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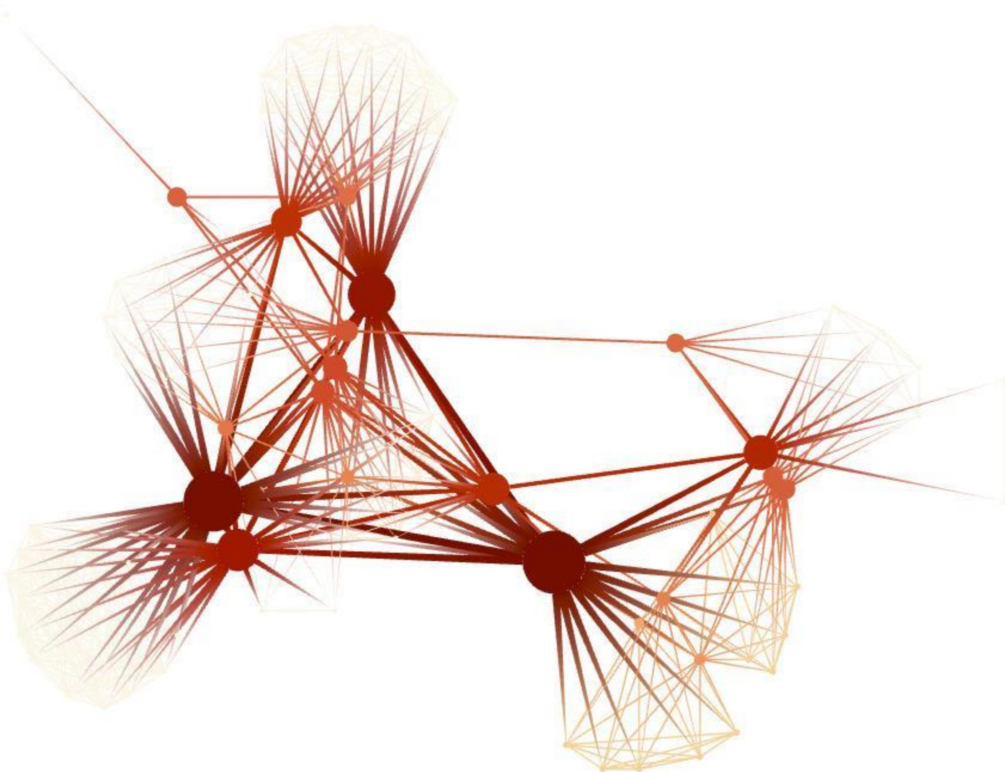
InnoNet-Energy

Diffusion of Innovations in the Energy Landscape: The role of supply and demand side network effects for integrated energy management systems



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Zusammenfassung

Energiemanagementsysteme (EMS) sind relevant, um die Schweizer Energiewende hin zu CO_2-armen Lösungen und nachhaltigen Praktiken zu unterstützen. Obwohl technologische Lösungen verfügbar sind, gibt es eine Diskrepanz zwischen der Technologie und der Akzeptanz der Benutzer:innen. Das InnoNet-Energy-Projekt zielt darauf ab, diese Lücke zu schließen, indem es Informationsnetzwerke von Akteuren untersucht, die die Angebots- und Nachfrageseite von EMS verbinden. Nach einer qualitativen Analyse von Experteninterviews zur Konzeptualisierung dieser Informationsnetzwerke, wurde eine quantitative Umfrage entworfen und im Juni 2022 durchgeführt. Die Umfrage richtete sich an EMS-Anwender:innen, mit dem Ziel, ihren Entscheidungsprozess zur Einführung der Technologie besser zu verstehen. Der vorliegende Bericht konzentriert sich auf die Umfrageergebnisse von 4.880 Befragten, die entweder EMS, Photovoltaik (PV) und/oder Elektrofahrzeuge (EV) eingeführt haben.

Die Umfrageergebnisse zeigen, dass sich die Merkmale der Technologieanwender:innen in der Schweiz deutlich vom Durchschnitt der Schweizer Bevölkerung unterscheiden (männlich, höheres Bildungsniveau und Haushaltseinkommen, häufigeres Wohnen in Einfamilienhäusern, die sie selbst besitzen). Die Studie zeigt, dass die Schaffung günstiger Rahmenbedingungen zur Förderung von EMS und PV für Wohnungseigentümer:innen in Mehrfamilienhäusern ein ungenutztes Potenzial birgt. Zweitens gibt es immer noch ein erhebliches Potenzial für PV- und EV-Besitzer:innen, um EMS zu integrieren, während PV der Schlüssel für die Einführung von EMS zu sein scheint. Drittens sind die wichtigsten Treiber für die Einführung von EMS, PV und EV, die wahrgenommenen Umwelt- und Energieeffizienzeigenschaften der jeweiligen Technologie und die Wahrnehmung, wie leicht oder schwierig die Installation und Verwendung der Technologie ist. Viertens benötigen potenzielle EMS-Anwender:innen Informationen über ihren Beitrag zur Energiewende, während derzeitige EMS-Verweigerer mehr finanzielle Unterstützung benötigen. Und schließlich sind persönliche Kontakte und das Internet die wichtigsten Kanäle, um potenzielle UMS-Anwender:innen zu erreichen, während die Informationen am effektivsten durch Expert:innen und ihr persönliches Netzwerk aufgenommen werden.

Résumé

Les systèmes de gestion de l'énergie (SGE) jouent un rôle important dans la transition énergétique suisse vers des solutions bas carbone et des pratiques durables. Malgré la disponibilité des solutions technologiques sur le marché, il y a cependant un écart important entre la disponibilité de la technologie et son adoption par les utilisateurs. Le projet InnoNet-Energy vise à mieux comprendre cet écart en étudiant les réseaux d'information des acteurs qui relient l'offre et la demande des SGE en Suisse et les informations qui y sont échangées. Après une analyse qualitative des entretiens semi-structurés pour conceptualiser ces réseaux d'information, une enquête quantitative a été menée et publiée en juin 2022, ciblant les utilisateurs des SGE dans le but de mieux comprendre le processus décisionnel de l'adoption de la technologie. Dans ce rapport nous nous concentrons sur la présentation des résultats de l'enquête quantitative à laquelle 4,880 personnes ont répondu qui ont adopté soit un SGE, soit une installation photovoltaïque (PV) et/ou un véhicule électrique (EV).

Les résultats de l'enquête montrent que les caractéristiques des adoptants (utilisateurs) des technologies (SGE/ PV / EV) sont différentes d'une manière significative de la moyenne suisse (plus masculin, un niveau de formation et un revenu de ménage plus élevé et plus souvent domicilié dans une villa qui leur appartient). L'enquête montre premièrement que la création de conditions-cadres pour la promotion du SGE et du PV ciblant les propriétaires d'appartements dans les logements collectifs présente un potentiel inexploité. Deuxièmement, il existe aussi un potentiel important pour les

propriétaires des installations PV et des véhicules électriques d'installer un SGE et donc intégrer les trois technologies. Les installations PV semblent être la clé pour l'adoption du SGE. Troisièmement, les facteurs les plus importants pour l'adoption d'un SGE, d'une installation PV ou d'un EV sont les caractéristiques écologiques et d'efficacité énergétique perçus de la technologie respective et la facilité ou la difficulté perçue de son installation et utilisation. Quatrièmement, les utilisateurs potentiels d'un SGE ont davantage besoin d'informations sur la contribution concrète d'un SGE à la transition énergétique, tandis que les personnes qui refusent un SGE ont plutôt besoin d'un soutien financier. Les contacts personnels et l'internet sont finalement les deux canaux les plus importants pour entrer en contact et informer les utilisateurs potentiels du SGE, les informations sont, par contre, plus efficacement reçues par les experts et le réseau personnel des potentiels utilisateurs.

Summary

Energy Management Systems (EMS) are important to support the Swiss energy transition towards low-carbon solutions and sustainable practices. Although technological solutions are available, there is a gap between the technology and the adoption by the users. The InnoNet-Energy project aims at addressing this gap through studying information networks of actors that connect the supply and demand side of EMS and the information exchanged within this network. After a qualitative analysis of semi-structured interviews to conceptualize these information networks, a quantitative survey was designed and released in June 2022 targeting EMS adopters with the aim to better understand their decision making process to adopt the technology. This report focuses on the survey results of 4,880 respondents who either adopted EMS, photovoltaics (PV) and/or electric vehicles (EV).

The survey results show that the characteristics of technology adopters in Switzerland are significantly different compared to the average Swiss population (male, higher level of education and household income, more often living in single-family houses which they own). The survey first shows that creating favorable framework conditions to foster EMS and PV for apartment owners in multi-family housing holds untapped potential. Secondly, there is still significant potential for PV and EV owners to integrate EMS, while PV seems to be the key in pushing EMS adoption. Thirdly, the most important drivers for EMS, PV and EV adoption are the attitudes about ecological and efficiency characteristics of the respective technology, and the perceived ease or difficulty to apply it. Fourth, potential EMS adopters need information about their contribution to the energy transition, while EMS rejectors might need more financial support. And finally, personal contacts and the internet are the most important channels for reaching potential EMS adopters, while the information is most effectively received through experts and their personal network.

Contents

1 Introduction

1.1 Background information and current situation

The ongoing sustainability transition towards low-carbon solutions is key to tackle the current challenges tied to climate change. The energy transition has a central role in enabling a systemic change towards more sustainable ways of living. With the Energy Strategy 2050, the Federal Council of Switzerland is pushing more than ever to reduce its carbon footprint and explore ambitious energy-based strategies by improving energy efficiency, increasing renewable energies, phasing out nuclear energy and developing the electricity grid (Swiss Federal Office of Energy, 2019). Besides the use of renewable sources to generate energy, a central aspect to tackle the energy challenge is the efficient management of available energy.

Energy Management Systems (EMS) are key to address these needs. They aid at balancing the supply and the demand, to effectively align production and consumption in time and space. With the widespread electricity production from photovoltaics (PV) and increased electricity consumption from electrical vehicles (EV), EMS are becoming crucial. However, although innovative technological solutions are available, a broad uptake of these innovations is still missing in the Swiss context (Tagliapietra, 2019). The most important challenge is therefore to bridge this gap and take energy technologies to the final users. As such, there is a need of addressing the energy transition from a social perspective, considering the role of information and peer effects, including supply and demand actors, and analyzing their interrelations while also integrating the geographic context.

1.2 Purpose and objective of the project

Access to information and its reliability has been identified as having a signif-icant effect on the diffusion of innova-tions (Rogers, 1995; Rai et al., 2015). In line with that, proximity and peer effects have been found to be key at enabling the information exchange (Rai et al., 2015; Palm, 2017; Bernards et al., 2018; Mundaca & Samahita, 2020; Noll et al., 2014). Therefore, there is an interest in investigating how information is circulat-ing, how it is affecting the adoption of energy technologies and which role proximity effects play in different geographic contexts. The InnoNet-Energy project focuses on analyzing the gap between energy technologies and its implementation through understanding the information networks of actors that connect the supply and demand side.

The main objective of the project is therefore to understand the information networks of actors on the supply and demand side of EMS in Switzerland, particularly focusing on proximity and peer effects and its role for the diffusion of the technology. We are analyzing the link between the supply of the technology and the adoption by the user, accounting for the key actors, how they are connected, the information circulating between them, the impact of the geographic context for proximity effects and how all this influences the technology adoption.

2 Procedures and methodology

The project takes 4 regions of Swit-zerland as case studies representing the 3 official languages of the country: Solothurn and St. Gallen (German), Vaud (French) and Ticino (Italian). It is structured in 5 work packages (WPs) applying a mixed-methods approach. First, a qualitative analysis is conducted (WP1) with semi-structured expert interviews to conceptualize the information networks of supply and demand side actors. Second, a quantitative supply and demand side survey is performed to obtain data related to the technology adoption process as well as information exchange. WP3 is a spatial network analysis (WP3) focusing on the role of spatial and social proximity effects. WP4 and WP5 are about disseminating the project findings and managing the project. Past years' project work was centered on two large-scale surveys (WP2), first with technology adopters to cover the demand side, and second with key actors on the supply side of the technology.

2.1 Demand side survey

To reach our target sample of EMS adopters, we relied on a co-adoption perspective. A dataset recording the adoption of EMS does not exist, however data on PV and EV adopters is available. Two entities, the Swiss Federal Office of Energy (SFOE) and the Federal Road Office (FEDRO), provided us with contact information. In June 2022, we distributed the survey to 15,000 PV owners and 15,000 EV owners who invested in the technology within the last 2 years with a focus on our case study regions. We contacted them via email and post and shared with them a link to the online survey.

The online survey is structured into two main parts (Figure 1) and was made available in 4 different languages (German, French, Italian and English). The first part of the survey aims to understand the personal background of the respondent, i.e. socio-demographic data, personal context, household characteristics and attitudes. The second part focuses on the technology adoption process including the factors influencing the adoption and specific characteristics about information exchange situations. The respondents filled in the survey related to either EMS, PV or EV (adopter groups). In case they had EMS, they answered the survey questions related to EMS. If not, we asked them if they had PV, EV or both. In case they had both, we used the first technology they adopted to filter them into the PV or EV adopter group.

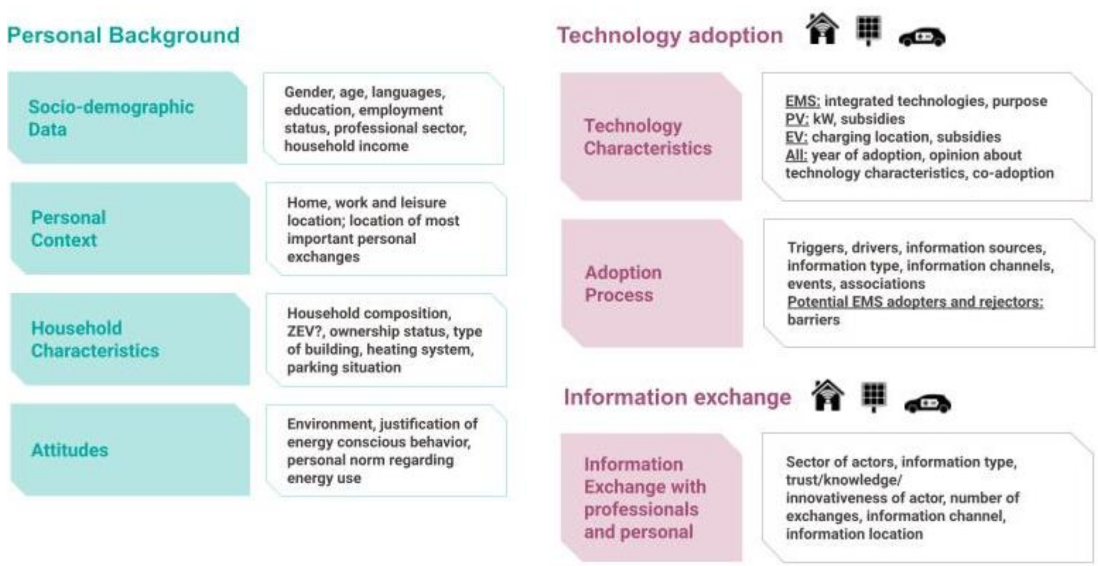

Figure 1: Demand side survey structure.

2.2 Supply side survey

To select the supply sample of key actors or organizations relevant for the diffusion of EMS we went through several steps. We started using the expertise of our project partners Energie Zukunft Schweiz and Protoscar as well as our regional partners (Yverdon-les-bains Energies, Aare Energie AG, Weesen, Energietal Toggenburg). In a workshop, we collected a first list of actors they found relevant for the diffusion of EMS. This list was complemented by the actors mentioned in the 26 guided interviews we conducted in WP1 with technology adopters and key actors on the supply side of EMS (i.e. energy utility companies, energy technology providers, academia, consultancy and advocacy). Based on this preliminary list of actors, we conducted desktop research collecting all their partners mentioned on their websites. Once we had the results of the demand side survey, we expanded this list with the actors mentioned as information sources for the respondents' decision making process of the technology they adopted. Finally, the actors went through a validation process that categorized and assessed the supply actors considering their field of activity, their connection with the demand side users and their location. The final supply side sample contains around 1,000 organizations which will be contacted in January 2023 via post and invited to fill in the online survey.

The online survey is as well structured into two main parts (Figure 2) and will as well be available in 4 different languages. The first part of the survey contains questions about the characteristics of the organization (f.e. sector, number of employees, location etc.), the technologies the organization works with and/or the role they take in the diffusion of energy technologies. The second part focuses on the information exchange of organizations related to the technology, as well as their perspective on the drivers and barriers for adopting the technologies. Also for the supply side survey, we filter the organizations into 3 main groups depending on if they work with EMS, PV and/or EV and let them answer the survey questions according to one of these technologies.

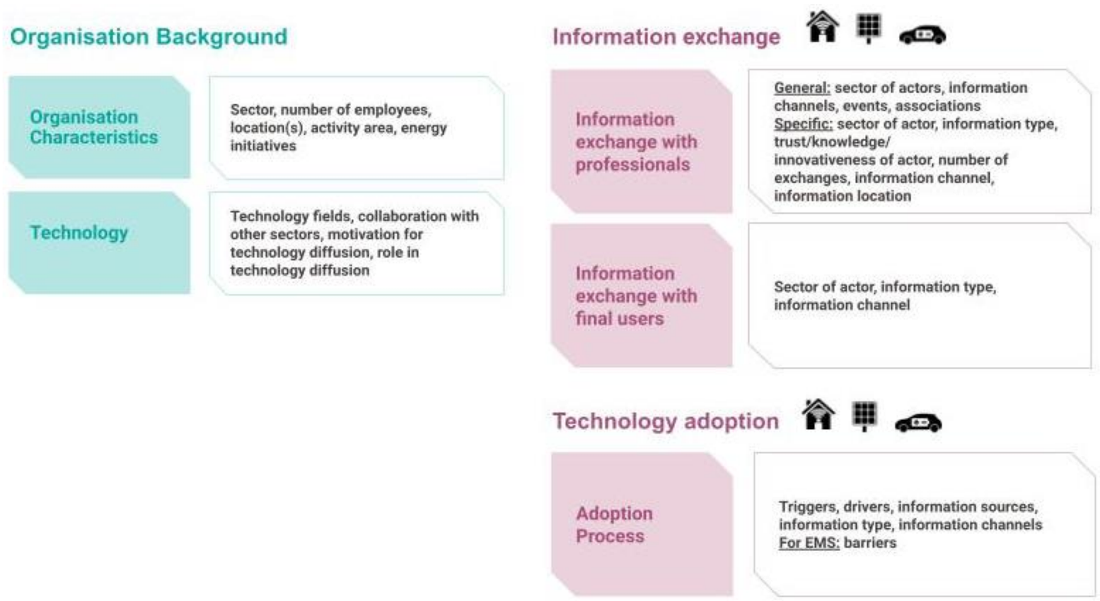

Figure 2: Supply side survey structure.

3 Activities and results

3.1 Demand side survey respondents

Table 1 shows the numbers of the survey respondents categorized by linguistic region (cantons) and technology adopter group (for our technology filtering approach please see chapter 2.1). In total, we reached 4,880 technology adopters, while 2,230 of these have an EMS (46%), 1,410 respondents are assigned to the PV adopters group (29%), and 1,240 respondents to the EV adopters group (25%). While most of the respondents are from our case study regions (in total 3,100), we also collected data from other cantons in order to make some additional comparisons.

Table 1: Distribution of sample by technology (according to filtering principles) and by linguistic region.

	German (SO + SG)	French (VD)	Italian (TI)	Total case study regions	Other cantons (BL, BS, VS, ZR)	TOTAL
EMS	560	510	270	1,340	890	**2,230 (46%)**
PV	370	410	140	920	490	**1,410 (29%)**
EV	320	350	200	770	470	**1,240 (25%)**
TOTAL	**1,250**	**1,270**	**610**	**3,100**	**1,500**	**4,880 (100%)**

In the survey, we asked the ones who did not adopt EMS, if they had considered installing an EMS. 44% had considered installing EMS and had not made a decision yet (750 potential EMS adopters), 6% rejected to install EMS (100 EMS rejectors), while 50% had never considered installing the technology (850 EMS non-adopters).

3.2 Characteristics of technology adopters

Table 2 and Table 3 show the socio-demographic characteristics and the household characteristics for EMS, PV and EV adopters compared to the Swiss population, where we can identify some significant differences. When distributing the survey, we asked the person who was mostly responsible for the technology adoption decision in the household, to fill in the survey. The socio-demographics therefore refer to the persons who mostly feel responsible for the decision to adopt the technology. The results show that the majority of these are male, they are older than the Swiss average, they are fairly educated, they have a middle to high income, and there is a higher share of working full time and retired people. Regarding household characteristics, technology adopters tend to live in single-family houses, a clear majority are owning their house, and they live in a couple with children. Compared to the Swiss population, a high share of technology adopters use heat pumps as a heating source and they have more cars.

When looking at the differences between EMS, PV and EV adopters, we see that PV adopters have lower income levels compared to EMS and EV adopters and a higher percentage of them are retired. EV adopters hold the lowest share of retirees and have slightly higher education levels than the other groups, particularly PV. Regarding housing characteristics, there is a very strong difference in terms of building type and ownership. 83% of PV adopters live in single-family housing and 90% of PV adopters own their house. The shares for EMS adopters are a bit lower, though show the same trend. However, only 50% of EV adopters live in single-family housing and only 55% are house owners. Many of them are tenants or apartment owners and they rather live in single or one-person households. Besides that, EV adopters have a lower share of heat pumps compared to EMS and PV adopters and their share of being part of an auto-consumption community is significantly lower.

Table 2: Socio-demographic characteristics for EMS, PV and EV adopters compared to the Swiss population.

SOCIO-DEMOGRAPHIC CHARACTERISTICS	EMS adopters (N=2,230)	PV adopters (N=1,410)	EV adopters (N=1,240)	Swiss population
GENDER				
Male	88%	84%	82%	50%
Female	12%	16%	18%	50%
AGE				
Age in years (mean)	56	60	51	43
LEVEL OF EDUCATION				
Compulsory school	1%	1%	1%	16%
Secondary level professional	37%	40%	34%	32%
Secondary level general	4%	5%	5%	13%
Higher vocational education	11%	10%	11%	14%
University	45%	42%	48%	25%
INCOME				
Up to CHF 5,000	4%	7%	4%	49%
CHF 5,001 to CHF 7,000	11%	15%	12%	27%
CHF 7,001 to CHF 9,000	17%	22%	18%	12%
CHF 9,001 to CHF 13,000	28%	28%	29%	8%
Above CHF 13,000	26%	17%	28%	4%
EMPLOYMENT STATUS				
Employed	69%	58%	80%	59%
Family work	2%	1%	1%	4%
Undergoing training	0%	0%	0%	3%
Unemployed	1%	1%	1%	3%
Retired	26%	38%	16%	23%
Others	2%	2%	2%	8%

Table 3: Household characteristics for EMS, PV and EV adopters compared to the Swiss population.

HOUSEHOLD CHARACTERISTICS	EMS adopters (N=2,230)	PV adopters (N=1,410)	EV adopters (N=1,240)	Swiss population
BUILDING TYPE				
Single-family housing	79%	83%	55%	57%
Multi-family housing	19%	14%	43%	28%
Other	2%	3%	2%	16%
OWNERSHIP				
Condominium / apartment owner or co-owner	10%	9%	21%	12%
Cooperative member	0%	0%	1%	3%
House owner or co-owner	87%	90%	50%	24%

HOUSEHOLD CHARACTERISTICS	EMS adopters (N=2,230)	PV adopters (N=1,410)	EV adopters (N=1,240)	Swiss population
Tenant or sub-tenant	2%	1%	27%	58%
Other	0%	1%	1%	3%
HOUSEHOLD COMPOSITION				
Couple with children	52%	49%	48%	27%
Couple without children	34%	36%	33%	27%
Extended family (several generations)	3%	3%	2%	1%
Non-family shared household	1%	1%	2%	2%
Single parent with children	2%	2%	2%	6%
Single- or one-person household	6%	6%	12%	36%
Other	2%	3%	1%	0%
HEATING ENERGY SOURCE				
Electricity	12%	12%	8%	31%
Fuel oil	12%	17%	25%	30%
Heat pump	54%	47%	29%	12%
Gas	10%	12%	21%	15%
Solar collector	2%	1%	1%	3%
Wood	6%	8%	5%	5%
Other	1%	1%	1%	1%
NUMBER OF CARS	1.9	1.8	1.8	0.58
PART OF AUTO-CONSUMPTION COMMUNITY	30%	23%	8%	-

3.3 Technology co-adoption

Technology co-adoption refers to the situation in which users adopt more than one technology, either at the same time or within a fairly short time period. And, the decision to adopt one technology is connected to the other. Our survey results show that 60% of the PV owners and 50% of the EV owners also have EMS. 63% of PV adopters also have EV while 71% of EV owners also have PV. From those only having PV and EV, excluding the EMS owners, 77% adopted PV first.

For EMS adopters, we asked about how much having another energy technology impacted the decision to adopt EMS. Table 4 shows that PV is the biggest driver for EMS adoption, followed by EV and hot water boilers with about the same levels of impact. Heat pumps and battery storage have the lowest impact on the adoption of EMS.

Table 4: Impact of other technologies to invest in EMS (N=2,230). Answers to the survey question “How much having another technology impacted your decision to adopt EMS?”.

	I do not have an EMS	No and rather low impact	Rather high and very high impact	Total
PV	6%	7%	87%	100%
EV	32%	13%	54%	100%
Heat pump	32%	22%	46%	100%
Battery storage	56%	9%	35%	100%
Boiler for hot water	17%	29%	54%	100%

3.4 Drivers and barriers for technology adoption

The survey respondents assessed a set of factors which influenced the decision to adopt their respective technology. The factors can be categorized into the respondents' attitude, perceived behavioral control, contextual factors and social norm. Table 4 shows the drivers for EMS, PV and EV adopters and how much each of them influenced the adoption decision.

For EMS adopters, the results show that non-economic attitudinal factors about the technology mostly influence the adoption decision. EMS adopters want to promote renewable energy, they want to optimize their energy self-consumption, they want to be energy independent and they like to use innovative technologies. Second, the perceived ease or difficulty to apply the technology has a high impact on their decision. A bit lower, but still influential are the contextual factors such as the respondents` financial situation, their building infrastructure, the support by professionals, and lastly the regulatory framework. The least impact on the adoption of EMS have the factors related to the respondents` social norm, i.e. recommendations from others and the influence from their perceived social environment.

When looking at the drivers for PV adoption, we observe a similar pattern with the non-economic attitudinal factors mostly impacting their decision, followed by the perceived behavioral control and contextual factors. Also here, the attitude about the economic performance of PV and factors related to the respondents' social norm has a relatively low impact.

For EV adopters, we observe a slightly different picture. Using new and innovative technologies as well as promoting renewable energy are the most impactful drivers for EV adoption, followed by the perceived behavioral control factors. The respondents state that feeling capable of applying the technology and having access to sufficient information have a high impact on their decision. The economic attitudinal factors have about the same impact as the contextual factors, whereas the benefit from the legal framework and the support by professionals during the decision and implementation phase have a lower impact compared to EMS and PV. Also here, the factors related to social norms have a rather low impact on the decision, with the recommendations from neighbors and professionals being even lower than for EMS and PV.

Table 5: Impact of factors when adopting EMS, PV and EV (0 = no impact; 3 = very high impact; don`t know excluded; Sig. = testing for significant differences with Chi-square test of independence for sample groups).

DRIVERS	EMS adopters (N=2,230)	PV adopters (N=1,410)	EV adopters (N=1,240)	Sig.
ATTITUDE				
I believed the technology was financially attractive for me	1.65	1.48	1.75	Yes
I expected my electricity or fuel costs to increase in the future	1.62	1.39	1.43	Yes
I wanted to promote environmentally friendly renewable energies	2.57	2.58	2.36	Yes
I wanted to become more energy independent	2.31	2.13	1.52	Yes
I wanted to optimize my energy (self-)consumption	2.51	2.32	1.91	Yes
I liked using a new or innovative technology	2.16	1.98	2.37	Yes
PERCEIVED BEHAVIORAL CONTROL				
I felt capable of applying the technology appropriately	2.15	2.00	2.16	Yes
I had access to sufficient information on the technology	2.09	2.04	2.08	Yes
CONTEXT				
I benefited from a regulatory framework that facilitated to implement the technology	1.35	1.34	0.75	Yes
I had favorable infrastructural framework conditions to implement the technology	1.86	1.86	1.44	Yes
I had a favorable financial situation that facilitates to implement the technology	1.92	1.93	1.68	Yes

DRIVERS	EMS adopters (N=2,230)	PV adopters (N=1,410)	EV adopters (N=1,240)	Sig.
I was supported by professionals during the decision or implementation phase	1.75	1.75	0.77	Yes
SOCIAL NORM				
Someone from my personal network recommended that I should be using the technology	0.82	0.75	0.75	Yes
A neighbor recommended that I should be using the technology	0.39	0.38	0.25	Yes
A professional recommended that I should be using the technology	0.92	0.84	0.45	Yes
I saw an increasing number of people implementing the technology around me	0.78	0.76	0.81	Yes

Table 6 shows the results for potential EMS adopters and EMS rejectors, compared with the results for EMS adopters we already discussed above. When asking the ones who are considering installing EMS about which factors would influence their decision to adopt EMS, we observe about the same patterns as for EMS adopters. However, and most interestingly, the factors related to the respondents` social norm are evaluated to be much more impactful, especially the recommendations from their personal network and from professionals). When asking the ones who rejected to install EMS about which factors prevented them to adopt EMS, the statement that it was financially not attractive to them was evaluated to be the most impactful. All the other factors seem to have a very low impact in their decision not to adopt EMS, but mostly contextual factors, like the infrastructural framework conditions and their financial means to implement the technology.

Table 6: Impact of factors for potential EMS adopters and impact of barriers for EMS rejectors (0 = no impact; 3 = very high impact; don`t know excluded; Sig. = testing for significant differences with Chi-square test of independence for sample groups).

DRIVERS and BARRIERS *(in brackets)*	Potential EMS adopters (N=750)	EMS rejectors (N=100)	EMS adopters (N=2,230)	Sig.
ATTITUDE				
I believe*(d)* the technology is financially *(not)* attractive for me	1.56	1.63	1.65	No
I expect my electricity or fuel costs to increase in the future	1.67	-	1.62	Yes
I want to promote environmentally friendly renewable energies	1.91	-	2.57	No
I want to become more energy independent	1.92	-	2.31	Yes
I want to optimize my energy (self-)consumption	1.94	-	2.51	Yes
I like *(tended to hesitate)* to use a new or innovative technology	1.82	1.12	2.16	No
PERCEIVED BEHAVIORAL CONTROL				
I feel *(did not feel)* capable of applying the technology appropriately	1.82	1.20	2.15	No
I *(did not)* have access to sufficient information on the technology	1.70	1.09	2.09	No
CONTEXT				
I benefit from a regulatory framework that facilitates *(The regulatory framework hindered me)* to implement the technology	1.46	1.19	1.35	Yes
I have favorable *(had unfavorable)* infrastructural framework conditions to implement the technology	1.68	1.40	1.86	Yes
I have a favorable financial situation that facilitates *(I did not have the appropriate financial means)* to implement the technology	1.66	1.35	1.92	No
I am supported *(was lacking support)* by professionals during the decision or implementation phase	1.63	1.11	1.75	Yes
SOCIAL NORM				
Someone from my personal network recommends *(discouraged me)* that I should	1.53	1.07	0.82	No

DRIVERS and BARRIERS *(in brackets)*	**Potential EMS adopters (N=750)**	**EMS rejectors (N=100)**	**EMS adopters (N=2,230)**	**Sig.**
be using the technology				
A neighbor recommends *(discouraged me)* that I should be using the technology	1.26	1.02	0.39	Yes
A professional recommends *(discouraged me)* that I should be using the technology	1.60	1.16	0.92	Yes
I would see an increasing number of people implementing the technology around me	1.35	-	0.78	No

3.5 Information and proximity

This section gives an overview of the information sources, information channels as well as the type of information that was useful for technology adopters in their decision making process. Further, it gives some preliminary insights into proximity effects. Table 7 shows that technology adopters mostly rely on energy technology providers, which are the suppliers and the installers of the specific technology. Also, they rely on energy or e-mobility service companies, energy utility entities, as well as public and non-profit organizations. When it comes to their personal network, technology adopters mostly exchange with their partner (i.e. persons living in their household), friends, work colleagues and acquaintances, and not so much with their neighbors as it is often stated. When comparing across the 3 technologies, we can observe that energy service companies and energy utility entities have a higher importance for EMS adopters, than they have for PV and EV adopters. And, EV adopters tend to exchange much less information with their neighbors than EMS and PV adopters do (although the exchange with neighbors is generally on a low level).

Table 7: Used information sources for EMS, PV and EV adopters (multiple choice; percentage of adopters who used the source; Sig. = testing for significant differences with Chi-square test of independence for sample groups).

INFORMATION SOURCES	**EMS adopters (N=2,230)**	**PV adopters (N=1,410)**	**EV adopters (N=1,240)**	**Sig.**
PROFESSIONAL				
Energy technology providers	76%	73%	58%	Yes
Energy or e-mobility service companies	33%	23%	25%	Yes
Energy utility entities	28%	23%	17%	Yes
Construction sector	17%	17%	6%	Yes
Public and non-profit entities	24%	26%	14%	Yes
Associations	8%	9%	7%	No
Academia	13%	9%	10%	No
Private funding companies or insurances	4%	3%	3%	No
PERSONAL NETWORK				
Person(s) living in my household	30%	33%	31%	No
Other family member(s) or relative(s)	20%	19%	17%	Yes
Friend(s)	21%	20%	25%	No
Neighbor(s)	12%	12%	6%	Yes
Work or study colleague(s)	26%	19%	25%	No
Acquaintance(s)	23%	25%	18%	No

Table 8 shows the information channels technology adopters mostly use. Overall, interpersonal face-to-face contact and the internet act as key information channels across all technologies. Technology adopters also actively seek information through media (TV, newspapers, magazines etc.). When comparing between the technologies, we see that EV adopters tendentially use less internet websites with information about subsidies or legal regulations, inform themselves less at events, however use significantly more social media channels.

Table 8: Used information channels for EMS, PV and EV adopters (multiple choice; percentage of adopters who used the channel; Sig. = testing for significant differences with Chi-square test of independence for sample groups).

INFORMATION CHANNELS	**EMS adopters (N=2,230)**	**PV adopters (N=1,410)**	**EV adopters (N=1,240)**	**Sig.**
Media	29%	34%	38%	No
Internet websites with information on the technology	75%	66%	77%	No
Internet websites with information on subsidies or legal regulations	51%	47%	36%	Yes
Mailings	5%	5%	3%	No
Digital newsletters	8%	7%	8%	No
Events	14%	14%	6%	Yes
Social media	9%	5%	22%	Yes
Interpersonal face-to-face contact	56%	56%	42%	Yes
Interpersonal digital contact	18%	12%	11%	Yes
Communities or projects related to the technology	15%	12%	9%	No

Regarding the type of information (Table 9), knowing about general characteristics and functionality of the technology, strives out to be important for all technology adopters. Also, information about financial support as well as the benefits and risks of implementing the technology are useful. However, we can observe significant differences, mostly related to EV adopters. Information about financial support and investment strategies are significantly less important than for EMS and PV adopters. On the other hand, success or failure stories of others who adopted EV are of higher importance.

Table 9: Type of information which was useful for EMS, PV and EV adopters (multiple choice; percentage of adopters who used the type; Sig. = testing for significant differences with Chi-square test of independence for sample groups).

INFORMATION TYPES	**EMS adopters (N=2,230)**	**PV adopters (N=1,410)**	**EV adopters (N=1,240)**	**Sig.**
General characteristics and functionality of the technology	64%	62%	73%	Yes
Specific ways to implement, use or maintain the technology	35%	26%	28%	Yes
Financial aid	48%	53%	21%	Yes
Investment possibilities	30%	32%	9%	Yes
Benefits and risks of implementing the technology	37%	32%	43%	Yes
Success or failure story of someone who adopted the technology	19%	17%	27%	Yes
General characteristics and functionality of the technology	4%	3%	6%	Yes

Regarding spatial proximity, two preliminary observations can be made. Firstly, we can see how owners of the 3 technologies are not equally distributed across Swiss territory (Figure 3). There is a higher concentration of EV owners in urban areas, PV owners in rural areas, while EMS owners have a mixed distribution. Secondly, there are also differences between where respondents live and where they exchange information about the technology, be it with professionals or personal contacts (Figure 4). In this case, the differences are not visible at the national scale but at the municipality level, where we can see how there is a higher concentration of exchanges in city centers while the home location hotspots are more dispersed. This trend is visible not only in Lausanne but also in other major cities (such as Lugano, Zurich, Solothurn or St. Gallen).

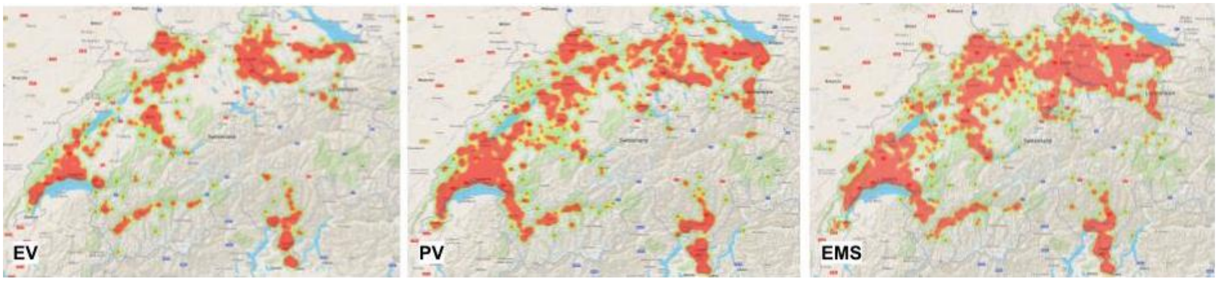

Figure 3: Heatmap of respondents' home location in Switzerland based on the technology they adopted. Source: Maptionnaire.

Figure 4: Heatmap of respondents' home location in Lausanne, VD and the location where they exchanged with professionals and personal contacts. Source: Maptionnaire.

4 Discussion of results to date

This report mainly focuses on the survey results of 4,880 technology adopters who either adopted EMS, PV and/or EV. With the support of the SFOE and FEDRO, we contacted 30,000 PV and EV owners in Switzerland, mainly focusing on our case study regions (SO, SG, VD and TI). Therefore, we could achieve a fairly high response rate with 16%. Among the respondents, 46% have an EMS installed in their home. The survey serves us to answer the following questions:

- How are technology adopters characterized compared to the Swiss population?
- Which technologies are co-adopted in Swiss households and how much potential do we still have for EMS?
- What are the drivers and barriers for the adoption of EMS, PV and EV?
- Through which actors and channels should information be spread to foster the diffusion of energy technologies in Switzerland?

The results show that in Swiss households, mostly men feel responsible for the technology adoption decision as above 80% of the respondents were male. They are between 50-60 years old and therefore older than the Swiss average, they are well educated, they have a middle to high income, and they are working full time (especially EV) or are retired (especially EMS and PV). Clearly, there are also cases where the technology adoption decision in the household was taken collaboratively, however, due to the survey design, we do not have more information on the persons who were as well involved in the decision process. About 80% to 90% of the EMS and PV adopters live in single-family housing and own their house, while this percentage is significantly lower for EV adopters (about 50%) who are rather tenants or apartment owners of single- or multi-family housing. These results show that creating favorable framework conditions to foster PV and EMS for apartment owners in multi-family housing holds untapped potential.

In terms of technology co-adoption, there is still significant potential for PV and EV owners to integrate EMS in their systems with about 50% who do not yet have an EMS installed. Also, PV is shown to be the key technology driving EMS adoption, while EV amplifies this trend. Efforts to further expand and support PV installations for Swiss households as well as targeted information for PV and EV owners about the advantages of integrating technologies, managing and optimizing their energy consumption, seems to be very promising.

The results show that the most important drivers for EMS, PV and EV adoption are the attitudes about ecological and efficiency characteristics of the respective technology, and the perceived ease or difficulty to apply it. EMS and PV adopters particularly want to promote renewable energy, optimize their energy consumption and be independent, while EV adopters want to use an innovative technology. Secondly, we observe that potential EMS adopters are influenced by others, especially by people from their personal network and professionals. And thirdly, we see that EMS are mostly rejected due to financial reasons and because of unfavorable infrastructural conditions. Potential EMS adopters might therefore be most effectively convinced by information about their contribution to the energy transition when installing EMS, ideally from people they trust. The ones who currently reject EMS, however, might need financial incentives.

When looking at the actors who are key for spreading information, the results show that the ones who provide and install the technologies, energy service companies as well as energy suppliers are the most relevant, while the influence of the personal network as an information source should not be underestimated. Technology adopters particularly rely on the internet and interpersonal face-to-face exchanges in urban areas, and are mostly interested about the general characteristics and functionality of the technology. There are several take-aways from this. Firstly, there is an opportunity to take advantage of the reliance on close contacts, e.g. through providing information and training to energy technology suppliers to exploit their potential as change agents. A second aspect would be to consider how to integrate personal information exchanges and peer effects in diffusion strategies, e.g. to work closer with the community through neighborhood organizations or associations. Thirdly, public institutions could use the internet as a platform to deliver concise information that addresses the aspects relevant for potential adopters. And lastly, information campaigns in urban areas might reach more people than individual household-based approaches.

Policy recommendations to foster the diffusion of EMS

1. Create favorable framework conditions to foster PV and EMS for apartment owners in multi-family housing.
2. Further expand and support PV installations and inform PV and EV owners about advantages of EMS.
3. Potential EMS adopters and EMS rejectors need to be addressed differently: Potential adopters need information about their contribution to the energy transition; rejectors need financial support.
4. Personal contact and the internet are the most important channels for reaching potential EMS adopters; information is most effectively received through experts and the personal network.

5 Next steps

Our immediate next steps are two main tasks that will happen in parallel. On the one side, we will implement and release the supply side survey (see chapter 2.2). This includes the translation of the survey questions, the pre-release and the release in January 2023. On the other side, we will continue the in-depth analysis of the demand side survey results. This includes creating the actors' clusters, categorizing the nodes of the network, identifying the connections between actors, the links of the network and situating it in the geographic context (WP2). Once having collected the data from the supply side survey, we will conduct the spatial network analysis (WP3). In this way, we will be able to connect the two sides of the network and use the different analysis results to build a comprehensive network and understand the information flows. The preliminary results of the network analysis will be presented and validated in a project workshop with experts, also supporting the derivation of policy implications.

6 Communication

In order to disseminate the project, we created a second project booklet in February 2022 providing the key results derived from the 26 guided interviews with key actors on the supply side of EMS (i.e. energy utility companies, energy technology providers, academia, consultancy and advocacy) and with various types of residential adopters (e.g. home owners, condominium owners, auto-consumption communities) in the 3 linguistic areas in Switzerland (download booklet). The booklet was distributed across our regional partners and all interview partners. In cooperation with our project partner Energie Zukunft Schweiz, we published an article about EMS in the bulletin.ch magazine in April 2022. A representative of Energie Zukunft Schweiz presented the project in November at the Solar-Update 2022. In November 2022 we organized an event in Zurich to present the preliminary results of the demand side survey to about 50 survey respondents. For the French speaking audience, a second event is going to take place in Lausanne in December 2022. For the scientific community, we presented one poster at the International Conference of Energy Research and Social Science in Manchester in June 2022 showcasing the main results of the guided interviews, and a second one at the Urban Transitions Global Summit in Barcelona in November 2022.

7 References

Bernards, R., Morren, J., & Slootweg, H. (2018). Development and Implementation of Statistical Models for Estimating Diversified Adoption of Energy Transition Technologies. IEEE Transactions on Sustainable Energy, 9(4), 1540–1554. https://doi.org/10.1109/TSTE.2018.2794579

Federal Council of Switzerland (2019). Federal Council aims for a climate neutral Switzerland by 2050. Press releases by the Federal Council. https://www.admin.ch/gov/en/start/documentation/media-releases.msg-id-76206.html

Mundaca, L., & Samahita, M. (2020). What drives home solar PV uptake? Subsidies, peer effects and visibility in Sweden. Energy Research & Social Science, 60, 101319. https://doi.org/10.1016/j.erss.2019.101319

Noll, D., Dawes, C., & Rai, V. (2014). Solar Community Organizations and active peer effects in the adoption of residential PV. Energy Policy, 67, 330–343. https://doi.org/10.1016/j.enpol.2013.12.050

Palm, A. (2017). Peer effects in residential solar photovoltaics adoption - A mixed methods study of Swedish users. Energy Research & Social Science, 26, 1–10. https://doi.org/10.1016/j.erss.2017.01.008

Rai, Varun; Reeves, Cale; Margolis, Robert (2015). Overcoming barriers and uncertainties in the adoption of residential solar PV. Renewable Energy. http://dx.doi. org/10.1016/j.renene.2015.11.080

Rogers, Everett M. (1995). Diffusion of Innovations. Free Press; 4th edition (February 1, 1995).

Tagliapietra S, Zachmann G, Edenhofer O, Glachant J-M, Linares P, Loeschel A. (2019). The European Union energy transition: Key priorities for the next five years. Energy Policy 2019; 132:950-4. https://doi.org/10.1016/j.enpol.2019.06.060.