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IEA Users TCP: Social License to Automate: Switzerland Country Profile

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www.bfe.admin.ch

Authors:
Dr. Selin Yilmaz, University of Geneva, Selin.Yilmaz@unige.ch
Julien Michellod, University of Geneva, Julien.Michellod@etu.unige.ch
Dr. Christian Winzer, ZHAW, winc@zhaw.ch

SFOE project coordinators:
Astrid Sontag, Astrid Sontag, Astrid.Sontag@bfe.admin.ch
Dr. Michael Moser, michael.moser@bfe.admin.ch

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Zusammenfassung

Dieses Projekt zielt darauf ab, automatisierte Demand Side Management (DSM)-Projekte in der Schweiz zu analysieren, um die wichtigsten sozialen, organisatorischen, wirtschaftlichen und regulatorischen Determinanten für eine erfolgreiche Kundenbeteiligung an automatischen Laststeuerungsprogrammen zu verstehen. Als Teil der 'International Energy Agency Users TCP Social License to Automate Task' trägt es zur Entwicklung eines internationalen Rahmens für relevante Faktoren bei, die das Vertrauen der Endverbraucher in die Automatisierung beeinflussen, und gibt einen Überblick darüber, wie diese Faktoren in verschiedenen nationalen Projekten berücksichtigt werden. Das Dokument präsentiert die wichtigsten Ergebnisse und Lehren aus der ursprünglichen Forschung, die elf Umfragen mit der Schweizer Bevölkerung und acht Automatisierungsprojekte umfasst, die in der Schweiz demonstriert, erprobt und/oder kommerziell genutzt werden. Es schliesst mit politischen Empfehlungen und Hinweisen für künftige Forschungen zu automatisierten Demand-Side-Management-Projekten im Schweizer Wohnungssektor.

Résumé

Le but de ce projet est d'analyser les projets de gestion de la demande (DSM) automatisée en Suisse pour comprendre les principaux déterminants sociaux, organisationnels, économiques et réglementaires pour la réussite de l'engagement dans les programmes de contrôle automatique de la charge. Dans le cadre de 'International Energy Agency Users TCP Social License to Automate Task', ce projet contribue au développement d'un cadre international de facteurs pertinents qui influencent la confiance des utilisateurs pour automatiser leurs appareils chez eux et compose une vue d'ensemble de la manière dont ces facteurs sont traités dans différents projets nationaux. Le document présente les principales conclusions et enseignements tirés de recherches impliquant onze enquêtes menées auprès du public suisse et huit projets d'automatisation testés et/ou commerciaux en Suisse. Il se termine par des recommandations politiques et des orientations pour les recherches futures concernant les projets DSM automatisés dans le secteur résidentiel suisse.

Summary

This project aims to analyse automated demand side management (DSM) projects in Switzerland to understand key social, organizational, economic, and regulatory determinants of successful customer engagement in automatic load control programmes. As part of the 'International Energy Agency Users TCP Social License to Automate Task', it contributes to the development of an international framework of relevant factors that influence end-user trust to automate and compose an overview how these factors are addressed in different national projects. The document presents key findings and lessons learned from original research involving eleven conducted surveys with Swiss public and eight automation projects demonstrated, trialled and/or commercial in Switzerland. It concludes with policy recommendations and directions for future research regarding the automated demand side management projects in Swiss residential sector.

Contents

Abbreviations

DLC: Direct Load Control

DSM: Demand Side Management

DSO: Distribution System Operator

EV: Electric Vehicle

HEMS: Home Energy Management Systems

HVAC: Heating, Ventilation and Air Conditioning

ICT: Information and Communications Technology

IEA: International Energy Agency

IoT: Internet of Things

PV: Photovoltaics

SFOE: Swiss Federal Office for Energy

SLA: Social License to Automate

SLO: Social License to Operate

STS: Science and Technology Studies.

TCP: Technology Collaboration Programme

1 Introduction

1.1 Population

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. 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[1].

1.2 Energy mix

According to the Swiss Federal Office of Energy, petroleum and other fuels are the main sources of energy in Switzerland (43.9%), followed by electricity (26.8%), gas (15.1%), coal (0.5%), wood (5.3%), district heating (2.8%), industrial waste (1.5%) and other renewable energy (4.1%) in 2020. Electricity is mainly generated by hydropower (58.1%), nuclear power (32.9%) and conventional thermal power plants (1.7% of them renewable) and various renewables sources (5.0%), The renewable sources (5.0%) comprise of wood (0.56%), biogas (0.55%), solar PV power (3.7%) and wind (0.2%) in 2020[2].

The shares of the transport and household sectors in total final energy demand remained approximately at 32.8% and 29.3%, respectively. Swiss service (including agriculture) and industry sector accounted for 18.4% and 19.5% of the final energy consumption. For electricity, the largest sector consuming electricity was the household sector (34.6%), followed by industry (29.9%) and the services sector (28.7%). The transport sector and agricultural sectors consumed 5.0% and 1.6% of the total electricity consumption. The electricity consumption of households was used mostly for heating space and hot water production (35.1%). Processes (which includes the use of refrigerators/freezers, washing machines and dishwashers) constitute 22.4% of the household's electricity consumption; air conditioning and ventilation constitute 6.8%.

1.3 Challenges in the energy system

Following the nuclear disaster of 11 March 2011 in Fukushima, Japan, the Swiss Federal Council instructed the Federal Department of the Environment, Transport, Energy and Communications (DETEC) to examine the energy strategy and update long-term planning and strategy documents. These documents, especially the *Energy Outlook 2035,* have been regularly revised since the 1970s. After several debates and revisions, a new Energy Act was adopted by Swiss voters with 58.2% of the vote in a referendum in 2017[3]. Based on new scientific findings published by the Intergovernmental Panel on Climate Change, the Federal Council at its meeting on 28 August 2020 decided to set an even more ambitious target: Switzerland plans to reduce its net carbon emissions to zero by 2050, thus meeting the internationally agreed target of limiting global warming to a maximum of 1.5°C when compared with the pre-industrial era.

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[1] https://www.bfs.admin.ch/bfs/en/home/statistics/population/effectif-change/households.html

[2] https://www.bfe.admin.ch/bfe/en/home/supply/statistics-and-geodata/energy-statistics/overall-energy-statistics.html

[3] https://www.bk.admin.ch/ch/d/pore/va/20170521/det612.html

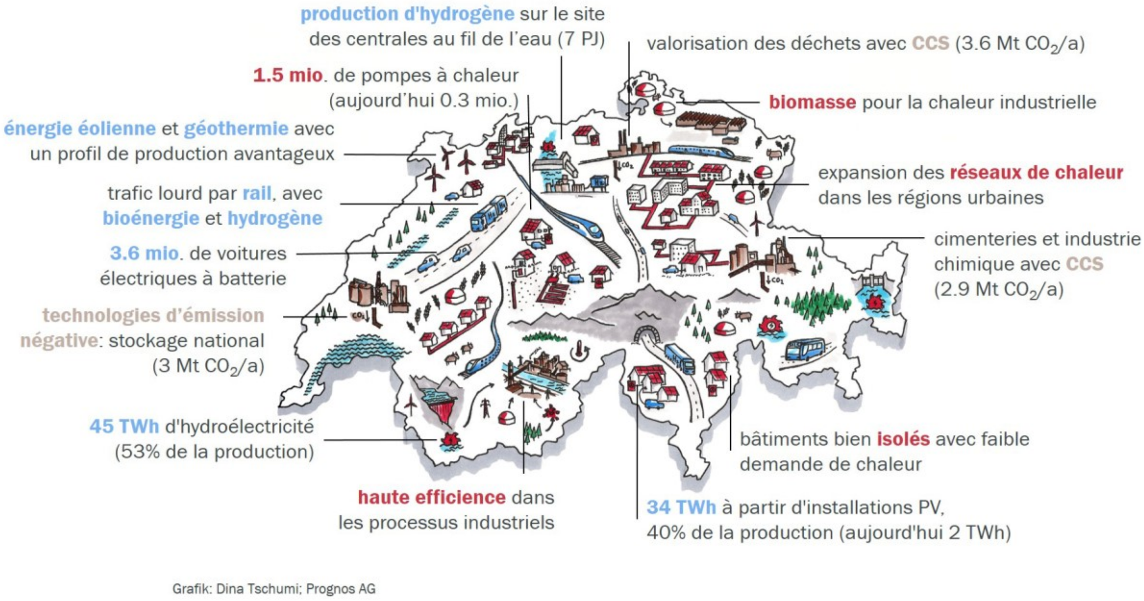

Figure 1 Swiss scenarios to reach zero GHG emission 2050

The Energy Perspectives 2050+ (EP 2050+) analyses how to develop an energy system that is compatible with the long-term climate goal of net-zero greenhouse gas emissions by 2050 and, at the same time, ensures a secure energy supply[4]. Several variants of this scenario are considered (Figure 1). They differ in their combination of technologies and the speed of the renewable energy transition in the electricity sector. The large-scale deployment of rooftop PV is foreseen in the following years (34 TWh which is 40% of the production) in addition to the hydropower (53% of the production). Also, 1.5 million heat pumps are envisaged to be installed (now 0.3 million) and 3.6 million EVs (now only in thousands) will be in the usage to the grid by 2050.

The small-scale production of renewables such as rooftop PV and low carbon technologies such as heat pumps, EVs are distributed throughout areas where people live, commute and work. Inevitably, these forces are reshaping the energy systems towards more user-centred systems. Far more consent and engagement of energy users will be needed than ever before. This includes gaining planning permission for new distributed assets, automation of devices such as heat pumps and EVs, and trust in the responsible collection and use of energy data. The self-consumption communities (ZEV/RCP)[5], in which people (e.g. households, municipalities, or commercial enterprises) join to share electricity, are increasing. Typically, a PV system is installed on one of the buildings and the participants within spatial proximity can use the self-produced electricity. The community is wired through a single coupling point. It is evident that people are increasingly playing more active roles than mere consumers, becoming prosumers by investing in PVs and storage capacities (batteries, hot water tanks) therefore producing, storing, and trading energy services with multiple parties via emerging digital technology platforms. **This highlights a change in paradigm as the transition from centralised fossil energy to decentralised renewable energy systems.** Such decentralisation introduces new challenges for the operation and governance of energy systems. A rescaling of operating and governing activities, and an increase in

[4] https://www.bfe.admin.ch/bfe/fr/home/politique/perspectives-energetiques-2050-plus.html

[5] The new rules for implementing groupings for self-consumption in force since 1 January 2018 (loi sur l'énergie art. 16-18). RCP stands for 'Regroupement dans le Cadre de la Consommation Propre (RCP) and ZEV stands for ZEV (Zusammenschluss zum Eigenverbrauch).

both the number of actors, technology, and in socio-technical complexity of the overall system are foreseen.

Against this overall picture of Switzerland and the socio-technical imaginaries that are foreseen within the context of Swiss energy transition, the greatest challenges by far are associated with the management of the distribution network. This is due to the increasing stochasticity and bi-directional electricity flow raised from intermittent renewable resources such as PV installations on rooftop and other increasingly deployed low carbon technologies such as heat pumps, electric vehicles (EVs) distributed throughout urban areas. Considering the intermittent nature of the renewable technologies, integration of demand flexibility is recognised as vital to the operation of the distribution networks to tackle these above-mentioned challenges. While hydropower may still balance renewable generation at the high-voltage grid level (centralised level), imbalances between renewable supply and demand together with other related problems remain to be solved at the distribution level. Therefore, **a better coordination of flexibility resources (energy use) between buildings to match local production is increasingly required at building, district, and city scales to balance supply and demand within the electricity distribution networks.** These developments and changes contrast with the traditional centralised system involving only the energy company-user relationship. New business models, arrangement and organisations are increasingly needed to broaden the scope of interventions to target a wider repertoire of technologies, possible investments and actors in districts and cities while aligning the interests of different actors with applicable technologies and infrastructure as a whole energy system.

1.4 Context of automated DSM

1.4.1 Drivers and benefits

Considering the intermittent nature of the renewable technologies, demand flexibility (the capacity to adapt consumption patterns) realised through DSM is at the heart of the success of unlocking the potential of distributed energy resources to avoid imbalances in distribution grid networks of districts and cities. Specifically, obtaining decarbonisation benefits depends on temporal alignment of heat pumps and EV charging with stochastic renewable generation to avoid the operation of fossil fuelled plants at peak times. DSM tools include a range of automation technologies from direct load control (DLC), which involves the remote control of household systems and appliances such as heating and ventilation systems and electric vehicle (EV) charging via a third-party provider (e.g. utility company), to the management of appliances via a Home Energy Management System (HEMS), or manual demand response or control of appliances based on price signals. Manual control with price signals does not require a firm commitment by the consumer to adjust consumption at specific times, but leave it to the consumer’s discretion, how and when to react to the price signals given. Detailed international reviews report that people’s interaction with the systems decline over time (Kessels, Kraan, Karg, et al., 2016). Automated DSM is viewed as a means to overcome the ‘engagement deficit’ with manual demand response and circumvent the challenge posed by the largely habitual nature of household energy consumption behaviour (Ballo, 2015). Hence, utility-controlled DSM schemes (i.e. DLC) are becoming increasingly attractive where household appliances are fully automated to ensure a fast-acting and reliable system responsiveness in decarbonised and decentralised energy systems. DLC programmes could offer a more reliable source of demand flexibility by providing greater certainty over the amount, timing, and location of demand flexibility than solely depending on the households with price signals.(Stenner, Frederiks, Hobman, et al., 2017)

1.4.2 Regulatory context and digitalisation

Swissgrid plays the role of Transmission System Operator (TSOs). Its role is to keep the demand and supply physically in balance after the market closes (i.e. gate close) in the transmission grid with its balancing markets (e.g.: balancing services, voltage control, redispatch). Contractual relationships with the TSO exist through possible bidding with large industry (storage dams, suppliers) that provide flexibility via DSM with a condition of minimum amount of power as balancing groups. They can provide ancillary services to meet the operational requirements such as frequency containment (maintaining frequency at 50 Hz etc.).

The utility companies can represent three roles, DSO, electricity supplier and producer, but they are completely unbundled inside. The overall benefit is in the foreground even though unbundling should be always respected. DSOs as part of the unbundling (almost) of utilities have the task to securely operate and develop an active distribution system comprising networks, demand, generation, and other flexible DER. Direct load control via ripple control systems is an existing automated DSM practice carryout by several DSOs for approximately 50 years with a self-given privilege to use their ripple control on demand side resources. The electric water heaters and the heat pumps were already switched off during constant and pre-configured time intervals (boilers mostly daytime, heat pumps only during midday time) via the ripple control signal of the DSO. Currently these do not consider current market prices or customer self-interest/comfort limits. The current revision of the energy law foresees an obligation to ask the owners of the assets that should be controlled (e.g. the respective customers) for consent and remunerate them adequately for participating in flexibility provision (e.g by means of ripple control).

Thanks to the digitalisation (smart meters and new platforms) and new regulations, new business models are emerging to manage demand with new actors such as flexibility services distribution market operators, aggregator services and forecasting service providers (i.e. weather forecast, load forecasting etc.). Different companies could take the role of **'aggregators'** and develop **VPPs** to participate in balancing markets for example as taking the role of ancillary service providers by bidding weekly/daily in auctions for the ancillary services.

The extent of smart meter adoption coverage is low. The Swiss Federal Office of Energy (SFOE, 2015) reported the share of Swiss households equipped with smart meters at 2% in 2015. According to the latest statistics from the Swiss Household Energy Demand Survey (SHEDS)[6] 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[7]. The narratives are to enable the grid security and system voltage stability in distribution networks and give value to flexibility.

1.4.3 Challenges

Despite offering a range of potential benefits for consumers, utilities, and DSOs etc., and despite ongoing technological advances with the variety and capability of automation devices, asking energy users to automate their home devices in their daily lives is a delicate matter as it strongly links to end-users' daily practices and hence subject to their individual capacity, willingness to shift energy-use and other social-temporal context. Besides, the sense of agency is also asked to be removed from the user as the control of such appliances which people use for their daily lives (e.g. commuting to work with their

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[6] Weber, S., Burger, P., Farsi, M., Martinez-Cruz, A.L., Puntiroli, M., Schubert, I. and Volland, B., 2017. Swiss household energy demand survey (SHEDS): Objectives, design, and implementation (No. 17-14). IRENE Working Paper.

[7] See Article 31e of the *Stromversorgungsverordnung* (StromVV, in German) or the *Ordonnance sur l'approvisionnement en électricité* (OApEl, in French).

EVs) is ceded over to a third party (e.g. utilities, DSO). This complexity is amplified even more when the energy users do not rationalise why or what for the third parties operate such programmes (Adams, Kuch, Diamond, et al., 2021). To-date, consumer engagement in DLC programmes remains globally low despite its benefits, reflecting the challenges in addressing these questions (Xu, Chen, Zhu, et al., 2018). Evidence shows that shows that public should be convinced that there is a worthy reason for engaging in DLC programmes so that they would approve such programmes and allow system operators manage or control household energy resources such as EVs, heating and cooling devices as a new economic and security resource of flexibility within energy systems.

1.5 Social License to Automate

Against this background, it is evident that in order to successfully establish automated DSM as a mean to decarbonise the future electricity systems, it is therefore vital to continue to build a better understanding of the circumstances and conditions of users' acceptance and resistance to automation for DSM. There is a growing acknowledgment of the concept of 'Social License to Operate (SLO)' in research related to automated DSM including DLC, accelerated with the formation of IEA Users Centred Energy Systems Technology Collaboration Programme Social License to Automate (IEA Users TCP Social License to Automate)[8].

The 'social license' concept is based on a 'social license to operate', which was developed through experiences in the mining sector. It has been used first by James Cooney, an employee of the mining industry, in 1997 while mining industries were confronted to increasing community resistance when they tried to build new projects. SLO was, originally, representing a metaphor to express the community opposition in the mirror of a government refusal to issue permit and has been, since the last two decades, widely used in the mining sector. It refers to the extent to which an initiative has the approval or acceptance of communities of stakeholders and captures a cluster of factors beyond that of formal legal approval which can shape its reception (Boutilier, 2014) (see Figure 2).

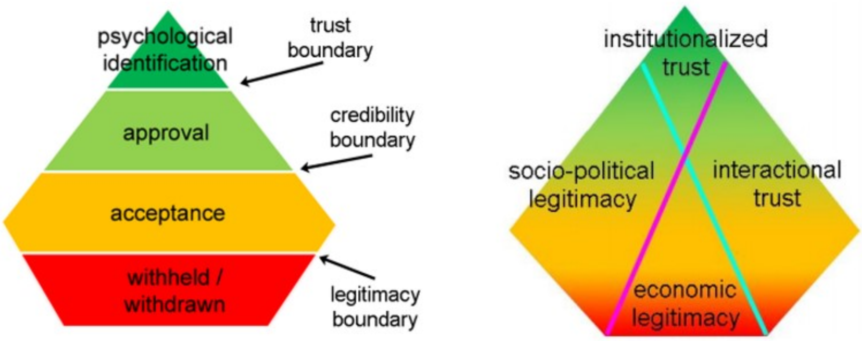

Figure 2 Threshold conditions for a Social License

[8] https://userstcp.org/task/social-license-to-automate/

In the context of energy systems, the concept of a 'social license' appears to sit between the formal and informal rules of conduct for the electricity companies, grid operators and network businesses piloting and trialling automation in DSM. It aims to go beyond terms such as 'trust' and 'privacy' only and aims to better understand the context and rationale of DLC programmes, the impact on public receptiveness, and conditions of household engagement in such programmes to successfully obtain "Social license" to deploy DLC programmes. Furthermore, the concept of 'Social License to Automate' bridge the aspects of the expectations of actors within the energy system on the one hand, and household practices, sense of control and stake in the energy system, on the other.

2 Goal of the national report

The purpose of this report is to examine the experience built in Switzerland regarding the automated DSM by inferring social and practitioner variables as well as institutional and structural components. The analysis includes how end-user trust between participants (customers and energy industry) and acceptance to automate is built to achieve Social License for automation and maintained across different contexts in Switzerland. The project is part of the larger international consortium of the IEA Users TCP Social License to Automate Task (see also the international report including case studies from Norway, the Netherlands, Austria, Sweden and Australia[9]). This report presents findings from original research involving eleven conducted surveys and eight automation projects (mostly pilots) in Switzerland.

3 Data and Method

The first data comprised of surveys and questionnaires collected from different case studies in Switzerland. These include the surveys which looked at into the level of acceptance of automated DSM of different appliances, or in aggregated level as well as the difference across socio-economic characteristics. Finally, we present a high-level analysis on several factor (e.g. incentives, social-psychological factors) influencing the acceptance levels in Swiss households.

The second set of data includes empirical and experimental data collected from different pilot projects and programmes run in Switzerland within the context of automated DSM. With the researchers of the IEA Users TCP Social License to Automate Task, we have developed an analytical framework / a common template to provide the empirical evidence on Social License within Swiss context (Table 1). It also enables a cross-country comparison with other countries such as Austria, the Netherlands, Norway, Sweden, and Australia. The common templates were filled for each pilot project through the reading of

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[9] Final international report: https://userstcp.org/wp-content/uploads/2021/10/Social-License-to-Automate-October-2021.pdf
Executive summary: https://userstcp.org/wp-content/uploads/2019/10/UsersTCP-Social-License-Executive-Summary.pdf

the publications related to the case studies but also information personally given by project managers via e-mails, phones, and meetings.

Table 1 Common template / Analytical framework to collect and analyse empirical data

Section	**Variables collected**
Project details	Leading and partner organizations; funding bodies and amount; project timeline (start and end), aims and focus of the project
Context, aims and framing	Characteristics of the local/regional energy system, energy users involved; communication of expectations and benefits, the rationale used to recruit participants; purpose of the automation, expectations; dialogues used. technical components installed to enable the automation
Involved Actors and regulatory aspects	Automation controller, actors involved; tasks each actor performs; interactions/relationships between actors, regulatory framework, governance and market rules, protocols.
Technical parameters of the automation and impact	Loads automatically activated; level of automation; frequency, duration per activation; minimum advance notice period; number of rights of overrides
Incentive	Level of incentives; price signals, revenue achievable and split of it; developed business cases
Information provision and data sharing	type of information communicated and accessed, information channels used to communicate; consumer data stored and managed.
End-user interaction with the automation System	interface used; engagement and interaction with the automation system
Project results	Main results, learnings: success and failures; percentage of acceptance and uptake

4 Description of Swiss pilot projects, case studies and programmes

This chapter presents the summary of documented experience from Switzerland regarding the automated demand side management (DSM) collected via surveys (experimental research) and pilot projects implemented in Switzerland.

4.1 Surveys

This section presents the surveys studies that were conducted in Switzerland regarding the level of acceptance of automated demand side management of household appliances in Switzerland. The findings include the analysis of end-user's characteristics as well as factors that are impacting the level of acceptance of automated DSM.

Table 2 presents the list of surveys conducted in Switzerland measuring the level of acceptance of automated DSM of household appliances, by indicating the study reference, date the survey was conducted, type of appliances asked to be automated by the third party or HEMS, purpose of the survey, purpose of the automation (if specified) in the survey and the sample size recruited for the survey. We selected 11 studies that focus on the acceptance of automated DSM or others related elements, such as trust in the energy provider and we limited the setting to Swiss households. We combined the findings of the surveys bellow to build the beginning of a credible narrative about how to earn the Social License from Swiss households in the context of Automated Demand Side Management.

First, the comparison of the studies showed us that the population is mostly motivated to accept DSM automation for batteries, heating systems, boilers, electric cars, washing machine, dryers, and dishwashers, but they categorically refuse the automation of time-dependent loads (such as TV, ovens, etc.). It is difficult to really conclude a hierarchy of the loads most likely to be accepted since the studies shows results that are quite different. Secondly, the studies show us that we can separate the households into several groups and that the people who are ready to accept automation tends to be interested in energy technologies (eventually owns PV or EVs, previously), live in multi-family homes, and have a higher level of education or work at home. Those who are more opposed to automated DSM tend to live in single-family homes and are more likely to have children. However, the profiles are highly dependent on the automated loads. For example, heating systems and dishwashers are more likely to be accepted by households living in multi-family homes as they are already used to share these loads.

The review of the studies also allowed us to know what conditions are necessary for acceptance. We learnt that the notion of comfort is the most important element for acceptance of heating systems automation, while for EVs it is less important and for batteries it almost have not any impacts. It is therefore necessary to make users understand that they will not feel any discomfort induced by automation or to give them the power to choose which discomfort they are ready to accept. The surveys also showed us that the ability to have a button generally increases acceptance and can even raises it to a level where most people are ready to accept. Studies also suggest that control is more important or even capital for certain loads, such as washing machines and dishwashers. Also, the perception of control is built primarily by trust in the actor to whom it is given, since households fear that they are unfit to manage these loads. Trust in project managers is also important for the perception of data security. But the surveys showed that the perception of data security does not have any importance for acceptance of Swiss households, since they are not sufficiently aware of potential data misuse.

However, one study suggests that project managers should anyway inform about the risks and manage them, since information that is perceived as hidden by end-users can lead to a potential permanent loss of trust.

Table 2 List of Surveys

Study reference	Date	Appliances Automated	Purpose of the study	Purpose of automation communicated	Sample size (N)
(Kaufmann, Künzel, & Loock, 2013)	2010	Not specified the appliance but a general curtailment of the load	Reveal which attributes and at what level of smart metering are more important for the customer and their willingness to pay for it.	Not specified	87
(Toft, Schuitema, & Thøgersen, 2014)	2011	Heat Pumps, air condition or electricity heating with no distinction	Investigate the influence of attitude, perceived usefulness, perceived ease of use and personal norms in acceptance smart meters with remote control.	Enhance user's efficiency, benefit from the fluctuations of price, contribute to a reliable electricity supply.	324
(Broman Toft, Schuitema, & Thøgersen, 2014)	2011	Not specified	Investigate the influence on acceptance of framing (opt-in, opt-out or neutral) benefits presented (personal, public or both) and the mention of possibility of personal control or not.	Contribution to securing the supply and improving the utilization of RE or optimize the electricity consumption and reducing the costs (minus 8-10% in the bill).	945
(Gamma, Loock, & Cometta, 2014)	2014	Dishwasher	Measure the effect of punishment and rewards depending the reasons on intention to join, attitude towards joining and loyalty, and discrepancy between self and collective interest.	Not specified	254
(Gamma, 2016)	2015	Home automation linked to a grid load-based tariff	Measure the effects of different rewards (monetary and social) on consumer behavior, on behavioral and attitudinal customer loyalty with different rewards and on customer feedback provision.	Optimize the load base grid tariff	91
(Kubli, Loock, & Wüstenhagen, 2018)	2016	Heat Pumps, EVs, PV, in-home battery	Investigate what is the most important attributes for acceptance of DR contract and the difference technology.	Respond the flexibility needs of utility to match demand and supply	902
(Soland, Loosli, Koch, et al., 2018)	2016	Home Battery, general devices with DLC and smart devices (HPs)	Investigate what Swiss residents think about DSM mechanisms and what are the barriers for acceptance.	Appliances activated with thresholds of price, no precision for DLC	55
(Moser, 2017)	2017	Dishwasher	Investigate the influence of control over the use and data security perception on load shifting programs.	Only operating when local production exceeds the demand	250
(Yilmaz, Xu, Cabrera, et al., 2020)	2019	Electric Boilers, Heat pumps, EVs, in-home batteries, PV systems, dishwashers, washing machine and tumble dryer	Identify DSR preferences (including DLC appliances preferences) and how socio demographics influence it on different types of devices	Keep network costs low and manage situation of high network demand	622
(NETFLEX, 2021)	2020	Dishwasher, Washing Machine, Tumbler, EV, Battery, Heat pumps and HPs	Measure the acceptance rate of automated DSM for different appliances and user's characteristics (PV, EVs, HPs owners versus non-owners).	Increase self-consumption and avoid the grid reinforcement and expansion	112
(Gamma, Mai, Cometta, et al., 2021)	2020	Dishwasher	Measure the influence of rewards and punishment (50 CHF or 5 CHF/month) in joining DR programs (automatic control of the dishwasher) considering loyalty towards energy provider and ratio between personal benefits on public benefits and concerns about technology.	Improve security and matching demand renewable supply (for example allow excess solar energy to be used or prevent energy shortages).	150/ 119/ 352

4.2 Pilot projects and case studies

This section presents the pilot projects that were implemented and are currently being implemented in Switzerland performing automated DSM by third parties (e.g. utility companies, aggregators). The selection of pilot projects and case studies is limited strictly to those that have implemented automated DSM (at least for a part) in households. In other words, pilot projects that included only manual DSM which people shift appliances themselves are not included. Similarly, automated DSM practices applied in industry and service sector were not included. We also excluded studies based on modelling.

In total, eight case studies were selected that includes automated DSM as part of their study. Seven of them were pilot projects and one of them is a commercially run programme (project #7 by Tiko). These projects were implemented in all three parts of Switzerland; therefore, the language of the data was French, German, and Italian (Figure 3).

Table 3 presents the eight pilot projects and case studies analysed in detail in this report.

Figure 3 Mapping of the locations where the automated DSM projects are conducted in Switzerland

Table 3 List of pilot projects and programmes in Switzerland

	Project name	Project partners	Date	Appliances Automated	Purpose of the automation in the pilot project	Size/scale
1	Decentralised flexibility	Groupe E, University of Geneva	2020-2022	electric boilers, heat pumps, EVs	To decrease the network costs and congestion by automating the devices	45 heat pumps and electric boilers in single family houses and multi family flats
2	Innovative self-consumption optimization for multi-family area development with local electricity exchange	Setz Architektur AG FHNW (Fachhochschule Nordwestschweiz), RTB Möriken-Wildegg	2017-2022	heat pumps, EVs, washing machine and dishwasher	To increase the part of local PV consumption by automating heat pumps by storing thermal energy in the buildings and automating the household appliances as well as the EV charging stations and reduce energy costs	35 multifamily flats in 4 buildings (4 heat pumps, one EV charging station, 70 mixtures of washing machines and dishwashers)
3	Quartierstrom	ETHz, EW Walenstadt	2017-2020	Decentralised community battery	Maximise the self-consumption of the community by automating the community battery to decrease exports and imports and keep the PV production consumed in the community	37 households (28 of them prosumer with rooftop PV), 8 battery (one decentralised shared by 4) and 7 other private in-home batteries (not automated)
4	GoFlex	ESR (Energie de Sion-Région) now Oiken, HES-SO Valais	2016-2020	Heating systems	To provide (buy/sell) flexibility to the built local flexibility market for the DSO to reduce the corrective costs (day-ahead and intra-day market), and shave peak loads to avoid congestion.	195 single family households 6 EV charging station

Table 3.cont. List of pilot projects and programmes in Switzerland

	Project name	Project partners	Date	Appliances Automated	Purpose of the automation in the pilot project	Size/scale
5	Luggagia Innovation Community	Supsi (*Scuola* universitaria professionale della Svizzera italiana), AEM (Azienda Elettrica Di Massagno) , Hivepower, Municipality of Capriasca	2018-2022	Electric boilers, decentralised community battery	To maximise the self-consumption of the community by decreasing evening peak, increasing afternoon consumption aligned with the PV electricity production and storing the difference with the district scale battery by charge and discharge	17 single family households (3 of them were prosumer with rooftop PV), 1 kindergarten with a rooftop PV installation
6	Warm-up	Ewz (Elektrizitätswerk Der Stadt Zürich), Misurio AG	2016-2018	Heat pumps, electric boilers	To provide and optimize flexibility holistically for cost minimization at day-ahead & intraday market, minimization of network charges and congestion as well as for renewables in the future and increasing the energy efficiency and the self-consumption of the buildings themselves.	4 zone (15 buildings with 22 hot waters fed by 9 heat pumps)
7	Tiko	Tiko	2014-commercial	heat pumps, electric heaters	To provide i) balance group optimization or peak shifting to the utility company which is to solve distribution grid congestion especially by peak shaving; ii) provide Day-Ahead or Intra-day optimization to the utility company and iii) provide ancillary services to the TSO (Transmission System Operator) such as frequency containment reserves (FCR) and automatic frequency restoration reserves (aFRR).	6,000 heating appliances. (50% heat pumps)
8	OKEE	Novatlantis gmbh, PSI (Paul Scherrer Institut), ADEV Energiegenossenschaft, ZHAW (Zürcher Hochschule für Angewandte Wissenschaften), Stiftung Habitat Smart Energy Control GmbH	2019-2021	EV sharing	To reduce grid charges (by lowering monthly peaks), and secondly use residual flexibility to generate additional revenues, by selling balancing energy	2 smart charging stations with 2 EVs for sharing with V2G capability

4.2.1 Decentralised flexibility

This project is a collaboration between University of Geneva and Groupe E the regional Distribution System Operator (DSO) of Fribourg et Neuchâtel. The project started in 2020, will end in 2022, funded by the Innosuisse (Swiss Innovation Agency). It aims to develop and demonstrate the feasibility of Direct Load Control (DLC) programmes as a service to harvest demand flexibility incorporating interdisciplinary approach. The novel approach integrates solutions by thorough survey among the real residential customers of the DSO, and then a trial allowing to identify the automation programmes that maximise not only customer acceptance and satisfaction and but also flexibility within the distribution networks. The purpose of the automation of electric boilers (used for hot water), heat pumps and EVs is to decrease the network costs and congestion by automating the devices in certain times of the day.

Figure 4 Neyruz pilot study

First, a survey among 556 households, from the DSO's customer database, was conducted to understand the acceptance and preferences of the households for the DLC of heat pumps and EVs and integrating the socio-technical factors in consumer preferences and engagement such as perceptions, motivations in order to develop programmes tailored to increase the adoption of such DLC programmes. According to the results of the survey in terms of preference for the design of a DLC programme, several services as a DLC programme were offered to the customers of the DSO. In the survey, the rationale for automation to be communicated to end-users was also tested before recruiting households, the rational which resonated the most, 'deploying DLC programmes to better manage situations of high network demand and lowering the network usage rates' was then communicated with households to recruit them via letters and e-mails for the pilot project.

The DSO (Groupe E) controls automated flexibility activation alone itself and owns the smart meters and remote switching devices to control the heat pumps, electric boilers in the pilot project of 45 households (EV will commence later in the year). The DSO switches the electric boiler for at least 6 hours per day, all year round, but may vary switching on times depending on network needs. For heat pumps, the DSO can curtail the heat pump for a maximum of 2 hours per day depending on the network situation. They receive a reduction of 3 cts/kWh for each device for the first 2,000 kWh consumed. The end-users can see the intervention history in the customer portal. The uniqueness of this project is that it attempts to co-design the automation programme design by conducting a survey before the pilot project. Moreover, interviews are being held with those who opted-in the pilot project as well as those who rejected to opt-in the pilot project bringing insights from both sides.

4.2.2 Innovative self-consumption optimization for multi-family area development with local electricity exchange

This project is a collaboration between Setz Architektur AG, FHNW (Fachhochschule Nordwestschweiz) and RTB Möriken-Wildegg, piloted in Möriken-Wlidegg (Aarau). The project started in 2020, will end in 2022 and is funded by the Swiss Federal Office of Energy. A new green quarter is built with four buildings including four heat pumps and a several PV installations with totally 160 kWp. The project's aim is to have a system that manages the heating consumption of these buildings, but also 70 appliances and EV charging with real time price electrification to maximize the PV self-consumption and minimize electricity bills. The project also has the purpose to be an innovation example in the region with the first realization of "real time pricing" for solar power in a local real-world environment.

Figure 5 Area development in Möriken-Wildegg AG with 4 apartment buildings (source: Setz Architektur AG)

End users are new inhabitants in the four buildings who had to accept specifically the full-automation systems for the heat pumps. The rationale for automation was communicated as 'the automation allows to increase the self-consumption of the buildings, consuming the PV production'. During the project, a visualisation in the buildings and an application on the smartphone also motivated the users to consume local PV power by encouraging them to set to activate their automation mode of their dishwasher and washing machines, and EV charging. The purpose of the automation is to increase the part of local consumption by storing thermal energy in the buildings and run the appliances as well as the EV charging stations with as much solar power as possible, also leading to reduction in the energy costs. Four smart energy system controllers drive the four buildings (appliances and heat pumps) and one is used for the parking (EVs). In total, there is 66 smart meters which are calibrated to save a value every 15 minutes, those will stay in the building as it seems to be included in the building project. Additionally, 70 actuators were installed to switch the household devices as well as a KNX connection to measure and influence the room temperatures. The local DSO is the contractor who owns the PV installation including the smart energy system, and the appliances such as heat pumps, household appliances, EV charging stations etc. belong to the building owners and households.

The utility company (RTB Möriken-Wildegg) controls the automated flexibility activation in contracting the self-consumption community (ZEV/RCP)[10], and Smart Energy Engineering GMbH is the technology provider for the optimisation of the automation. The DSO has the access to power demand of the households and communicates with the energy management systems provided by the Technology provider, Smart Energy Engineering GMbH, which have the data of room, hot water, and boiler temperature as well as the PV production and charging of the cars. Owners of the apartments (it also includes the PV installation) have a servitude administration contract within the frame of the law for self-consumption community[10] with the DSO which has the rules for the automation system, in addition to their classical renting contracts. Real-time pricing is used for managing the load shifting rather than fixed frequencies and durations, the system uses peak hours and off-peak hours of the DSO and PV local production price (according to the law of self-consumption which is lower than the standard costs provided by the DSO), is same for all end-users in the buildings.

Heat pumps are fully automated by the utility (changing the temperatures communicating with the sensors according to the real-time prices). EV users have to indicate the distance and the departure time when they plug-in their EVs, then the automation systems calculate the charging power and the use of PV electricity generation if it is possible, encouraging end-users to charge their EVs during daytime when the PV production is high. Moreover, washing machines and dishwashers semi-automated in other words are activated automatically when there is an overproduction of PV but should be manually loaded by the end-users and set a pre-request for the day. The end-users can indicate what time the laundry and dishwasher should be finished by, and these appliances are never interrupted when they are on. An advance period is never communicated to the households.

Real-time pricing is used to influence load shifting, the system uses peak hours and off-peak hours of the DSO and PV local production price. Depending on the electricity mix of the self-consumption community a price is determined on 15 minutes basis, which are also visualized in real-time for the end-users. The peak hours tariff is equal to 21.12 Rp/kWh, the off-peak hours tariff is equal to 17.89 Rp/kWh and the solar tariff is equal to 16.81 Rp/kWh. So, the ratio between the highest price and the price of PV corresponds to 0.796 and the ratio between the off-peak hours and the solar tariff corresponds to 0.939. The revenue of the whole system that uses the real-time pricing corresponds to saving of 7.8% on the bill for end-users. The revenue allowed by the automation is shared equitably between inhabitants (considering heating surface), nevertheless the electricity consumption for appliances and EVs (including laundry and dishwasher that can be switch into an automated mode) is calculated independently for each apartment.

In terms of information provision and data sharing and end-user interaction with the automation system, there is an interface in every apartment which can be seen on a smartphone also. The real-time price of the electricity, the electricity consumption, the actual consumption of EVs, the room temperature, the solar percentage of the electricity consumed for every apartment are indicated on the interface. The historical value of the consumption and self-consumption can also be seen for every apartment. The values of consumption and production in direct of the whole self-consumption community are also shared as well as the historical of its self-consumption, consumption, and PV exports.

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[10] The new rules for implementing groupings for self-consumption in force since 1.1.2018 (loi sur l'énergie art. 16-18). RCP stands for regroupement dans le cadre de la consommation propre (RCP) and ZEV stands for ZEV (Zusammenschluss zum Eigenverbrauch)

4.2.3 Quartierstrom

This project is a collaboration between Eenrgy Lab ETH-z and EW Walenstadt, the regional Distribution System Operator (DSO). The project started in 2018, ended in 2020, funded by the Swiss Federal Office of Energy. It was piloted in Walenstadt, the canton of St. Gallen. The QuartierStrom project's aim is to investigate the feasibility of a real-world P2P energy market from different perspectives, the technical feasibility, market design, acceptance and behaviour of households participating in the market, privacy aspects, regulatory hurdles and potential business models.

Figure 6 An aerial view of the neighbourhood in Walenstadt (Source: Quartierstrom)

The end-users are 37 households including one retirement home with 470 MWh yearly consumption (28 of them prosumer with rooftop PV; approximately yearly generation of 250 MWh), 8 battery (one decentralised shared by 4) and 7 other private in-home batteries (not automated). They were recruited by receiving a letter announcing the project from the local utility (EW Walenstadt) also inviting them also to an information event with the utility. The purpose of automating the community battery of 28kWh is to decrease exports and imports and keep the PV production consumed in the community and help to maximise the self-consumption of the community. This purpose is communicated as the rationale of the automation with end-users, and several benefits are mentioned such as financial benefits (i.e. they will receive lower electricity bill) as well as the promotion of fair, green, and local communities as the project is all about optimizing the exchange of clean PV electricity generation between the neighbours in the community. Smart meters have been installed in every end-user's house to enable a data collection of energy consumption and production on a 15-minute basis as well as charge/discharge of the community battery. For the control of the community battery the API (application programming interface) of the energy system management (EMS) has been used through the cloud.

The block chain system (installed conjointly with a ETHZ lab and the EW Walenstadt (the DSO)), which function in a decentralized way through the public grid infrastructure, gives a schedule for the battery to charge/discharge and verify if the battery owner has agreed to control the battery or not. The technology provider for the blockchain is the ETHz laboratory “Bits to Energy Lab”. End-users of the community are linked via a blockchain and a trading platform from which they have established a contract between themselves. It is a market rule that is led between every user with auction mechanism or with a mechanism of automatically calculated price. Grids operators may not use information of the electricity grid for other areas of activity. Self-consumption consumption is governed by private law internally and the self-consumption community is then treated as an end user as itself (the DSO must buy its PV exports and furnish its electricity demand). An agreement should be made between the consumers but also between the community and the grid operator. Quartierstrom use the public grid infrastructure and a trading platform which is very different than a traditional self-consumption community in Switzerland (normally the private micro-grid by law).

The community battery shared by 4 households was fully automated, which was charged when there are exports from the community and discharged when there are imports to the community. Therefore, there no fixed duration, frequency, or specific time window which the automation is scheduled. There are no direct incentives were offered for the consumers or prosumers to join the P2P energy market; however household indirectly save money on the electricity bills with the possibility to buy cheaper electricity and to sell at a better price the PV overproduction. In the scale of the P2P energy market, the incentives to shift corresponds to a real time pricing (with a 15-minute resolution). There is also a system of auction for electricity produced within the community, so the electricity is cheaper when there is the maximal production in the community and the minimal consumption. In the scales of the P2P energy market, the highest price corresponds to 20.75 cts/kWh from the utility and the minimal price for the tariff corresponds to 4 cts/kWh. Sellers asked for 7.37 cts/kWh and buyers were willing to pay 18.9 cts/kWh. As there is a system of auction which divide by two the price of the seller and the buyer it results to an average price of 9.79 cts/kWh. Consequently, the ratio to consume the electricity from the P2P energy market instead of the electricity from the grid is 2.11. Consumers pays the grid tariff plus the trading price, which is equal to 0 for a household, to 5.79 cts/kWh for the community and to 13.03 cts/kWh from the utility.

In terms of information provision and data sharing and end-user interaction with the automation system, e-mails were sent every first day of each month to every user with a monthly summary report. There was an online application to fix the price of the willingness to sell and buy to and from the community and to see the load curve of households with the provenance and destination of their consumption/production and the percentage of self-consumption and self-sufficiency. Users have also sent some request of technical nature regarding the web application (related to the firewall, web browser of the users). Interviews have been done at the end of the project, to collect user's perception about the project. Nevertheless, no feedback has been performed during the project.

4.2.4 GoFlex

This project, entitled GoFlex (Generalized Operational FLEXibiltiy for Integrating Reneables in the distribution Grid), is a collaboration between ESR (Energie de Sion-Région) and HES-SO Valais. The project started in 2016, will end in the beginning of 2021. It has been piloted in the City of Sion (Valais) and is funded by the European Union's Horizon 2020 research and innovation programme. The project aims to propose a bottom-up system that allows end-users (both residential consumers and prosumers) to activate flexibility (buy and sell), and by this to provide an optimization of the balance for the DSO to reduce corrective costs (intra-day) and reduce peak loads on the distribution grid, thus reducing the need of upgrading the infrastructure in area where decentralised PV is growing.

End-users selected for the automation are residential customers who have heat pumps labelled as smart grid ready, hot water electric boilers (for hot water), electrical heating system, a previous ripple control and access to the optical fibre. One third of them also has PV system installed on their rooftops, being a prosumer. 195 households are recruited via three rounds of letters and a campaign on social networks for the direct load control (DLC) of their heating systems (heat pumps, electric boilers and electric resistance heating). The rationale for automation was communicated as 'to integrate renewables but also to better understand their own electricity consumption reducing it and earn money by this way'. The value proposition of the project is also communicated as contributing to the energy transition with zero costs of installation for the automation. DLC: Room temperature sensor, water temperature sensor (for DHW), Smart meter (Landis+Gyr E450) and sub system (with relay) in the heating system to perform the DLC are installed for free to these household and these installations belong to the DSO. 10 residential consumers installed a Home Energy Management System (HEMS) with temperature sensors in the room and domestic how water voluntarily to follow a dynamic pricing system. Similarly, 10 industrial partners which includes retailers with no-food storage, office with air conditioning also installed voluntarily a factory energy management system (FEMS) that follows a dynamic pricing system. These entities are not part of the DLC (full automation). Finally, and a CEMS (charging energy management system) to automate the EV charging and a CDEMS (charging discharging energy management system) to provide V2G (Vehicle to Grid) are installed in two EV charging stations.

Figure 7 demonstrate the GOFLEX system and its components. The DSO department of the ESR (energy utility company) does the activation of flexibility via the Direct Load Control through a global server, and also through a smart solution system which offers a VPP where all energy management systems (HEMS, FEMS, CEMS) communicate available flexibility to a FlexOfferAgen (which is an algorithm as part of the VPP) and provide the individual bottom-up flexibility to a centralized FMAN (flexibility manager). This FMAN aggregates FOA's flexibilities and places the offer on a FlexibilityMaerket (FMAR), and these offers are traded by the DSO on this market. DSO expresses the required flexibility as a buy-offer in this trading platform of the FMAR. The required flexibility of the DSO is calculated according to its operational needs on Service Platform, gird data in a separate unit called DOMS (Distribution Observability and Management System), once this flexibility is activated (either buy or sell), the FMAN notifies the energy management systems via the FOA (Flex OFffer agents) to optimize their load.

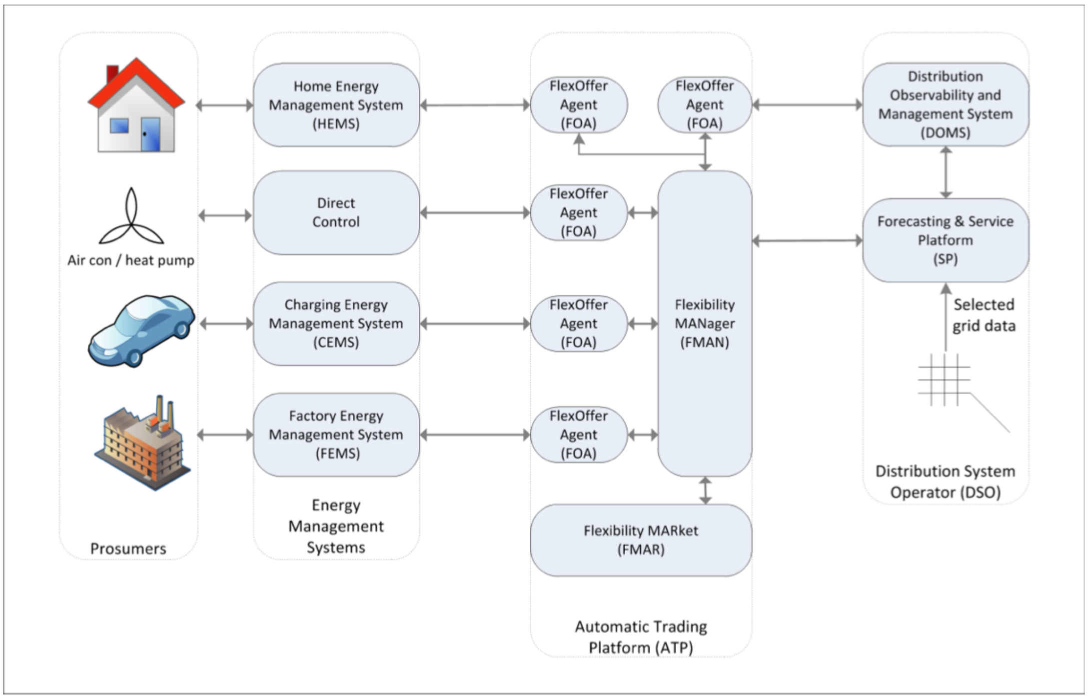

Figure 7 GOFLEX System Components (Source : HES-SO Valais)

There are several actors that have different roles, performing different tasks in the pilot project. ESR (Energie de Sion-Region) is the DSO but also just like many other energy utility companies in Switzerland, it serves as well as the energy supplier (though unbundled inside). HES-SO Valais, as the research partner, integrator, support ESR during the demonstration phase and coordinate the pilot experiments. GoFlex system developed as a VPP acts as a flexibility aggregator and comprises an automatic trading platform managed by a techno-economic algorithm/optimization that communicates with the DSO's global server for direct load control and energy management systems at homes and EV charging station. This system of GoFlex can also be seen as a local market operator as the FMAR manages local balancing market for energy flexibilities for DSO. Technology provides comprised of; INEA: provider and installer of the component FEMS to the factories as well as HEMS in the household for them to follow the dynamic pricing tariffs; AAU: developer of the CasaApp smart plug-in for the washing machines; ETREL: provider of the CEMS (charging energy management system; ROBOTINA: provider of the component of V2G which cis called charging discharging energy management system (CDEMS). The market rules of the GOFLEX system are based on the Harmonized Electricity Market model in Europe (ENTSO-E, 2009, ENTSO-2015), and its adaptation by Mirabel project. The optimization algorithm does a techno-economic analysis in order to enable local balancing market for energy flexibilities. There is no fixed frequency or duration for the activation of the flexibility. On the other hand, by law the DSO is eligible to interrupt the load to manage the grid overload (security reasons).

There is no direct incentive to participate, but the installation of smart components for both DLC and HEMS is free. The algorithm does a techno-economic analysis in order to enable local balancing market for energy flexibilities following the day-ahead and intra-day market (i.e. dynamic pricing) as well as other grid issues which later leading to lower electricity costs for the households.

In terms of information provision and data sharing and end-user interaction with the automation system, a web interface for the end-users under the DLC programme. It provides information on the electricity consumption, PV electricity production, thermal consumption, room temperature and hot water consumption and use of the flexibility. The end-users can see their own historical of use of flexibility, however it did not communicate the gained benefits such as money saved, reduced CO_2-Emissions. They also do not receive any early notice for the DLC that they will have an intervention. All this data is stored in a private cloud of the DSO (ESR).

4.2.5 Luggagia Innovation Community (LIC)

This project, entitled LIC (Luggagia Innovation Community), is a collaboration between SUPSI, the regional DSO AEM Azienda elettrica di Massagno), HivePower, Optimatik and Municipality of Capriasca. The project started in 2019, will end in 2023. It has been piloted in the municipality of Capriasca, in the village of Lugaggia and is funded by the Swiss Federal Office of Energy. The LIC project aims to test and verify the capability for self-consumption communities (SCC) to integrate renewable energies by leveraging on two novel technical solutions i) a centralized energy management platform, which uses the existing smart meter infrastructure for sensing and actuation and ii) a decentralized control approach secured by blockchain technology and requires the installation of computing and controlling unit, connected to the smart meters. Further aims include a) assessing blockchain as a decentralized billing management method introduced by the utility; b) comparing centralized vs decentralized load management methods from the DSO point of view (grid costs), energy consumption and economic point of view; c) assessing the local flexibility potential and the different ways in which it could be exploited from a technical point of view; and d) evaluating the degree of knowledge or acceptance among the community stakeholders to be willing to participate in these new self-consumption communities (a living lab to test users' acceptance will be set up).

In compliance with the new Swiss energy law[11], a self-consumption community was implemented to optimize and automate the use of local solar energy between the users in a district of Lugaggia. The community is located in the north-east suburbs of Lugaggia region and consists of 18 single-family houses and a kindergarten. The majority of the building stock is typical two-storey family houses constructed between 2010 and 2015 hosting approx. 75 residents and covering a total area of 18’000 sqm. The majority of the dwellings cover their energy needs by utilizing electricity as a source with a total annual consumption of approx. 270'000 kWh. The Lugaggia Innovation Community distribution network is served by a 250 kVA substation located in a short distance from the neighbourhood. The district counts 4 PV installations on the roof of the local nursery (30 kWp) and on the roofs of 3 dwellings (with a total installed power of 32.5 kWp). An electric storage (a decentralised battery) unit of 50 kWh owned by the DSO is also installed in the neighbourhood to increase the penetration level of the PVs and shift demand out of the peak hours. A number of the residential buildings have installed Heat Pumps and electric boilers (with a total power of 26 kW) to cover heating and Domestic Hot Water needs. The community is wired, connecting the kindergarten to the households through a single coupling point. The community battery is installed in the Lugaggia kindergarten and the decentralized monitoring and control equipment is installed and operational at the household main cabinets. The end users were recruited by direct invitation by their utility company (DSO, Azienda Elettrica di Massagno AEM), with the support of the local municipality (Capriasca). The specific households to engage were identified based on the characteristics of the local distribution network and the presence of a sufficient number of PV plants. The eighteen households of the Lugaggia Innovation Community are in fact all connected to a single grid substation, which also connects the local nursery hosting the PV plant.

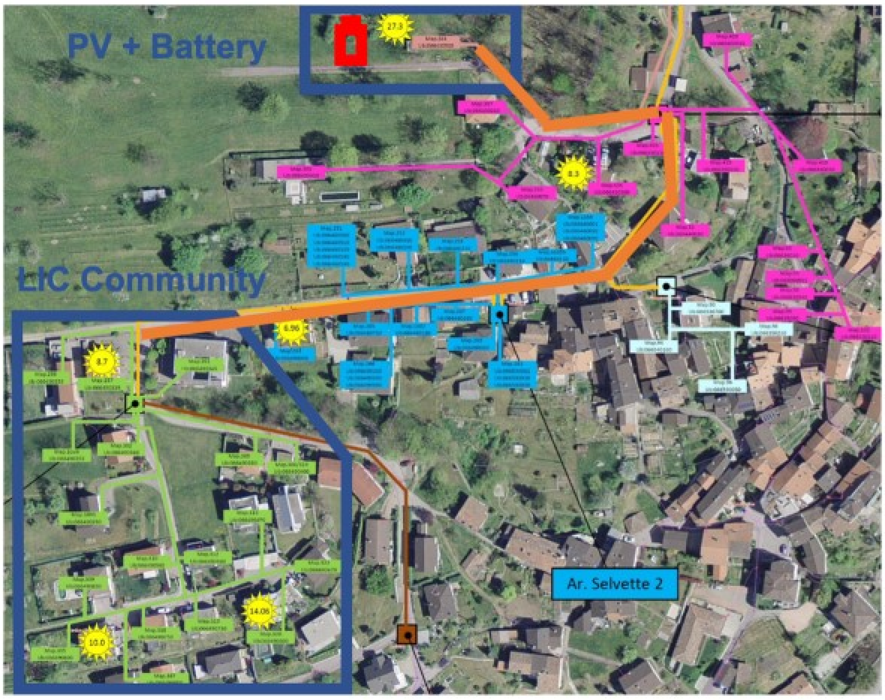

Figure 8 Luggagia Innovation Community (Source: SUPSI)

[11] The new rules for implementing groupings for self-consumption in force since 1.1.2018 (loi sur l'énergie art. 16-18). RCP stands for regroupement dans le cadre de la consommation propre (RCP) and ZEV stands for ZEV (Zusammenschluss zum Eigenverbrauch)

The eighteen households were recruited through targeted activities. They were first contacted by a written letter, sent by AEM, which was accompanied by a flyer introducing the project, and followed by a meeting aimed at explaining the project goals, opportunities and risks (e.g. such that shortages of hot water and heating were very low) for project participants. When households requested it, individual follow-up meetings were organized as well, again by the local DSO AEM. The local kindergarten and PV installation on the rooftop are owned and managed by the Municipality of Capriasca, therefore included in the project as the municipality acted as project implementation partner. The rationale for automation for hot water, heating and the decentralised battery was communicated as 'to enable and maximise the self-consumption of the community that integrates the local PV on top of the kindergarten'. The benefits prospected to the end-users were an increase in energy independency and the possibility to tangibly support the energy transition. An agreement was also signed with the local DSO, who committed to reimburse them in case the SCC electricity invoices were higher than the regular invoices by the DSO.

In the first case study, solution consists of a centralized energy management platform which is controlled by the local DSO (AEM) by using the existing smart meter infrastructure for sensing and actuation. In the second case, the solution implements a decentralized control approach secured by blockchain technology and requires the installation of computing and controlling unit, connected to the smart meters. In this case, the DSO does not have a direct control and can only steer the behavior of the SCC by proposing alternative tariff schemes. The electrical water heaters, heat pumps and decentralised are controlled via these two approaches. Other actors involves technology providers which are Optimatik which provides the product of Smart Grid solution, and HivePower which is developer of a turnkey solution for the creation and management of local energy community with this blockchain technology. SUPSI is the scientific advisor and also the project manager. Municipality of Capriasca: acts as a public authority guaranteeing fairness and correctness of the whole SCC process.

THE SCC operates in line with the law for the energy community to exist in Switzerland (The Chapter 3, Art. 17 of Lene[12]), market rules are also defined by this law. DSO plays a central role by directly controlling, loads and the storage, as a service to the community. For the blockchain-based solution being tested, it is not publicly accessible and the data are anonymized using pseudonymization which does not contradict with the current Swiss regulatory framework and could be applied in a real SCC setup. The end users are organized in an energy community (EC). In terms of the market design, the goal of the community is to maximize its welfare, by reducing the costs for the consumers and increasing the revenues of producers. They set up an automated market making (AMM) mechanism; this is defined by a set of simple and interpretable price formation rules:

- The energy consumed from the external grid shall be paid for as if the consumer were not part of the community and the energy injected into the external grid shall be remunerated as if the consumer were not part of the community.
- The energy consumed from inside the community is paid for at a total price lower than the standard tariff of the energy supplier and DSO, with a discount proportional to the ratio of the total produced and consumed energy. The energy injected, which is consumed inside the community is remunerated at a price higher than the standard tariff of the energy supplier, with a discount proportional to the ratio of the total consumed and produced energy.
- The self-consumed energy is equally split among the community members proportionally to their consumption and production. The instantaneous buying and selling prices are dynamic, but for a given time slot they are the same for everyone. The difference between the community buying and selling prices covers the cost to setup, operate and maintain the community infrastructure.

[12] The Chapter 3, Art. 17 of Lene. (https://www.fedlex.admin.ch/eli/cc/2017/762/it)

The community administrator pays the bill at the coupling point, where the DSO's prices are applied and gets paid by the end-users according to the above-mentioned pricing scheme. The internal and external buying prices are 16 and 21 cts/kWh, respectively. The internal and external selling prices are 9 and 6 cts/kWh, respectively. The district battery, heat pumps and hot water boilers are fully automated with no fixed maximum duration, but rather A minimum activation time is granted to the devices based on the usage profile, which is disaggregated from the meter readings. There were no fixed number of frequencies of automation, or fixed periods, completely depends on algorithm (the weather, grid needs etc.). The community members cannot override the automation.

In terms of information provision and data sharing and end-user interaction with the automation system, there is a web portal built in to communicate the consumption and production of the energy of the users (each user can see only his/her own prosumption) and of the community, the activity of the community battery. The automation is not explicitly communicated as 'three times last Saturday', but they can interpret it from the visualisation of the consumption. The project is now also preparing a page to show the instant prices and financial figures. However, web portal is only for visualisation there are no options for overriding or modification. Finally, a biannual newsletter ensures communication of general project progress and activities and notification of project highlights to all members of the SCC and the involved actors. In terms of data storage, for the central management case study, it is stored in a centralized cloud within the DSO. For the decentralized case study, a private blockchain developed by the start-up Hivepower running on the embedded computers connected to the smart meters.

4.2.6 Warm-up

This project is a collaboration between Misurio and Ewz (Elektrizitätswerk Der Stadt Zürich). The project started in 2013, ended in the beginning of 2018, comprised of three phases: Warm-up 1,2 and 3 It has been piloted in the City of Zurich, where the automation was tested for a year. The project is funded by the is funded by the Swiss Federal Office of Energy. The WarmUp project aims to investigate how flexibility offered by thermal storages can be used optimally, by improving economic and ecological aspects as well as efficiency and comfort for space heating and hot water with heat pumps. The project aims also, through different phases, to facilitate the technological implementation of an optimizing system to automate heat pumps in larger scales rather than individual building itself. The second phase of the project is a proof of concept in which the findings of simulation findings WarmUp 1 are implemented in a building, and Warm up 3 applies the concept on one of the energy systems in the contracting pool of Ewz consisting of 15 buildings with 22 hot water storage fed by nine heat pumps.

There was already an automation control for the heat pumps and hot water boilers in the buildings, therefore this project just connected their new energy management system to the existing system (to run their new algorithm that overrides the old system) without the need to recruit fresh new end-users. The rationale for automation is communicated as 'to maintain comfort in the building and at the same time improve efficiency, reducing costs for end users and the DSOs and decrease the ecological footprint of the electricity consumption of their heat pumps'. The purpose of the automation is quite holistic: to the minimize costs at day-ahead and intraday market, minimize network charges and congestion (it is not a problem for the DSOs for the moment, but it could be in the future), to bring the flexibility necessary for renewables in the future and increasing the energy efficiency and the self-consumption of the buildings themselves (which automatically decreases the cost). The end-users are not expected to do anything, the system is fully automated, the algorithm priority is always comfort, then the algorithm for the optimization weights different goals equally in monetary terms: these goals are self-consumption, ecological (matching with renewables), energy market goals (cheaper electricity buying from the intra-day/day ahead market prices) and network goals (decreasing grid costs by reducing the congestion, match with renewables). Smart heating system were installed on every building with temperature sensors in the hot water storage tankers and a measurement of the returning temperature of heat pumps and boilers accessed and controlled by the DSO and the Misurio energy management system.

Figure 9 shows the actors involved in the Warm-up project and their roles and tasks in the project. Through a VPP, the aggregator Misurio (the developer and operator of the energy management system as well as doing the load forecasting, optimization controlling and monitoring) has a contract with the DSO (Ewz). According to this VPP, the DSO operates, controls, and manages the flexibility activation. Ewz as the utility company (unbundled within the company), serves as i) an energy services (contractor) with the customers and the VPP operator and ii) distribution system operator that manages the congestion and frequency in agreement with the TSO, and as the iii) trade dealer / energy industry that buys and sells electricity through the EPEX spot. The VPP which optimizes the devices and aggregates the flexibility has a contract for the automation with the Ewz (the contractor) as well not directly with the consumers. People are charged according to this contract and pay their bills to the Ewz. According to the contract with the Ewz (energy services department), the VPP aggregates the flexibility and dispatches electricity accordingly.

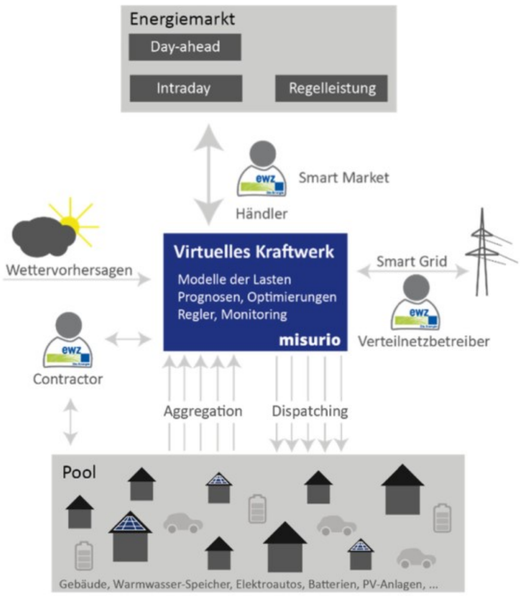

Figure 9 Actors in the Warm up project, their roles in the project (Source: Warm up)

Heat pumps are controlled by the DSO according to the automation system (VPP) developed by the Misurio, algorithms run according to the inertia of the building and temperatures in the boiler, return temperatures and forecasting about weather, electricity prices at the EPEX spot and self-consumption (depending on the renewables). In other words, the price signals (real-time pricing) calculated depending on the EPEX spot (day-ahead and intra-day market) are used in the model to optimize the automation given it provides the comfort limit and ecological (i.e. follows the PV production). For example, the heat pumps switch on to warm up the water (charge the water tank) when the prices are negative. However, the system stability of the transmission network take priority depending on the network issues (for example negative price if the excess energy must be drawn off), then the algorithm definitely prioritises this. All dimensions of the energy company (energy services, DSO, trader) involved in the WarmUp project belong to the same company (Ewz), so that the overall benefit stays in the company. Consumers gets charged according to the process (real-time prices) but since comfort, ecological and economically are favoured, they could save money.

In terms of information provision and data sharing and end-user interaction with the automation system, there is a web application which only shares money saved for the buy of the energy as well the price of power peaks for the users. The consumer data is stored in a server and use by the system driven by the DSO, the electricity market and TSO does not have any access to the personal data of users (boiler temperature and return temperature of households). The web-interface also allows the end-user switch off the algorithm for their flat for a day.

4.2.7 Tiko

Tiko (BeSmart project) which is fully operational, technically, and commercially since 2014 perform three activities in the Swiss electricity chain. They control almost 6,000 devices (50% heat pumps) in Switzerland (Figure 10). They have a role of aggregator to i) balance group optimization or peak shifting and ii) Day-Ahead or Intra-day optimization to the utility company, when the energy retailer requests to switch off all possible loads, they use their own flexibility activation systems. Thirdly, they use these aggregated home devices as part of their VPP to delivery ancillary services to the TSO like frequency containment reserves (FCR) and automatic frequency restoration reserves (aFRR). The relationship between the TSO (SwissGrid) and Tiko is that Tiko has to bid weekly/daily for the ancillary services (e.g. frequency control).

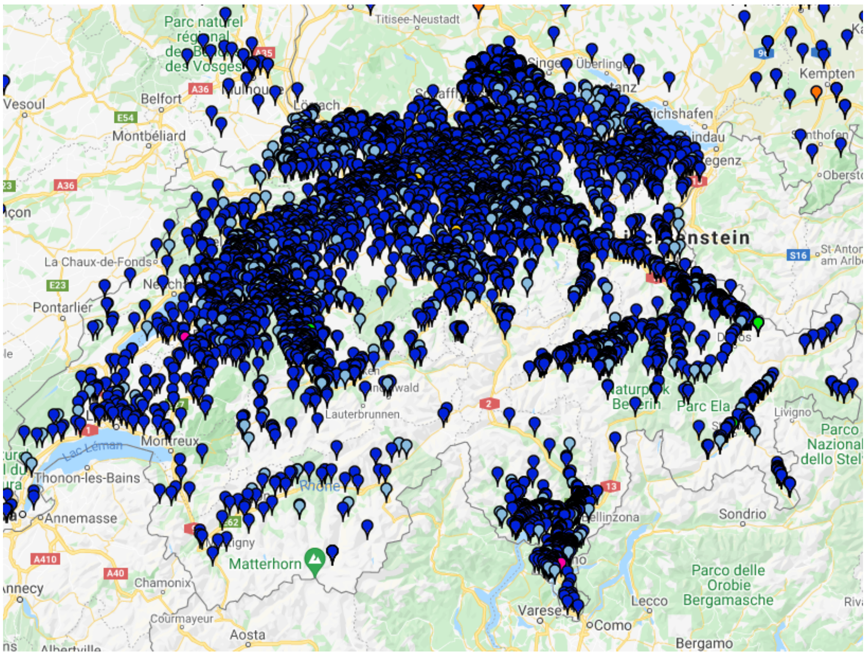

Figure 10 Tiko's clients in Switzerland and in other countries.

The tiko is offered to residential customers in partnership with utilities and vendors of heating devices. Utilities offer the service to their customers thereby strengthening the customer relation and increasing customer retention. The rationale of the automate is communicated as 'helping the Swissgrid by offering ancillary services to. Additionally, other values such as transparency and visualisation of their energy consumption for heating, comfort security ensured by the alarming system, and the possibility of realizing energy savings using the Eco Mode. Households were ensured that they will not have very high electricity bills due to the direct load control of their devices.

The home devices are shifted were heating devices (hot water boilers and heat pumps), therefore there are no specific energy practices that people need to change which are related to daily routines, activities etc. Full automation controlled by the third party a.k.a. Tiko. However, people can change sometimes the mode: energy saving mode, self-consumption parameters and let the software run its optimization. There are many technical components installed in the homes (installed freely) to allow the automation. These devices are connected to the appliances (heating, water boiler, PV-Inverter and e-car charger). It consists of a combination of communication and measurement devices and actuators, as well as Software Services. These are listed below:

• Measurement and Actuator: The metering and control tiko device “K-Box” measures the active power consumption of the connected device. It also contains a relay that is used to control the device in an on/off manner. Metering and control actions are communicated within the house via power line carrier (PLC) basis.

• Gateway: “M-Box” serves as a gateway between the in-house PLC network and the mobile communication network, which connects the device to the backend system. An industrial 3G network or the internet of the customer can be used to transfer the data between the end customer residence and the backend system.

• Backend: A backend system collects all information about the connected devices, combines it with additional information such as parameters derived from consumption history, local weather conditions, individually estimates the state of each connected asset and decides upon allowed and necessary control actions. It controls the devices in a way that the overall pool consumption follows the required activation signal.

• Client and End-Customer components: end customers can monitor the consumption of their devices in real time and receive alarms if the devices show unexpected behavior. The end Customers realize energy savings by putting the heat pumps in an energy saving mode, and by setting the Photovoltaic self-consumption parameters and let the software run its optimization. The clients can use the VPP solution to generate additional benefit.

• Other systems: Besides the basic functionalities, the tiko systems is supported by various other components such as Rollout and Installation Support Portal (ISP), Customer Support Portal (CSP), Asset and End customer Management System

In terms of information sharing and interfaces, the customers benefit from various functionalities accessible via webpage and mobile app applications. Users can see the instant and historical power consumption of their heating devices, as well as the expected benefits. Money saved and reduced CO_2 emissions can also be seen from the interface. They can also benchmark themselves with other participants in the tiko network in terms of energy consumption.

4.2.8 OKEE (Optimierung der Kopplung zwischen Elektrofahrzeugen und (Gebäude-Energiemanagementsystemen)

The OKEE (Optimierung der Kopplung zwischen Elektrofahrzeugen und (Gebäude-) Energiemanagementsystemen) project is a led by two partners, Novatlantis GmbH and PSI (Paul Scherrer Institut), in collaboration with ADEV Energiegenossenschaft, ZHAW (Zürcher Hochschule für

Angewandte Wissenschaften), Stiftung Habitat and Smart Energy Control GmbH. The project started in 2019, will end in the beginning of 2022. It has been piloted in the City of Basel, in the Erlenmatt Ost district where the automation was tested for two years. The project is funded by the is funded by the Swiss Federal Office of Energy. The OKEE project aims to examine how new solutions for smart mobility can be developed for a site with multi-stakeholder management. The project manages a physical testing of e-car sharing system with 2 EVs in the district with its 650 inhabitants and simulation of the impact that would result from adding larger numbers of EVs (without car-sharing).

In the district, there are more than 650 inhabitants in 13 buildings (approximately 200 flats as well as a couple of commercial consumers. 650 kWp PV panels is install, and 13 decentral heat-pumps (total 900 kW) with ground-water heat-recovery and thermal storage. There are two V2G EVs and EVTEC-charging stations. The recruitment was done through the apartment advertisement. The rationale for automation is communicated as ‘to help renewables integration and reduce peaks’, lower grid-charges were not communicated with the end-users.

Figure 11 One of the EV used in e-car sharing OKEE project. (Source: Novatlantis GbmH)

The EV charging stations are controlled by Smart Energy Control GmbH who acts as an aggregator and controls the automated flexibility activation. ZHAW as the research partner calibrate simulations, improve load control algorithm. There is no protocol signed with the end-users as this is a e-car sharing scheme if people want to use the car they use it, if not they are not obliged to do anything. The aggregator Smart Energy Control GmbH communicates via e-mails (newsletters) and via post for the bills. This is a prototype, so not a standard market framework, but partially financed by outside funding. For billing the car charging, following prices applied determined by the aggregator:

- Peak charge: 8.51 CHF/kW = 34.4 CHF/kWh (applied to 15-min period with highest load)
- Normal charge: ~0.14 CHF/kWh (Mo-Fr, 6:00-20:00)
- Reduced charge: ~0.10 CHF/kWh (other times)

The fully automated EVs charging has no fixed maximum duration, meaning EV charging could be interrupted as long as it need to lower peak demand. The EV had to be 80-90% full at the time of departure. This means for EVs with a lower state-of-charge, the interruption of charging is no-longer possible during last hours before the scheduled departure fixed via the app. There is no fixed maximum frequency (although in practice, it was max 1x per day), Similarly, there are no fixed activation windows – activations were allowed at any time (although in practice, activation mostly happened during evening hours, to avoid the daily peak-load). Finally, when participants complained (via mail, phone), the automation was suspended until the algorithm had been adjusted to avoid comfort loss. Similarly, end-users never received any notified activation, nor had any right to veto the automation.

In terms of information provision and data sharing and end-user interaction with the automation system, there is an online portal to only to book EVs and indicate their planned trips and e-mail/ phone for complaints, however no other information such as CO_2 savings, cost benefits are shared with the end-users, limiting the interaction with the automation system.

5 Experience in Swiss case studies

5.1 Key findings

- **Surveys conducted in Switzerland shows that that the acceptance of automated DSM is highly variable (Figure 12).** Nevertheless, there has been a broad consensus among end-users of the study concerning the fact that automation is only acceptable for a certain type of appliances. **Activities that are not bound to a specific time (such as boilers, heat pumps or washing machine) as seen as acceptable whereas appliances with a time-specific use (such as stove or TV) are seen as unacceptable.** When comparing between heating systems (heat pumps and electric boilers) with washing machines and dishwashers, **they are relatively more linked to daily routines and practices. The acceptance for automated DSM of heating systems is higher.**

- **Surveys indicate that preoccupations concerning both the level of control and data security also have a huge influence. Lack of trust to the utility companies**, which is discussed with users' concerns about loss of control, is found to be a major barrier by many studies to engage in DLC programmes as the control is ceded to a third party.
- **Differences among gender, household types (e.g., family with children, couple with no children) and education emerged in the acceptance.** Households with higher education are more likely to accept than reject the automated DSM. Men are more likely to accept the automated DSM.
- **Acceptance of automated DSM is high in the survey, however the engagement in practice in pilot projects is low.** There are several surveys that have measured the acceptance rate of automated DSM in Swiss residential sector. Figure 12 shows the acceptance rate measured by different survey conducted in Switzerland for several appliances. Pilot projects however show lower numbers. It varied between 28% to 50% which were mostly the automation of heating systems.
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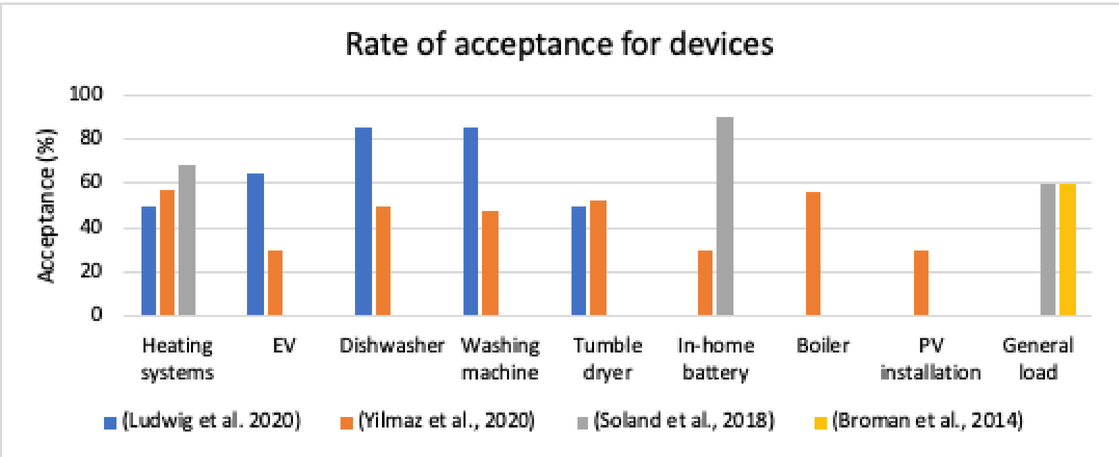


Figure 12 Automation acceptance rate measured by different survey conducted in Switzerland

Communication of the rationale, translating the value of automated DSM

- Literature suggests that **targeted value framing** that applies altruistic, biospheric, and hedonistic messages in a selective manner, could be a key component in recruiting more consumers to participate in flexibility programmes. The analysis shows that several rationales were utilised to recruit the end-users for the pilot projects implemented in Switzerland. The context of the rationale that was used by the project manager varied depending on the project aim, actor involved and end-users (Figure 13).

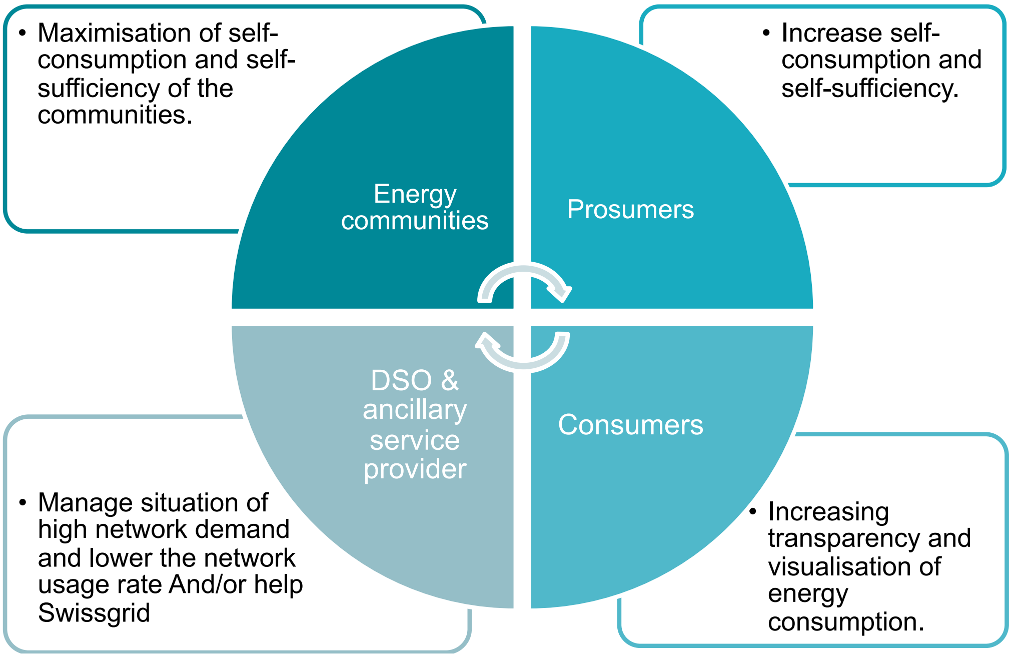


Figure 13 Categorisation of rationales communicated with the end-user types

- **With energy communities** (such as project #2, #3 and #5), the rationale communicated was to decrease exports and imports and keep the local PV production consumed in the community and **help to maximise the self-consumption and self-sufficiency of the community**.
- **With prosumers, similar rationale was used 'increase the self-sufficiency of the household**' by increasing the self-consumption of the rooftop PV (project #4).
- **DSOs** (project #1) and Tiko (project #7) as **the ancillary service provider** for the Swissgrid, on the other hand, communicated the rationale as '**to better manage situations of high network demand and lowering the network usage rates' and helping the Swissgrid by offering services to it.**
- **Other values such as transparency and visualisation of their energy consumption** for appliance consumption **were also a prominent feature** of the participation rationale. This was the case for project#1 and project#7.
- **Cost reduction or monetary savings,** on the other hand, **were not directly used as the rationale** for implementing automation programmes but presented rather as benefits.

- **People do not understand what automation technologies do exactly.** In project #2, most of the participants indicated that their motivation to participate in DLC was to 'save energy'. In project #4, 88% of the respondents asked for further information on how the technology controls the homes devices and influence their energy use and the bills.

- **Several means were used to recruit participants.** Participants were general recruited either via e-mails (project #1 before the letters) and letters (project #1, #3, #4, #5) sent by the utility companies. Project#4 sent three rounds of letters to increase the engagement rate and also did advertisement on social media network (recruited 50 households, then only 25% was eligible). Two projects additionally invited for an information session in the community aimed at explaining the project goals, opportunities, and risks for project participants (project#2 and project#5). Tiko, as the commercial service provider partners with a heat pump seller to install its system as well as separately recruiting people (project #7). E-car sharing was advertised in the apartment bulletin board in the neighbourhood.

Communication of benefits and risks

- **Almost all the pilot projects communicated the risk of discomfort explicitly,** and it was presented as something that will not happen or that have very little chance to happen. Key words included warranted ‘maximum comfort’, preserving comfort etc. Project #7 even offered an alarm if discomfort occurs.
- **Data security was not communicated as a risk.** Only one project (project#4) mentioned the data security (though this is found as a huge barrier to accept automated system). They explicitly told the end-users that they can ask, at any time, their data to be permanently deleted.
- **Most of the projects did not offer direct incentives**. Only one project (project #1 as the DSO was legally obliged to), proposed direct incentive to the end-users a discount of 3cts/kWh yearly for opting-in the programme. **The possibility to have a smart meter and other interfaces installed freely is another indirect incentive that increase the perception of benefits.**
- **The environmental benefits were not communicated as the main rationale** (e.g. by joining the automated DSM, you are fixing the climate change problem) but were presented as benefits in a very general sense (e.g. local clean energy consumption, contribute to decrease in energy consumption, provide ecological heating etc.). **Indeed, project #1 found out in one of their survey feedbacks that the rationale of deploying automated DSM programmes to integrate renewables to reach the climate targets resonated less with the end-users.**
- As mentioned, **cost reduction or monetary savings,** on the other hand, **were mainly presented as benefits** rather than a sole rationale to deploy automated DSM programmes. For example, as possibility of realizing energy savings using different modes of the automation project#7; or understanding their own consumption and save money by this way (project #4).

Involved actors, institutional roles, and interests

Figure 14 Categorisation of actors in link with the purpose of the automated projects

- The analysis shows that **initiating actors mostly concerned a coalition of stakeholders, and only in some cases individual entities.**
- End-users recruited are mostly prosumers and self-consumption energy communities (RCP/ZEV). Their interests are mainly on increasing their self-consumption and self-sufficiency with the automated DSM, aligning consumption with the local rooftop PV production.
- Consumers as end-users has also other motivations such as bill-saving etc., **almost in all projects end-users are adequately compensated in ways that were deemed fair by the users**. For example, in LIC project (project #5). An agreement was also signed with the local DSO, who committed to reimburse them in case the SCC electricity invoices were higher than the regular invoices by the AEM, the local DSO.
- **DSOs as the grid operators are key actors in the automated DSM projects,** partnering with research centres or academic bodies, and/or technology providers. They involved in the project actively from the beginning actively in the design process as well as in the implementation. They also held a key role to recruit participants for the projects.
- DSOs either control the automated flexibility activation themselves through their own cloud systems, or owned energy management systems developed by technology providers / smart algorithms designed and provided by research bodies. **DSO's main interests and business models (if available) include the network (peak) capacity management, and their actions therefore included peak shaving by curtailing highly intensive loads (mainly heating devices)** in certain periods. These models will indirectly save costs by deferring grid reinforcement needs into the future.
- **The retailer department of with supply assets (energy suppliers) were also actors in projects.** Their interests were to improve the real-time management of demand and supply via automated DSM to reflect the intra-day market which then reduced the corrective cost (difference between day-ahead and intraday market). The aggregators help the energy suppliers with contractual agreements and optimise the load to provide day-ahead or intra-day optimisation for the retailer. In other words, they aggregate flexibility depending on the price spreads on the energy exchange market where the retailer can send a signal to the VPP operator to reduce consumption during peak price hours or increase it during low price hours.
- **New emerging actors as the role of 'Aggregators' were also prominent in the automated DSM projects in Switzerland** (project #4, #6, #7 and #8). These institutions/companies **control the**

automation virtually through their own VPPs (Virtual Power Plants)** where signals are sent to turn on and off the household devices through the internet. Aggregators either have contracts with the utility companies (DSO, retailer departments) (project #4 and project#6) or act alone as the Ancillary service providers such as frequency containment reserves (FCR) and automatic frequency restoration reserves (aFRR) in the balancing market, interacting with the TSO, Swissgrid (project #7).

- **Municipalities were rarely involved in initiating or implementing the project** except for one case study: the Luggagia Innovation Community in Switzerland.
- There are two pilot projects (project #3 and project#7) where flexibility is activated via **blockchain technology.** The projects include Quartierstrom discharging/charging the decentralised battery with blockchain developed by the ETHz laboratory 'Bits to Energy Lab' and Luggagia Innovation Community in their second case study, with blockchain developed by Hivepower as a decentralized management method
- **It is evident that the profiles of the participants of the pilot projects are skewed.** They are mostly comprised of single-family households, which are early adopters of rooftop PVs, heat pumps, EVs, and batteries and/or already engaged in self-consumption communities. Pilot projects rarely collected any information on the socio-economic characteristics (e.g., gender, age), **but the existing analysis showed that it is mostly men who were engaged in the process and the interviews.**

Appliances automated and their automation levels:

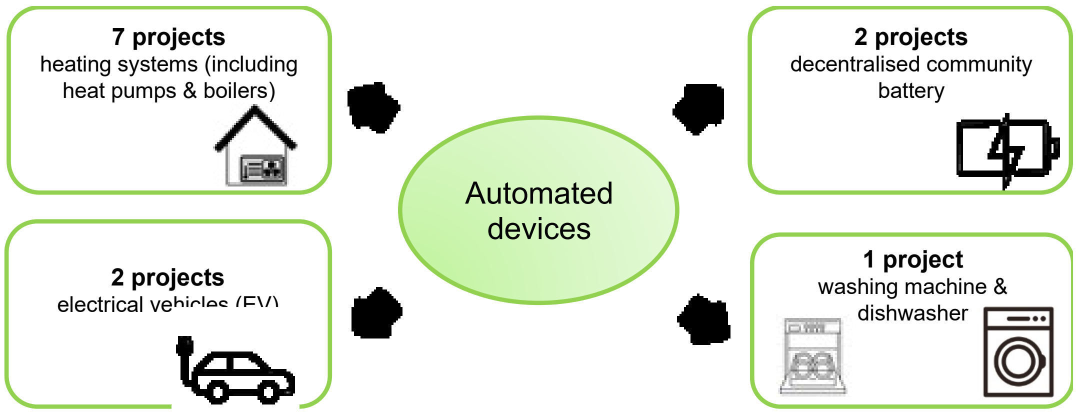


Figure 15 Categorisation of automated devices in different projects

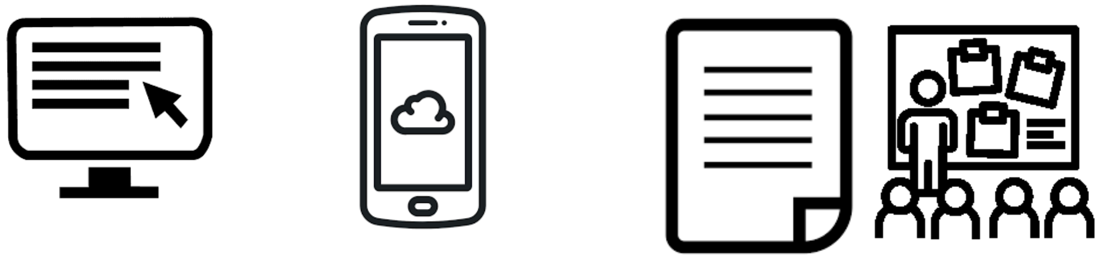
- The **most common household appliance that was automated was the heating systems including electric heaters and heat pumps, and electric boilers for hot waters** (almost all the projects automated heating systems). These devices were fully automated (i.e., end-user has no possibility via the provided interaction system to interrupt automation events) or have a restricted / consensual automation (i.e., possibility to restrict automation to specific requirements like periods (project #1) and or contact via the system and offered the chance to veto the automation event (project #7)).
- Heating systems were followed **by the automation of decentralised battery (project #3 and project #5)**. In two projects which concerned a self-sufficient energy community, a decentralised battery was installed to increase the self-consumption and self-sufficiency of the community. In other words, the decentralised battery charges when there is PV production of the community us greater than local community consumption, and discharges when local consumption is greater than PV

production. **These devices were fully automated** (i.e., end-user has no control over the automation of the battery).

- There were **two projects which included the automation of EV charging.** One was about e-car sharing where the automation of the two EVs was optimised by an Aggregator (project #8) and the other one was automated two private EVs in a community where the EVs were charged in private garages (project #2). In the latter case, the EVs were optimised with a consensual automation with acceptance, where EV owner can choose to use the smart plug which optimises the charging users or not; but they must indicate the distance and the departure time when they plug-in their EVs, then the automation systems calculate the charging power and the use of PV electricity generation independently within these constraints.
- **Only one project automated washing machines and dishwashers (project #2), which can be categorized as consensual automation with acceptance.** The end-users manually load and set a pre-request (e.g., I want the washing to be finished by 6pm) and the algorithm between that time switches on the WM&DW depending on the forecasting of the PV generation, real time price in the market.
- In terms of level of automation, even though control over automation is indicated as a significant factor in literature, **almost every project fully automated the heating systems.** Exceptionally, project#7 has given its clients **an overriding option to skip the automation for the day**, and project#2 has allowed the households to change the set point temperature of the house. **For EV charging and washing machines and dishwasher, end-users had more control** and could decide to use smart plug or not (project #2). **Nevertheless, almost every pilot project offered the option of opt-out from the project.**

Visualisation and information sharing

- **Visibility of how automated DSM is being controlled** is another factor that influences whether people see automated DSM as being in their interests.
- **Participants of the pilot projects mostly have articulated that it is important to them to be able to monitor how and when the automated DSM takes place**. Some indicate that they would not want to have to monitor it constantly, however, and there appears to be some discrepancy between their preference to have access to information and how much they use the information. **Almost all trials have shown that people rarely checked their interfaces.**
- **Social comparison was only available in one project where the clients can also benchmark themselves with other participants** in the tiko network in terms of energy consumption (project #7). For project #2, #3 and #5 **which implemented automated DSM in energy communities, the values of consumption and production of the whole self-consumption community was also available in addition to the individual households.**
- **Interaction channels were mainly web portals (all the pilot projects) and several projects had smart apps which was downloaded to people's phone mobiles** (project #2 and #4) to share information in terms of feedback (e.g., consumption, production) as well as sharing the benefits of the automated DSM (Figure 16).



Web portals **Smart apps** **Monthly reports, newsletters & workshops**

Figure 16 Information channels used to inform people about the automated DSM (e.g. process, benefits)

- **Almost all projects shared the current and historical consumption,** production (if rooftop PV is available) for individual households as well as communities (if it is a community project like project #2, #3 and #5). Some even provided further information such as the individual consumptions (EV in project #2 and hot water consumption in project #4) and room temperatures (project #4). **Projects nevertheless did not explicitly share the number of interventions.**
- **Project shared benefits of the automated DSM depending on the context.** Specifically, project #6 and #7 shared money saved thanks to the automation, or CO_2 emissions reduced (project #3, #7), for energy communities the benefit and value of the automated was communicated by showing the increased self-sufficiency of the community.
- **Direct interaction elicited by the system was noted only in medium automation level cases** (e.g. EV charging and automation of dishwashers and washing machines), **people rarely communicated with the interface for fully automated appliance if there is no discomfort.**
- **There was a spill-over effect, and people have obtained new energy management practices.** Households not only allowed the operators to fully automate their heating devices such as hot water boilers and heat pumps, but there was a clear observation that they also shifted other non-automated or semi-automated practices such as EV charging and the use of washing machines and dishwashers once they saw that the automation was in fact increasing the self-sufficiency of the community. This was similar to In project #3, some children claimed having begun to charge their phones in the sunshine hours once parents have communicated. Additionally, in project #4, the participants asked the installed technologies to automate a lot more devices (for the moment only heating & hot water).

5.2 Lessons learned

- **A one-size-fits-all approach does not exist, there is no simple lesson about user acceptance at different levels of automation**. It highly depends on the context, actor implementing as well as benefits and costs communicated.
- **Public support for renewable energy does not translate straightforwardly into support for demand side management programs.** The question of which changes automated DSM will bring to energy users' lives is crucial to a social license to automate, rather than whether the amount of renewables is increasing.
- **Successful recruitment does not only depend on the DSM programme design.** Percentage of engagement (i.e. rate of opt-in) in pilot projects varied between 28% to 50%. It was 100% for the

energy communities, as the whole community was engaging in the project. These values are much lower than the percentages stated in the survey (i.e. rate of acceptance) conducted in Switzerland which varied between 45% to 90% for different devices.

- **Decentralised batteries** which are shared by the community and charge/discharge according to the community scale import/export **are valuable in the sense that it certainly increases the community's self-consumption and leads to total peak reduction of the community**.
- **Problem definition (e.g. grid problem, low self-sufficiency) and the solution for it** (why and how the automated DSM will solve this problem, the rationale) **should be communicated clearly with the end-users. Articulation of shared problems** underpins a social license.
- **Aligning rationale of the automated DSM with users' values, expectations and motivations are key for engaging in automated DSM projects.** For energy communities and/or prosumers, using the rationale of deploying automation to increase the self-sufficiency of the community is effective. Similarly**, aligning the rationale and the role of actors and their narratives who are implementing the automated DSM is a key factor** too**.** For example, DSO is offering the automated DSM as a solution to solve the grid problems, grid security as the responsible actor envisaged by the people.
- In addition to the rationale of implementing an automated DSM project, **clear and transparent communication of benefits as well as risks and cost are vital for the Social License to automate.**
- **End users do not seek a direct monetary incentive** to join in the programmes as long as it is not them who pays for the project (for example they will not pay for an equipment to join a programme) or they are assured that they will not be worsened-off. **The possibility to have a smart meter and other interfaces installed freely is also an effective non-monetary incentive that increases the perception of benefits of the automated DSM projects.**
- **The translation of the value automated DSM should be transparent and effective,** from the establishment of the problem to which it is addressed, through the articulation of the automated DSM solution by the actors involved and their appeals to the interests of the household participants.
- **Personal engagement and relationship building with the participants is crucial to the recruitment of participants as well as to the trial's success.** These should be effectively done through several means such as interfaces, workshops, apps, portal and phone-lines etc.
- **Trust could be built over through the initially automated appliances,** in this case, full automation of heating devices, and **proving the value and benefits observed by the participants, new energy management practices can be developed more easily**.
- **Visibility of how automated DSM is being controlled** is an important factor. Access to information proved important for many users - even if they do not actively or regularly use it.
- **At medium automation level (control)** interaction design must allow flexibility specification, easy decisions regarding automation on a semi-regular basis and provide clear and regular benefit communication
- **At high automation level (transparency)** interaction design must provide automation transparency , allow flexibility specification where needed and ensure continued alignment with *overall project goal* through regular benefit communication.
- **Business models and optimisation of automation tools do not have a holistic approach when automating the appliances**. They either focus on day ahead/intraday optimisation which is important for the retailer department, or grid solutions which are important for the DSO department.

Only the Warm-up project considered the alignment of several actors in the sector and defined so-called merit orders for optimising the devices (e.g. personal comfort, local PV production, market optimisation).

- **Utilities companies (either with the role of DSO or retailer) which work with third parties have more granular flexibility provision.** This is partly because the third parties i.e. aggregators, or technology providers have access to more information (e.g. EV state of charge, temperature of hot water tanks and room temperature), and DSOs have only the information of power demand reading. At the moment, DSO lacks information to create a bottom-up picture of energy consumption by end-users, and hence is limited in creating smart charging profiles, or heating patterns.
- **Peak reductions are achieved through either direct automation of devices 2 to 8% in the pilot projects or through batteries** which increased the self-sufficiency of the community. Similarly, project #5 reported that 89% of the additional photovoltaic energy that was fed into the grid previously was used in the community and increased local self-sufficiency by 16%. Techno-economic analysis: 15-18% cost reduction for the DSO. This implies benefits for the DSOs in terms of deferring the grid-reinforcement costs.
- **There is still less experience of automation related to EVs**. Projects unfortunately have very small numbers of EV users; therefore, it is hard to draw any conclusions/lessons.

6 Conclusions

In this section, we set out several policy implications and recommendations.

6.1 Policy implications and recommendations

- From the analysis of institutional settings, **it is evident that separation of energy (the focus of retailers) and grid (the focus of DSOs) during liberalisation contradicts holistic solutions in some areas**, therefore most of the projects had a one-sided focus (either energy or grid) depending on the actor involved. **Therefore, finding ways to bridge this gap, create synergies and incorporate both aspects into program design is an important future task for businesses and regulators to consider.**
- **Business models that make their optimisation solely dependent on the energy market will not solve the problems in the local grids.** Furthermore, it is currently unclear who determines how the flexibility will be governed - for example, how different goals will be weighted or with which boundary conditions.
- Policy makers should provide a harmonised and holistic framework to have integrated solutions where the different interests and goals of different actors are aligned.
- **Utility companies must increasingly collaborate with other actors to realise smart grid innovations.** Those projects which collaborate with third parties as technology providers on the other hand **have more granularity as these third parties have more access to information (household temperature, charging levels, pre-set options by the end-users).** Therefore, they could develop their own energy management systems that could perform automation with more sophisticated algorithms depending on temperature sensors, charging levels, PV electricity production, etc.

- **Policy makers should consider stimulating long-term relationships between DSOs and third parties,** because such relationships are more likely to produce incentives for collaboration.
- **Social science expertise should be included more in the policy making for automated DSM.** Industry failure to grapple with the social diversity of settings where automation projects are being trialled is a threat to its ongoing viability. Social science expertise has an indispensable role in the development, ongoing operation, and evaluation of automated DSM programs

7 Outlook: Directions for future research

Against the case study analysis, this report suggest the following directions for future research.

- **More information should be collected about why people refuse to opt-in to automated DSM projects,** in order to form tailored business models to increase the engagement. For the moment, only one project considered this (project #1). This is important in order to build a social license to automate that includes people that are the late majority, laggards, or simply not interested.
- More experimental data is needed, possibly using Living Labs as an innovation intermediary where different automated DSM products and services should be co-designed, on an iterative way (What works what does not), in real-life settings.
- **More integrated holistic solutions solving the future grid issues by aligning the interest of different actors are needed.** For this, iterative exploration is required, especially in decentralised systems through theoretical studies supported by urban energy system models.
- **The diversity of actors that are important for mobilising support** for the implementation of automated DSM solutions and services is often overlooked. Particularly, cooperatives and other institutions that are promoting and providing energy community should be given more attention in future research as they have proven important in the process of enrolling energy users in energy related groupings.

8 Academic Publications

List of publications from the IEA TCP Social License to Automate Tas

- S., Adams, D., Kuch, L., Diamond, P. Fröhlich, I.M. Henriksen, C., Katzeff, M., Ryghaug, S., Yilmaz (2021). Social License to Automate: A Critical Review of Emerging Approaches to Electricity Demand Management. *Energy Research and Social Science.* Vol: 80, 102210. https://doi.org/10.1016/j.erss.2021.102210
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- S. Adams, L., Diamond, T., Esterl, P., Fröhlich, R., Ghotge, R., Hemm, I.M., Henriksen, C., Katzeff, D., Kuch, J.L., Michellod, Z., Lukszo, K., Nijssen, S., Nyström, M., Ryghaug, C., Winzer, S., Yilmaz (2021). User-Centered Energy Systems, IEA Social License to Automate, International Report. Available from: https://userstcp.org/task/social-license-to-automate/

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10 Appendices

IEA DSM USER CENTRED ENERGY SYSTEMS TCP – SOCIAL LICENSE TO AUTOMATE COMMON TEMPLATE

This template was developed in order to collect information on a number of aspects of running and completed Demand Side Management Projects that are likely to be of relevance regarding end-user acceptance and the granting of a “Social License to Automate”. It consists of 8 sections:

Please address sections as appropriate for the project in question but try to cover as many of the points as possible. The descriptions at the top of each section can be used to as a guide for more open answers with the detail questions below to be used as pointers for aspects to be considered.

Section 1: Project Details

This section concerns basic information around the project and should be fully completed.

1. Project name:
2. Project lead organization:
3. Project partner organizations:
4. Project funding bodies:
5. Project funding amount:
6. Project start date
7. Project end date:
8. Project website:
9. Contact Name:
10. Contact Role:
11. Contact eMail:
12. Project aim:
13. Research focus:
14. Data sharing: possibilities and constraints:
15. Number of cases within study:
16. Case description:
17. Case location (Country, City/Region) :
18. For how long has the automation system been tested?

Section 2: Context, aims and framing

This section of the template covers the local starting point including the regional energy system characteristics and the user segment involved, the automation goal, and the involvement of end users to achieve it. This included the communicated rationale, expectations towards end-users, and opportunities provided for feedback and dialogue.

19. What are the characteristics of the local/regional energy system (including energy mix, status of the grid in the area)?
20. What are the characteristics of the energy users involved?
21. How were end-users recruited?
22. What was the rationale for automation communicated to end-users?
23. What is the purpose of the automation? *(i.e. solve distribution grid congestion, transmission grid congestion, grid balancing, minimize network charges, minimize costs at day-ahead-market, maximization of self-consumption, innovation …)*
24. What is expected from them in the project?
    a. If this includes a change of energy practices, which practices were changed?
25. Which expectations and benefits are presented to end-users? Were costs and cons communicated as well?
26. Was a sense of fairness and reciprocity established and if yes, how?
27. Was dialogue with consumers (ways to receive feedback, answer questions, etc.) enabled and were consumers encouraged to give feedback?
28. Was accountability communicated to end-users and if yes, how?
29. Which technical components to enable the automation were installed in the house of clients and which actor owns them? *(i.e. smart meters, smart sensors, smart appliances, smart heating systems, batteries, EV charging systems …)*

Section 3: Involved Actors and Regulatory Aspects

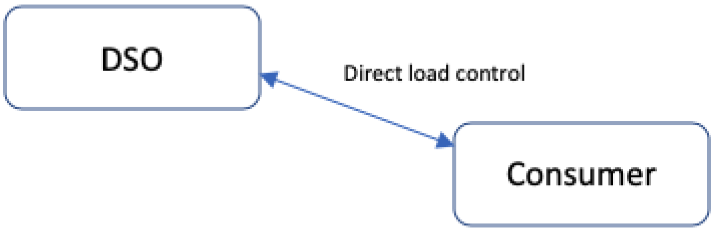
This section of the template covers involved actors, their roles and tasks performed within them, as well as establishment of relationships and interactions between stakeholders. Further addressed are regulatory framework, market framework, and any accountability-related protocols.

30. Who controls automated flexibility activation? (i.e. consumer/prosumer, aggregator/retailer, distribution system operator…)
31. Which actors were involved?
    - Suppliers
    - DSOs
    - TSOs
    - Component manufacturers
    - Regulatory instances/authority
    - Aggregators
    - Other technology providers -> Please precise:
    - Others: Please precise
32. Which tasks each actor performed / currently performs within the project?

Task/Role	**Actor**
Frequency control	
Congestion management	
Voltage control/regulatory	
Trading flexibility in day-ahead market	
Trading flexibility in intra-day market	
Providing power reserves	
Technology provider	
Other, please specify	

33. With whom do the actors interact and why?

Option 1: Draw a diagram instead of answering yes or no, and write down the characteristics of the interaction. Example:



Option 2: Example:

Actor 1	**Actor2**	**The relation**
DSO	Consumer	Direct load control
Aggregator	Consumer	Smart meter roll out

34. How were the relationships between involved stakeholders established and how are they governed? (i.e. on mutual regard, bilateral contracts, regulatory framework (protocols etc.), market rules, others etc. etc. …)

35. Briefly describe the regulatory framework for automation projects within the corresponding country context:

36. Briefly describe the market framework (e.g. rules) for automation project within the country context:

37. Are there any rules, protocols that hold energy companies accountable for their mistakes and unjust practices?

Section 4: Technical parameters of automatization and impact

This section of the template covers the details of the implemented automation procedures including level of automation, load types to activate, restrictions around activation (frequency and duration) and communication of such restriction to end-users, advance notice of automation activation and options for end-users to veto such processes. Further addressed is the expected impact of automated processes on end-users.

38. Which loads can be automatically activated? *(i.e. in-home-Battery, community battery, heat pump, e-car, electric boiler, EV charging system, air conditioning, smart appliances, other: please specify)*

39. Did you specify a uniform maximum duration per activation? (yes - same value for all participants, no- different values for each participant or choice, no- we did not specify this)

    - *What was the maximum duration per activation? (hours)*

40. Did you specify a uniform maximum activation frequency? (yes - same value for all participants, no- different values for each participant or choice, no- we did not specify this); If yes:

    - *Which units were used to specify maximum activation frequency? (none, activations per year/month/week)*

    - *What was the maximum frequency using these units? (activations per unit)*

41. Did you specify the time-window, when activations would take place? (yes - same value for all participants, no- different values for each participant or choice, no- we did not specify this)

    - *During which time of the day were activations allowed? (please specify all allowed time-windows)*

Season	*Weekday*	*Hour*
Summer/Winter/Anytime	*Weekday/weekend/anytime*	*1,2,...24, anytime*

42. Did you specify how many times participants could veto activations? (yes - same value for all participants, no- different values for each participant or choice, no- we did not specify this); If yes:

    - *Which units were used to specify maximum veto frequency? (none, vetos per year/month/week)*

    - *What was the maximum frequency using these units? (activations per unit)*

43. Did you specify a minimum advance notice period? (yes - same value for all participants, no- different values for each participant or choice, no- we did not specify this)

    - *What was the minimum advance notice period? (hours)*

44. What is the automation level? *(i.e. manual demand response, manual automation, consensual automation, monitored automation, full automation…)*

45. Is a home energy management system involved?

46. How does flexibility activation impact end-users? (Please provide details on fluctuation/availability impact and if measures have been taken to minimize that impact)

Section 5: Incentives

This part of the template covers questions surrounding consumer incentives such as if incentives were offered to consumers for initial participation and if yes of which type and size, as well details on provided incentives for load shifting and the prize signals that served as base (TOU, CPP, RTP, etc.).

47. Was there an incentive for consumers/prosumers for initial program participation? *(yes, no)*

    - *What form of incentive was chosen? (Bonus paid as reduction of monthly bill, shipping voucher, maintenance voucher, discount on purchase of new technologies but also sustainability reasons, curiosity (early adopters),…).* If the incentive was monetary, how much / what was the value?

    - *How high was this incentive?*

48. What price signals were used to incentivize load shifting? *(None, Time of Use pricing, Critical Peak Pricing, Peak Time Rebate, Real Time pricing, spot market prices, balancing market prices, other: please specify)*

49. What was the ratio between the highest price and the average price?

50. What are the overall achievable revenues of flexibility activation (for all stakeholders)? *(i.e. €/activation, €/component/a, €/customer/a, % of costs)*

51. How are the revenues split between stakeholders?

52. Have there been developed any business cases within the project? If yes, please describe them shortly.

Section 6: Information provision and data sharing

This section of the template covers information and data provided to consumers and channels used to do so. This includes reasons for DSM (only to include if not already addressed before / if communicated per automation incident), status- and process information, details provided on benefits, information on privacy and security measures, and options to access data.

53. Which information channels are used to communicate with end-users? *(i.e. App, Online Portal, In-Home-Display, alternative ambient display, SMS, E-mail…)*

54. Which general information on the automation does the system provide? (automation rationale, automation conditions, general expected benefits)

55. Does the system provide process information to end-users such as automation status, as well as post and planned automation?

56. Does the system provide specific information on gained benefits (e.g. money saved, reduced CO_2-Emissions, etc.)

57. Does the system provide information on safety, privacy and security measures?

58. Where is the consumer data stored and managed? *(i.e. Completely local, centralized cloud, decentralized cloud/blockchain, …)*

59. Which consumer data was accessed and which actors have access to the data?

	Which actors have access to the data?					
Data	TSO	DSO	Aggregator	Technology provider	Component manufacturer	Other
Power demand (smart meter reading)		X				
Household temperature						
Hot water temperature						
Boiler temperature						
Photovoltaic production						
Battery charging level						
Charging levels of cars						

Section 7: End-User Interaction with the Automation System

This section covers questions regarding interaction offers provided to consumers such as if a a system-interface for end-users exists, forms of engagement implemented including active contacting of end-users, and choices offered to end-users through the system. Any available information regarding the use and evaluation of such interaction offers is of interest.

60. Does automation system provide an interface for end-users?

61. Are consumers actively contacted by the system and if yes

    a. For which reasons? *(i.e. to inform about flexibility activation, for confirmation/rejection of flexibility activation, to suggest/request manual flexibility…)*

    b. How often? *(i.e. multiple times a day, once a day, weekly …)*

    c. Is a response required?

62. Are end-users actively engaged through the system and if yes, how? *(i.e. self-monitoring and feedback, social comparisons, challenges, cooperation, rewards…)*

63. Does the system provide choices to end-users regarding:

    a. Opt out

    b. Flexibility activation (e.g. interruption or adjustment)

    c. System personalization (e.g. comfort ranges)

    d. Data access

    e. Other

64. If available:

    a. Do end-users use the system actively?

    b. Did any aspects receive positive feedback?

    c. Did any system aspects receive negative feedback?

Section 8: Project Results (as available)

This section of the template collects any information available regarding relevant results of the project. This includes the number of consumers who signed up, achieved flexibilization (in comparison to expected flexibilization), and any acceptance measures that were taken such as overall satisfaction, specific positive and negative experiences, experiences usefulness and ease of use, and experienced trust. Further covered are if users' lives were experienced as changed, if users would like to continue within the program and why / why not, and any further lessons learned.

65. What were the main project results?

66. What percentage of invited consumers signed up for the project?

67. What was the average peak shifting that was achieved ?

68. Was the desired automation-outcome (e.g. shifts, peak-shaving) successfully achieved?

69. If acceptance of the system was directly measured:

    a. How was this done?

    b. Which acceptance factors were looked at? (such as usefulness, ease of use, trust, etc.)

    c. What were the results? (if possible please rate considered acceptance factors on a scale of 1 = very low to 10 = very high additionally to your answer)

70. What has been learned so far?

    a. What was the overall experience of the users? (broadly positive, negative, or mixed)

    b. What are the strengths and weaknesses of the system?

    c. Did it work as expected and if not, why?

    d. For whom did it work and for whom not?

    e. Other:

71. Has the system changed the users' lives and if yes, how?

    a. Were energy practices changed?

    b. Were household/workplace dynamics impacted?

    c. Other changes?

72. Would users want to keep the automation after the demo?

    a. Reasons for continuing it:

    b. Reasons for quitting it: