustFlex project is a direct result of the first SLA Task which highlighted the need to understand different types of end users.

Participation

This was not a technical pilot. The aim of this project was to discover how hard-to-reach customers could be engaged in automation and flexibility.

Methods

The empirical basis of JustFlex consists of 34 in-depth interviews on average 1 hour with various end-user groups, including older women, chronically ill individuals, and mothers with children under 10 years old. Furthermore, the project included two co-creation workshops with end-users over 60 who have no technical interest and families with poor economic conditions, along with actors from the R&D department of the DSO.

Results

This project provided us with insights into relevant concepts that explain why household flexibility can be challenging to access. We did find difficulties to engage Elvia's diverse customer groups in desired energy behaviors through an app alone. A broader and more creative approach is needed to reach the variety of customers. Energy consumption is influenced by socio-economic status and the societal

[4] Power, B., Ryan, G. and Eakins, J, O'Connor, Sirr, G and Le Maitre, J. (2023) Community Engagement in Wind Energy - Innovative approaches to achieving a social license, CommunityEngagementinWindEnergy.pdf (ucc.ie), November 17th 2023.

[5] Sirr, G., Power, B., Ryan, G., Eakins, J., O'Connor, E. and Le Maitre, J. (2023) An analysis of the factors affecting Irish citizens' willingness to invest in wind energy projects, Energy Policy, Special Issue on the Dynamics of Social Acceptance. Vol. 173, 113364

structures in which we live. People have different capacities for flexibility, both in terms of which consumption they can shift and how much time they have to make those shifts. Flexibility capital varies from individual to individual and from household to household. If the goal is to achieve a collective effort to reduce and shift consumption, differentiated measures are needed to reach as many people as possible.

We had two main goals in this project. The first was to find the opportunities and barriers different kind of end-users face regarding end-user flexibility, and to show how DSOs can actively promote a fair energy transition. They can, in example, work towards flexibility justice when developing R&D projects by involving household customers at an early point. This way, the DSO can also take an international stance to promote an inclusive and gender-sensitive approach to the energy transition, addressing a gap identified in the EU's Fit for 55 climate package (Clancy et al. 2022).

HousingFleks

Context and Objectives

The DSM pilot HousingFleks features smart hubs that can control slow loads such as floor heaters, heat pumps, and hot water boilers. The objective of this pilot was to automate the power consumption and for the DSO to test out the potential of fleet management of household costumers to provided flexibility. The pilot aimed to facilitate direct load control while allowing household participants to customize their setups via the FutureHome app, which integrates devices using Z-Wave and Zigbee protocols. The pilot ran from 2020 to 2023.

Participation

The recruitment strategy focused on a specific area rather than the entire town to ensure a diverse group of end users. The DSO employed various recruitment methods, including a local information movie, flyers, and media interviews. This strategy successfully onboarded 32 out of 96 households from the targeted area, representing one-third of the connected households. Eventually, the pilot included a total of 150 households from all over the city. The recruitment process was resource-intensive, involving local engagement and media coverage.

Methods

Household participants received smart home equipment for free, along with access to the smart home app. The hub and app served as the interface for remotely controlling devices. Users received notifications before a DLC event and could opt out if necessary.

Results

The project concluded in 2023 and the findings indicated that while it was possible to recruit a diverse group of participants, it required substantial effort and resources. One of the key technical challenges identified was preventing new peaks in energy demand when automated systems turned slow loads back on. Regarding SLA, the pilot customers had a positive experience of DSM automation and generally found it to be working well. The pilot customers can also be roughly divided into the "set and forget" and "play" groups. Where "set and forget" indicates that it's nice that the automation just works in the background and that they don't have to think about it, the "play" group is more technically interested and enjoys understanding and interacting with the technology. There were also several requests for an alternative to set automatic solutions without having to use an app.

Secret EV-buyer Interviews

Context and Objectives

In this study our focus was to gain insights into if car dealers that sell electric vehicles (EVs) promote flexibility and automation at any level. We were also curious if current electricity price levels influenced car sellers. Norway has 5 price zones meaning that the zones close to Europe have for the last years have had higher electricity prices than the zones in the North because of markets mechanisms. These five price zones formed the base for our interview partner selection.

Participation

We used an exploratory design where our research assistant took on the role of an EV buyer. He called 51 different car dealers distributed among the five different price zones in Norway. The assistant acted as EV-buyer that did not have any knowledge about EVs or charging. He asked questions like: How does the charging work? Can I just plug it straight into the wall? Can I set up a charging box myself? Is there a special cable? What about electricity prices? Isn't it expensive to charge an electric car now? What are smart solutions? Is it dangerous to charge at night? - typical question that an EV buyer who is not familiar with EVs would ask. The answers were registered in an Excel file and analysed after the completion of the 51 interviews.

Result

EV sellers' advice about automatic charging ranged from that automatic charging is only for those particularly interested to that it is a simple operation to set up either yourself or through a third party.

Out of 51 sellers, there were 20 who were inclined to package solutions for electric car sales that included charging box, electric cable and electricians. There was no relationship between car sellers who tended to pack solutions and price zones. Package solutions where electric car sellers also provide the installation of a charging box show that car suppliers are to a degree also expected to sell the infrastructure for EV charging, something they have not done before the EV revolution.

EV sellers could, if provided with training, be an important middle actor to get the social license of new EV owners to automatically charge their EV to avoid peaks.

Sweden

Enough?!

Context and Objectives

Enough?! is an on-going project concerning energy sufficiency – how to ensure that energy use stays within planetary boundaries, while still ensuring that people fairly can satisfy needs. The project involves both households and municipal energy and climate advisors (EKR). Interviews have been conducted with EKR regarding their job and the preconditions for adding advice surrounding flexibility and sufficiency to their practice. Provotypes (provocative prototypes) have also been tested by households to investigate how they view sufficiency and if/how they would be willing to adapt their lifestyles to reach sufficiency.

The long-term goal is to design support for energy and climate advisers to better assist households striving for energy sufficiency and flexibility.

<u>Participation</u>

For the EKR study: 12 energy and climate advisors (3F, 9M) spread across Sweden were recruited, using their national network.

For the provotype study: 20 households recruited through social media and through the EKRs. Mix of apartments and single-family homes, urban and rural, ages and size of household and house.

<u>Methods</u>

Energy and climate advisers were interviewed using an interview guide divided into questions about how they work, who seeks their advice, if/how they could expand the type of advice given and how they viewed sufficiency and flexibility of energy use. The interviews were transcribed and thematically analysed.

Households received one of two provotypes (a lifestyle magazine to show how less energy could be used/reflect on which activities they really wanted to use energy for, or the square meter challenge where they had 2-weeks to reflect on which square-meters in their home they could do without completely or do without heating. They were interviewed before and after. (Analysis ongoing)

<u>Results</u>

The results of most interest for the SLA2.0 project is the potential of EKRs to act as middle actors who can engage and interest households in the automation of flexibility. The results show that they have potential, but that they have their own engagement problems in who they can reach. They are also controlled by their mission from the energy agency and the form in which they are organised, but this can also be utilised.

(households preliminary show openness to be flexible, but also lock-in effects, disagreements/different priorities in households)

Swedish Interviews with “Automated households”

<u>Context and Objectives</u>

Interview study with households that already had adopted some form of automation of their electricity use. The study was performed in order to complement the Enough?!-project where the household studies took a different angle than originally planned, for the benefit of the SLA2.0 gender and diversity subtask. The interviews aimed to capture the gender and inclusivity aspects of how automated flexibility can impact a household and its practices.

Participation

14 households, comprising 18 participants, who utilized some sort of smart or automated technology for their energy consumption were interviewed. Most participants were male (M13, F5) but represented different ages and household compositions. The participants were mainly recruited through interest groups for home automation, solar panels, electric vehicles and heating systems on social media. A few women-exclusive groups were also targeted in order to find more female participants, but this did not yield the desired results.

Methods

Each interview took 45-60 minutes and followed a previously prepared interview template. The interview covered background information, household energy consumption, demand side management (DSM), home automation and finally direct load control (DLC). This way the participants first described their household situation, what type of energy they consumed and what responsibilities they had at home. They then moved on to speak about what they already did in terms of demand side management, as well as what they saw possible and not to load shift. In the automation section they were asked about what types of home automation they have and how it has affected them and the other family members. Finally, they were questioned about their thoughts on direct load control, what type of energy consuming things they could imagine letting someone else control and what would be required for them to accept such a solution.

Results

Participants were interested in energy and flexibility, kept close track of what they use, still lacked knowledge what is worth shifting, but also had different priorities. In half of households, both adults kept track of energy consumption or price, in the other half, only the male adult member of the households. In some households, older children were also involved.

It was almost exclusively the men that introduced the different smart technologies and automated systems into the homes. The technology was not considered up to standard by all members of the household to be involved, requires a lot of “handpåläggning” (need to actively do something, tweak, improve). Activities that they already shifted included optimizing space heating, water heating and EV charging, use of smart lighting and in some cases shifting of laundry washing and cleaning.

Participants had had mixed feelings towards automation controlled by someone outside the home and stressed it should be needs adapted/household tailored. However, some had already given control to the heat pump company or EV charging company and felt ok about this. If the DSM was invisible, it was fine - when automations do their job without noticeably affecting life quality, they work optimally.

European

ECHOES - Energy CHOices supporting the Energy union and the Set-plan

Context and Objectives

In the European context, the ECHOES data set was analysed. This data is derived from a comprehensive survey conducted in 2018-19 as part of the Horizon 2020 Project ECHOES across 31 European countries (EU27, CH, NO, TR, UK) with the aim of understanding the factors influencing individual and collective energy-related choices and behaviours. The dataset provides interesting insights with respect to the awareness of the benefits of automation and the willingness to accept it in one's home.

Methodology

The collected data in aggregated form (N= 5968) was analysed with respect to the questions: 1) "Suppose you allow your grid operator to remotely switch on and off non-critical appliances in your home. Would you say that would benefit the energy transition?" and 2) "Would you allow your grid operator to remotely switch on and off non-critical appliances in your home if you were offered an annual discount of […]". The responses to these two questions were first plotted and then analysed using a logit regression. Differences in responses between different socio-demographic categories (gender, age, social status, education, and country) were tested using Kruskal-Wallis, T-test and Chi-square test.

Results

Difference in genders, males tend to see less the benefits of automation for the energy transition, females have slightly higher awareness. Similar differences are visible when it comes to second question: females are more likely to accept automation in their homes if they were offered a discount. This result is statistically significant.

Younger respondents seem to be more aware of the benefits of automation for the energy transition compared to older age classes. Stronger differences in attitudes towards automation are visible when it comes to the actual willingness to allow automation in their homes in exchange for a discount: younger people are more willing to accept automation compared to other classes. The age class 55+ especially shows the lowest levels of acceptance. This result is significant for all age classes.

Social status (measured through self-placement, 1-worse-off, 5-best-off) was also looked at. In response to both questions less advantaged group tend to disagree more, and thus show lower levels of willingness to acceptance automation, compared to better-off groups. Nevertheless, this difference is not as large as, for instance, in the age class comparison. When regressing social status on responses to question 2), only the highest best-off category is statistically significant, pointing at the fact that belonging to more socially advantaged groups increases the willingness to allow automation, but that belonging to other social status category is not a significant predictor of such willingness.

Other variables such as education, employment or having children/children under 14 are not significant predictors in any of the analysed questions.

We also looked at the intersection between demographic categories. When looking at the share of disagreement responses to the question 2, we see that gender influences attitudes towards energy efficiency, but it variates across other categories, such as age groups and social status. Interestingly, the difference between gender responses is stronger when it interacts with social status, compared to age. In fact, being a male doesn't seem to have make a difference for disagreement responses across social status categories, whereas being a female does. In general, we see that young, advantaged females is the category that would be most willing (or the least not willing) to accept automation.

Lastly, we looked at differences in attitudes towards automation the countries involved in Subtask 3 (Austria, Switzerland, and the Netherlands). Automation is generally more accepted in Switzerland (~40% agree), compared to Austria (31%) and to the Netherlands (15%). This difference, however, is not reflected in responses to whether allowing automation would benefit the energy transition, where most respondents from all the three countries analysed are neutral or agree with this statement.

Link: https://cordis.europa.eu/project/id/727470

Flash Eurobarometer 514 Analysis

Context and Objectives

A global focus on the demand side of the energy equation has never been more important. Supply uncertainty, high prices and urgent climate targets all point to the value of energy efficiency and energy savings. The objective of this project was to examine the factors that determine the actions that EU citizens have taken (or are willing to take) to reduce their energy consumption. Previous research has suggested that a disaggregated approach to analysing energy saving behaviours is required, thus a range of individual specific energy saving actions undertaken by respondents were examined. In addition to this, the project also examined groups of actions based on curtailment, efficiency, and transport categories.

Data for the individual specific energy saving actions is taken from the following question asked in the Flash Eurobarometer 514 survey (Question 9). “And you, personally, what kind of action(s) are you already taking, or would you be ready to take to cut down on your energy consumption and your energy bills?”. The exact wording of the 11 possible responses is as follows (respondents could provide multiple answers):

- Unplug your electronic appliances when not in use.
- Use alternatives to your car/motorbike, such as walking, cycling, taking public transport, car sharing.
- Opt for renewable forms of energy in your home (e.g. solar panels, etc.)
- Install equipment at home to control and reduce your energy consumption (e.g. a programmable thermostat).
- Add better insulation at your home.
- Buy energy efficient equipment (with a good energy rating).
- Reduce room temperature at home or at work.

- Take the train rather than a plane for your journeys.
- Turn off lights when you leave a room for a while, at home or at work.
- Other.
- None.

The energy saving actions listed can also be grouped into specific categories, namely curtailment, efficiency, and transport. Under curtailment the actions, ‘Turn off lights when you leave a room for a while, at home or at work’, ‘Unplug your electronic appliances when not in use’ and ‘Reduce room temperature at home or at work’, are grouped together. Under efficiency the actions ‘Opt for renewable forms of energy in your home (e.g. solar panels, etc.)’, ‘Install equipment at home to control and reduce your energy consumption (e.g. a programmable thermostat), ‘Add better insulation at your home’ and ‘Buy energy efficient equipment (with a good energy rating)’ are grouped together. A final category groups the two transport related energy actions together, ‘Use alternatives to your car/motorbike, such as walking, cycling, taking public transport, car sharing’ and ‘Take the train rather than a plane for your journeys’.

Participation

The dataset used is the European Commission’s Flash Eurobarometer 514 survey. The survey was carried out to examine the EU’s response to the energy challenges arising from Russia’s invasion of Ukraine in 2022, and subsequent conflict. Fieldwork was undertaken by Ipsos European Public Affairs on a representative sample of EU citizens, aged 15 and over, in each of the 27 Member States of the EU. Interviews were conducted via computer-assisted web interviewing (CAWI) in November 2022. Sampling quotas were set based on age, gender and geographic region and a total of 26,325 individuals were sampled.

Methods

As the approach in this study is to test hypotheses and quantify relationships in relation to the energy actions undertaken (the dependent variable), quantitative multivariate methods were employed. Two different sets of multivariate models were estimated, binary logit models and ordered logit models. In each case the dependent variable was related to a set of socio-demographic and attitudinal independent variables.

Results

The results highlight the heterogenous nature of the underlying socio-demographic determinants. Respondents of a particular age, gender, household composition, occupation, standard of living, accommodation status and location undertake certain energy saving actions but not others. There is evidence to suggest that the effect of age is non-linear for many energy saving actions and the presence of children has counterbalancing effects on the probability of energy saving actions undertaken. The inclusion of a variable capturing expectations of general price increases levels of engagement in curtailment actions but also decreases levels of engagement in efficiency investment measures. Identifying group differences and correlates in energy saving behaviours is important for the development of policy in the area, as a one size fits all approach is unlikely to provide enough scope to incentivise higher levels of engagement. Detailed results have been reported in Ryan et al (2023)[6].

Link: https://search.gesis.org/research_data/ZA7950

Case Studies Subtask 3

Austria

PEAKapp – Personal Energy Administration Kiosk application: an ICT-ecosystem for Energy Savings through Behavioural Change, Flexible Tariffs and Fun

The PEAKapp dataset contains electricity usage data collected as part of the PEAKapp project, which sought to evaluate the impact of the PEAKapp (a smartphone app for home energy management) on residential electricity consumption, particularly focusing on household demand flexibility. The project was tested in four European countries and involved three groups: a control group, an "app group" (which received the app but not discounted electricity prices), and a "discount group" (which received both the app and discounted electricity rates of 10 cents/kWh at certain times via discount notifications). The reasons for the discount notifications were either environmental (availability of cheaper wind or solar energy) or economic (low-cost electricity). The dataset analysed includes 15-minute load profiles from 152 single households, drawn from an overall pool of approximately 1,500 households, and was collected over a 17-month period between 2017 and 2018 in Upper Austria through the local energy provider, Energie AG Vertriebs GmbH. Single households were chosen to isolate the gender effect on consumption. Additionally, surveys conducted with participating households provide information on socio-economic status and living conditions. Other relevant variables in the dataset include house size (m^2), building type (flat/house), ownership status, high electricity-consuming devices, and heating system.

Link: https://www.peakapp.eu/project-overview/

LEAFS - Integration of Loads and Electric Storage Systems into Advanced Flexibility Schemes for LV Networks

In the LEAFS project, the Sonnenbonus ("sun bonus") field experiment was conducted, where households utilized a specially designed smartphone app to monitor their energy consumption and were awarded a bonus of 10 cents per kWh when shifting electricity usage to designated times. The village of Eberstalzell in Upper Austria was chosen due to its extensive use of smart meters and the large presence of home-based solar panels. Recruitment started in February 2018, and about 180 households—around 25% of the village's population—participated. The purpose of this bonus was to reduce electricity costs to zero during certain hours, with qualifying

[6] Ryan, G., Power, B., & Eakins, J. (2023). Sparks of Change: How do Age and Gender Impact the Actions Taken to Reduce Energy Use? Conference Proceedings BEHAVE 2023. BEHAVE 2023, Maastricht, NL.

periods based on weather forecasts indicating high solar production. Participants, without needing extra technical equipment, voluntarily adjusted their energy consumption, driven by both financial incentives and app features that tracked usage and included an interactive game. Data from the field trial includes household details, such as composition, house size (in square meters), ownership status, and type of dwelling (house or flat). It also captured the number and type of household appliances, the presence of solar photovoltaic (PV) systems, and information about heating and water heating systems in use.

Link: https://www.ait.ac.at/en/leafs

The Netherlands

The Green Village

The Green Village at the Technical University of Delft is a practical lab for testing and showcasing sustainable ideas for homes and workplaces. It includes eight households of different housing types, including terraced houses, detached houses (3 Pret-a-Logers and 1 Dreamhus) and studios/apartments (2 Sustainer Homes and 2 Woody's). Electricity consumption data for these houses was collected using smart meters provided by the University's Data Management Unit. However, demographic and technology-related information was lacking, so a survey was needed to fill these gaps. The survey aimed to collect data on demographics, technology use and appliance usage patterns to better understand variations in consumption, a goal not achieved with previous datasets. Due to the small sample size, the survey results are not statistically representative. The data was collected in a scientifically sound manner, adhering to data privacy regulations.

The questionnaire, created using Typeform, was distributed via the Green Village WhatsApp group. Responses were received from 6 participants in 5 housing units, while responses from 3 units were missing. There were 4 women and 2 men among the respondents. Educational backgrounds and household composition varied, including single people, couples with and without children, and shared accommodation with adults with and without children.

Switzerland

CREM

From January to December 2015, the CREM project measured the electricity consumption of 656 households in multi-family flats in French-speaking Switzerland at 15-minute intervals. This dataset includes various socio-demographic factors such as gender, income, education level, household size, age, and occupation (e.g. employment status), as well as housing-related variables such as dwelling type (apartment or house) and ownership status. The number of dwellings per building was also recorded. Households in buildings with six dwellings and categories such as students and the unemployed were excluded from the analysis due to the high frequency of consumption outliers and the small sample size of these groups. The data includes 197 single-person households, which makes it possible to study gender differences in electricity consumption.

FLEXI

The FLEXI project aims to explore the potential for increasing the flexibility of electricity consumption to better match renewable energy production, particularly from photovoltaic sources. The data collected in the FLEXI survey consists of 15-minute electricity consumption records from 326 households in Western Switzerland. In addition to electricity consumption, the dataset covers various factors such as income, education, household composition, age, occupation, dwelling type (apartment or house), ownership status, house size (in square meters) and number of rooms. Sex information relates only to the person who completed the survey. Of the 90 one-person households in the dataset, 22 were female and 68 were male. The dataset also includes details on the types of appliances (such as refrigerators, freezers, dishwashers, washing machines, dryers, saunas, swimming pools, televisions, computers, aquariums and air conditioners), the presence of photovoltaic (PV) systems and the types of heating and water heating systems used.