Wunsiedel study: Insights Summary Report

VTT Design X GLocalFlex

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GLocalFlex

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Content

This document contains an extended report of insights gathered through the field trip to the GLocalFlex pilot site in Wunsiedel, Germany.

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List of abbreviations

CHP: Combined Heat and Power

EMS: Energy Management System

EV: Electric Vehicle

LLC: Limited Liability Company

PV: Photovoltaic

RES: Renewable Energy Source

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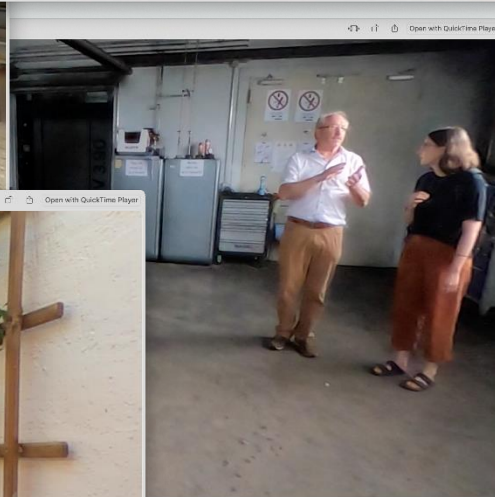
Wunsiedel and Schönbrunn, Germany

- **4 days** field trip (18 Jun 23 – 22 Jun 23)

- **Visits** to local facilities (Energy park, CHP plant, SWW Wunsiedel – local energy provider)

- **12 interviews** with local participants and stakeholders

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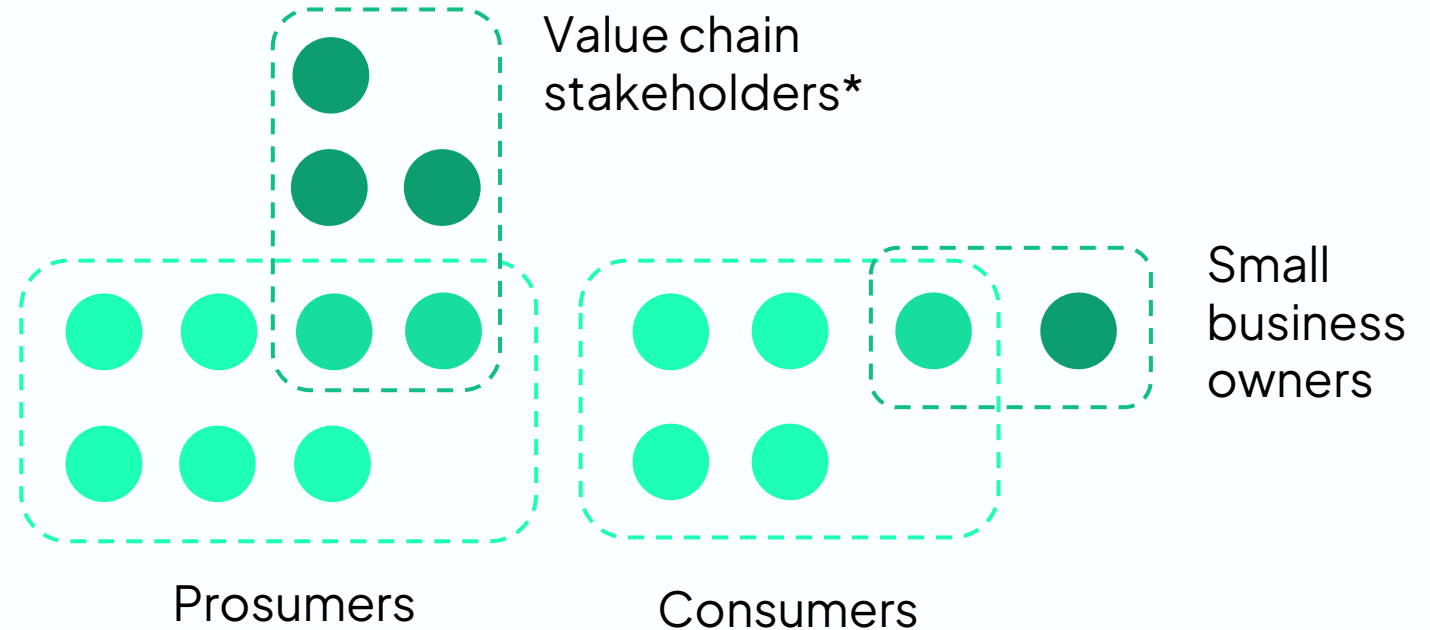the European Union
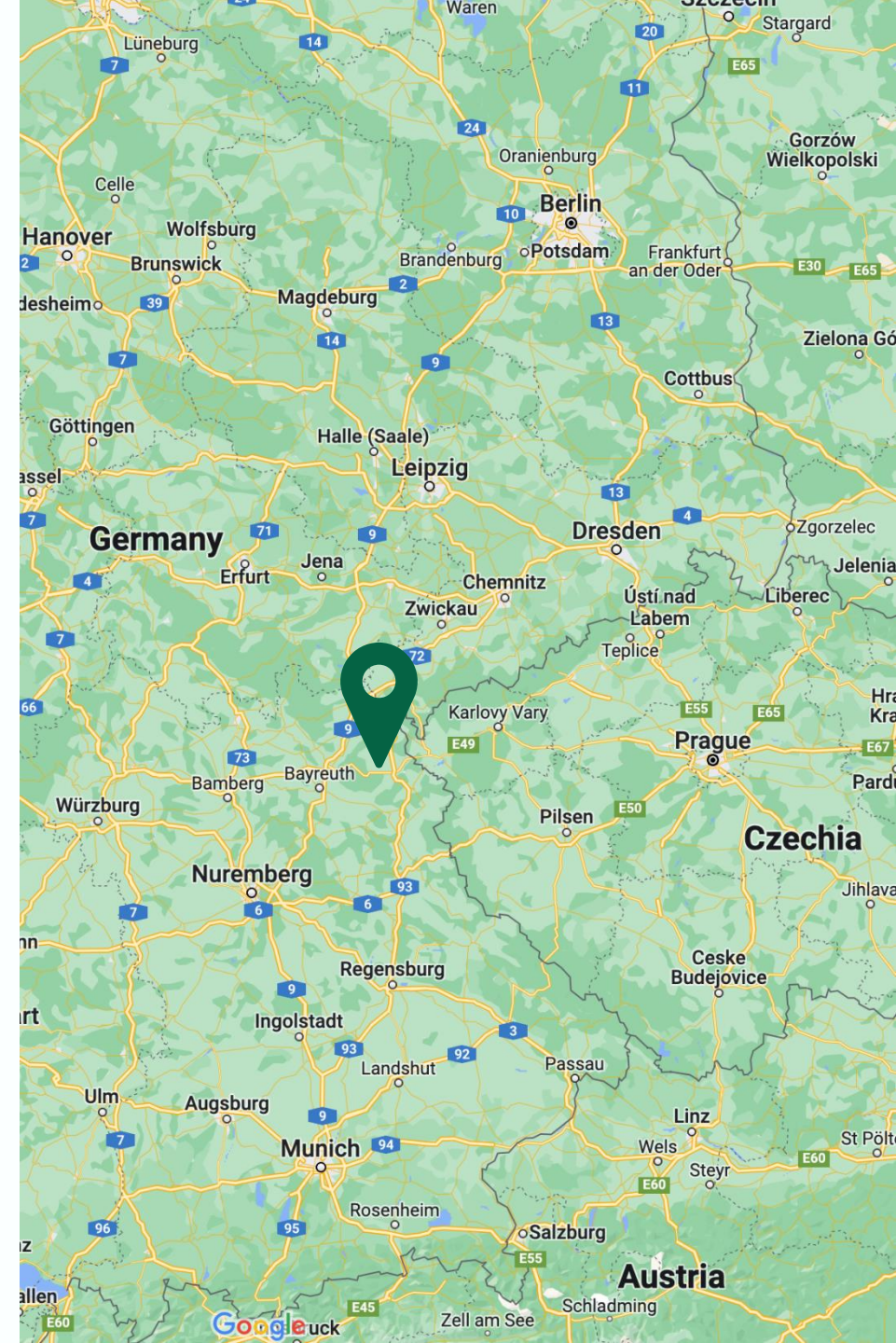
Introduction

Interview participants
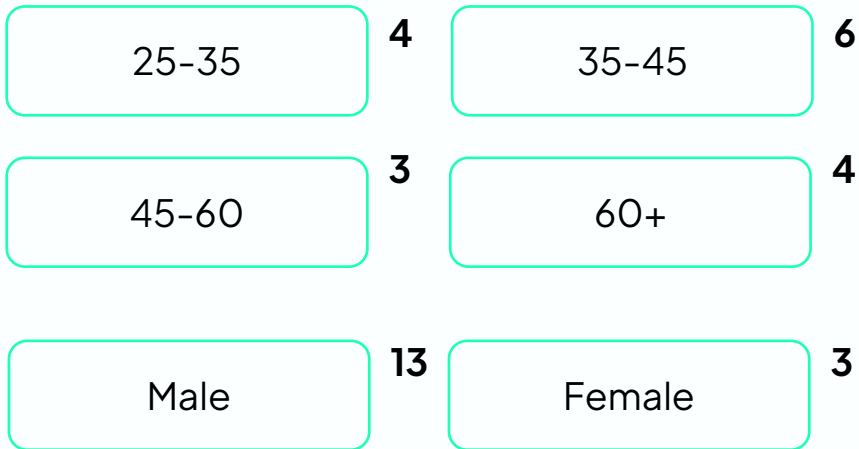
16 participants
12 interviews
1 group interview

Interviewees were gathered by SWW representatives, who were our point of contact in Wunsiedel and are the pilot owners. The interviewees represent a variety of consumer and prosumers types, as well as actors across the value chain.

It's important to note that, in part due to the gathering method, participants were generally positive towards the topics at hand.

Value chain stakeholders*

Small business owners

Prosumers

Consumers

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*energy production, grid operation, municipality

Interview participants

Demographics

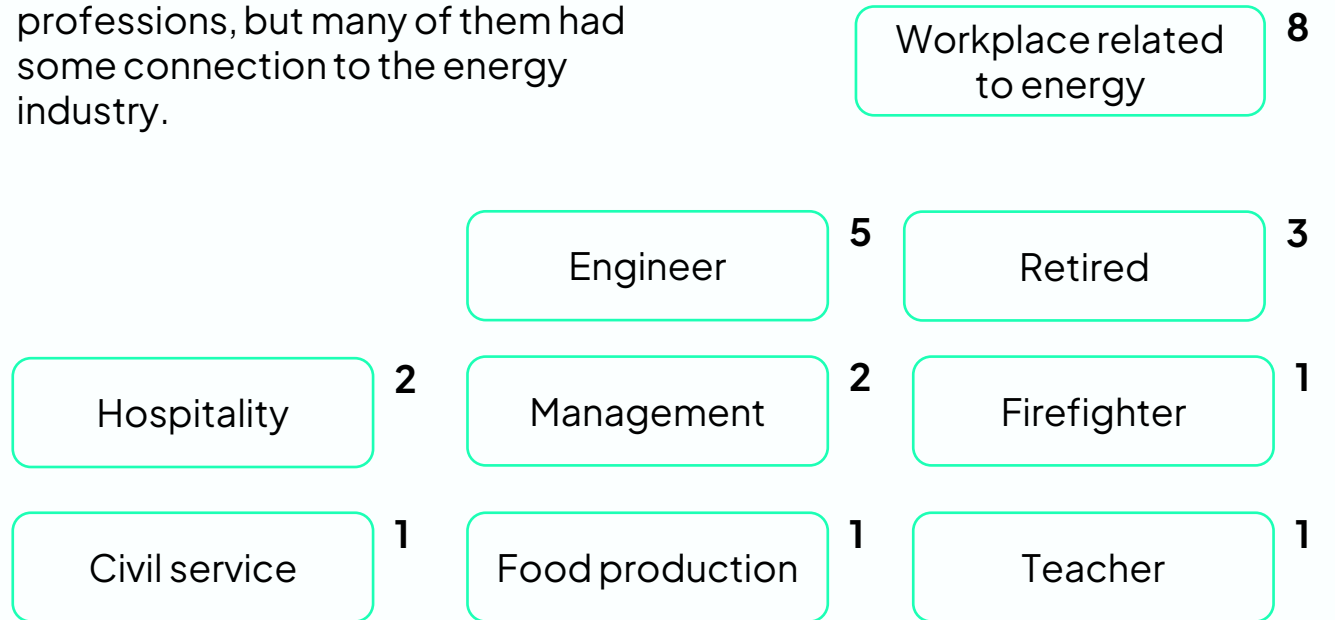|			
25-35	**4**	35-45	**6**
45-60	**3**	60+	**4**
Male	**13**	Female	**3**

There was a wide age diversity among the participants, however they were predominantly male.

Background

The participants came from various professions, but many of them had some connection to the energy industry.

Workplace related to energy	**8**

Engineer	**5**	Retired	**3**		
Hospitality	**2**	Management	**2**	Firefighter	**1**
Civil service	**1**	Food production	**1**	Teacher	**1**

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Interview participants

Home situation

| Rental apartment | 3 | Rental house | 1 |

| Own house | 9 | * 3 no data |

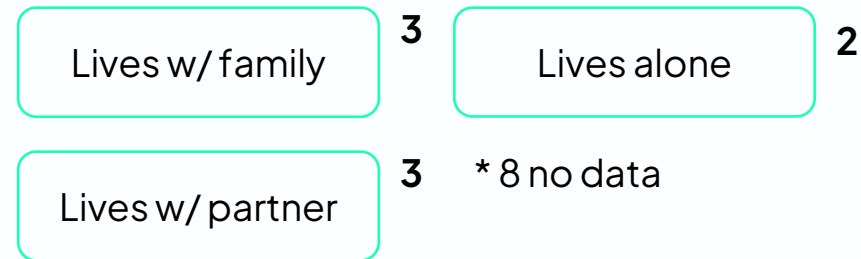| Historically protected building | 2 |
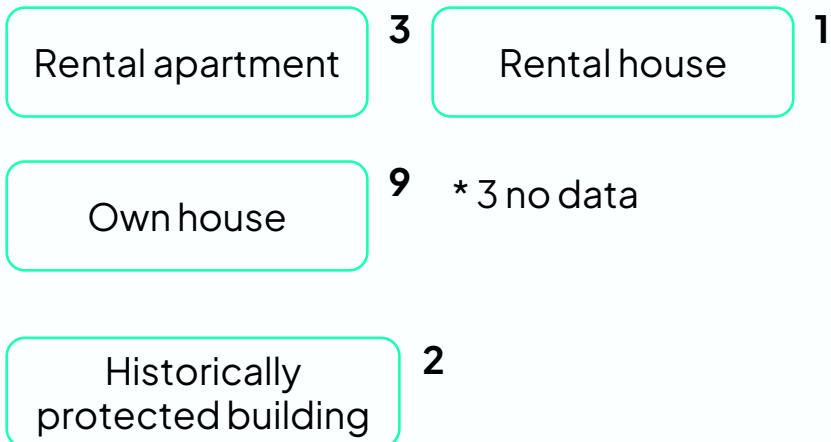
Most participants owned their houses, except for a few who rented. Two of homes were also subject to historical building preservation.

Living situation

| Lives w/ family | 3 | Lives alone | 2 |

| Lives w/ partner | 3 | * 8 no data |

There was no clear trend in living situations of the participants who shared their circumstances, all having different living arrangements.

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Interview content:
Consumers, prosumers, business owners

Context

– Who are they as a person?

– What is their living/working situation?

– Who are their stakeholders (family, employers/employees, etc.)?

Energy attitudes

– How important is energy for them and why?

– How engaged are they? Are they aware of their consumption, do they monitor it?

– What are their objectives and motivations?
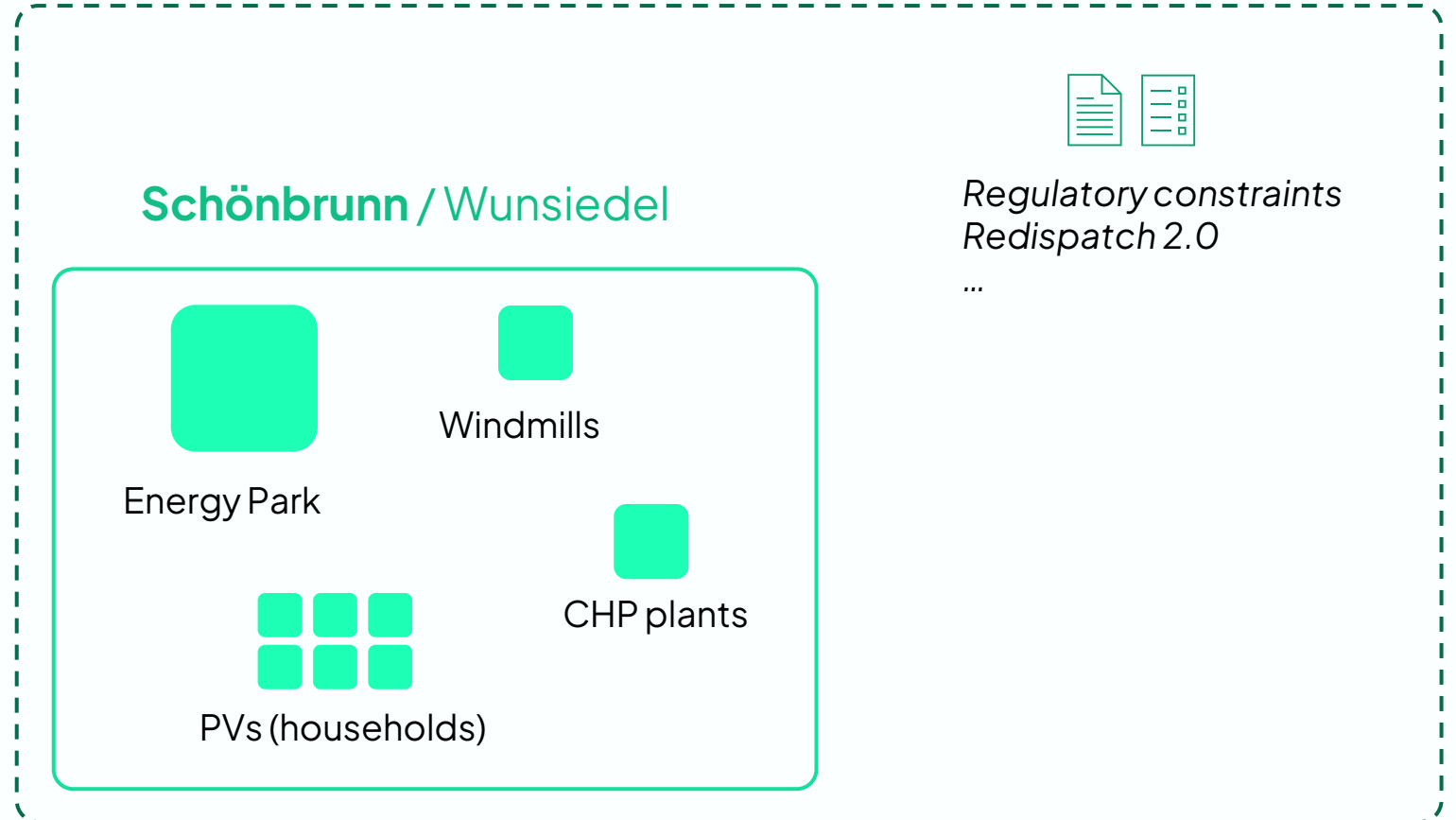
Energy systems & behaviour

– What systems or assets do they have?

– How do they use them?

– What are the perceived benefits and challenges?

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Interview content:
Value chain stakeholders

Larger contextual picture

- How is energy produced and distributed in Wunsiedel?

- What are the challenges?

- What are the goals?

Germany

Schönbrunn / Wunsiedel

Energy Park

Windmills

CHP plants

PVs (households)

*Regulatory constraints
Redispatch 2.0
…*

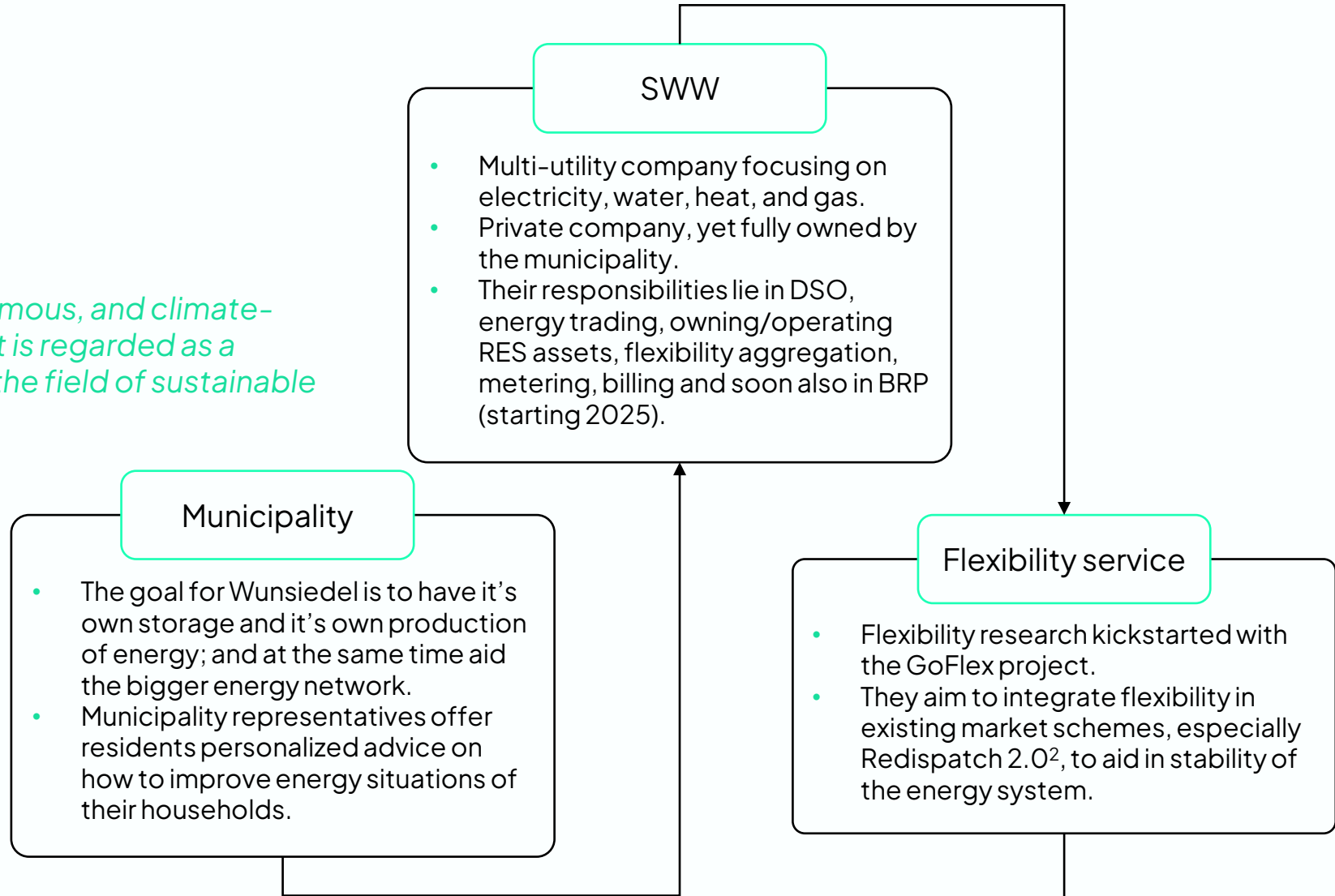GLocalFlex · Funded by the European Union

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Stakeholder insights
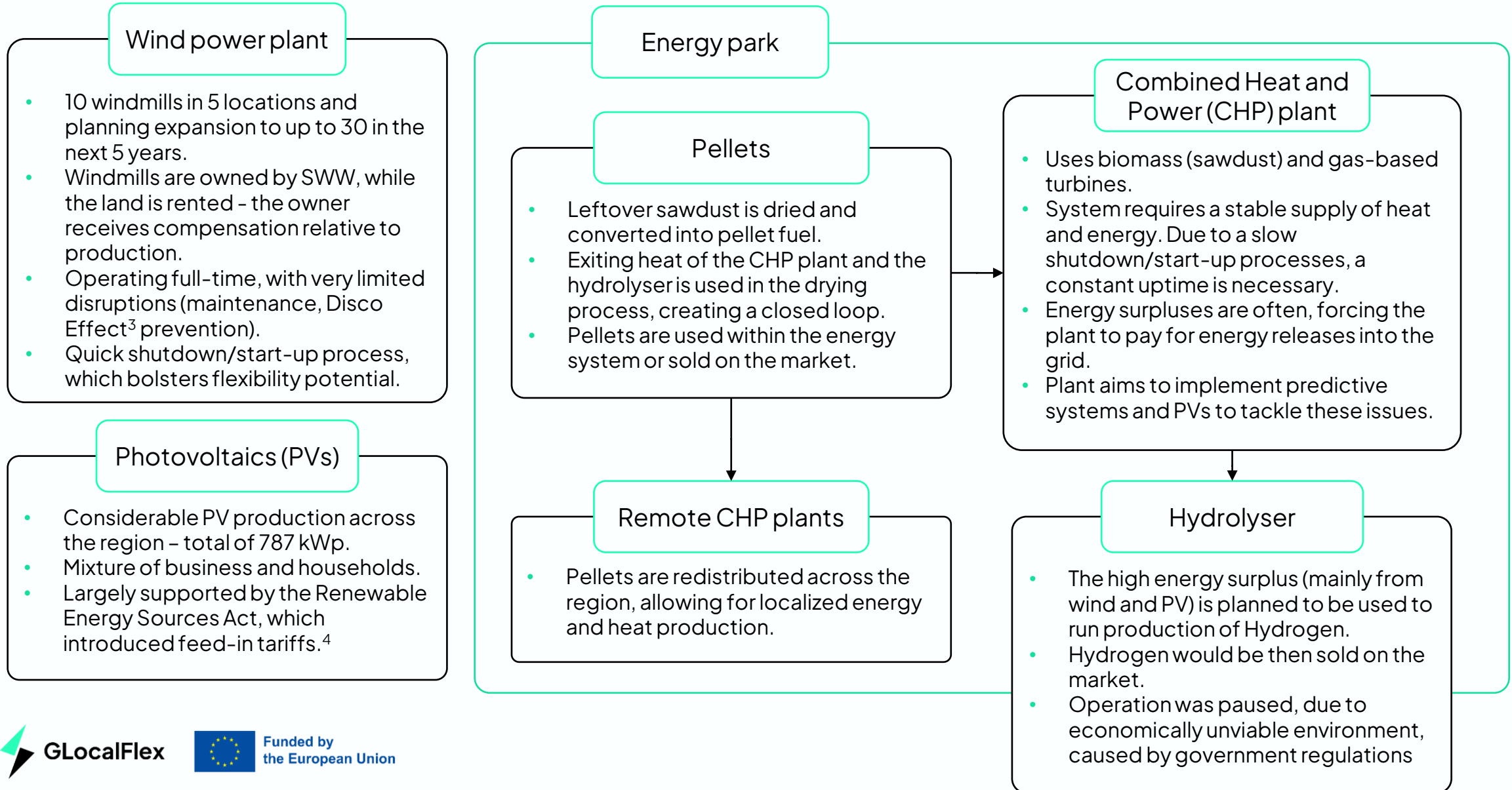
Energy system

System value chain

"The decentralized, autonomous, and climate-friendly Wunsiedel concept is regarded as a German pioneer project in the field of sustainable energy generation."

– MWM Energy Blog[1]

SWW

- Multi-utility company focusing on electricity, water, heat, and gas.
- Private company, yet fully owned by the municipality.
- Their responsibilities lie in DSO, energy trading, owning/operating RES assets, flexibility aggregation, metering, billing and soon also in BRP (starting 2025).

Municipality

- The goal for Wunsiedel is to have it's own storage and it's own production of energy; and at the same time aid the bigger energy network.
- Municipality representatives offer residents personalized advice on how to improve energy situations of their households.

Flexibility service

- Flexibility research kickstarted with the GoFlex project.
- They aim to integrate flexibility in existing market schemes, especially Redispatch 2.0[2], to aid in stability of the energy system.

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Grid balancing service

Energy park

Wind power plant

- 10 windmills in 5 locations and planning expansion to up to 30 in the next 5 years.
- Windmills are owned by SWW, while the land is rented – the owner receives compensation relative to production.
- Operating full-time, with very limited disruptions (maintenance, Disco Effect[3] prevention).
- Quick shutdown/start-up process, which bolsters flexibility potential.

Photovoltaics (PVs)

- Considerable PV production across the region – total of 787 kWp.
- Mixture of business and households.
- Largely supported by the Renewable Energy Sources Act, which introduced feed-in tariffs.[4]

Pellets

- Leftover sawdust is dried and converted into pellet fuel.
- Exiting heat of the CHP plant and the hydrolyser is used in the drying process, creating a closed loop.
- Pellets are used within the energy system or sold on the market.

Remote CHP plants

- Pellets are redistributed across the region, allowing for localized energy and heat production.

Combined Heat and Power (CHP) plant

- Uses biomass (sawdust) and gas-based turbines.
- System requires a stable supply of heat and energy. Due to a slow shutdown/start-up processes, a constant uptime is necessary.
- Energy surpluses are often, forcing the plant to pay for energy releases into the grid.
- Plant aims to implement predictive systems and PVs to tackle these issues.

Hydrolyser

- The high energy surplus (mainly from wind and PV) is planned to be used to run production of Hydrogen.
- Hydrogen would be then sold on the market.
- Operation was paused, due to economically unviable environment, caused by government regulations

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SWW Wunsiedel GmbH

A brand with heritage

The beggings of SWW lie in 1995, when the municipality decided to not switch to the regional Bavarian energy grid, but keep maintaning their locally owned grid. Based on their assestment, they saw potential in harnessing wind, sun and biomass.

Soon after, they've built the first windmills and a CHP plant that used residual woodchips as fuel. They've also started a PV program, where they implemented PV's on roofs of public buildings and invited private shareholders to invest in the developments. In 2001 SWW was turned into an LLC.

In recent years they've begun more actively involving citizens through R&D projects to steer the growing abundance of RES assets. Most prominent was the GoFlex project where 40 consumers actively joined the project and participated in workshops.

The trust in „stadtwerk"

"When we invite customers as a 'stadtwerk', people listen."

The SWW's municipal leadership have throughout the years actively promoted the company as a trusted municipal brand, assuring it's customers that everything they 'put-in' they will eventually recieve back.

Currently SWW issues a querterly customer newspaper, where they cover recent achievemtns and future plans. They're actively present on social media, have an informative website and maintain an easily accessible physicall helpdesk at their offices. Additionally, the company reguraly appears in the city issued newspaper and sponsors various events and municipally beneficial projects.

„There are 20% not willing to understand, 20% that want to squeeze out the prices, but the majority is really on the right track of the people."

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Energy system

Flexibility – SWW's concept

Based on their insights, SWW proposes the following flexibility service concept.

The customer signs a contract with SWW (as grid an operator, intermediator and trading enabler). SWW gets permanent allowance to steer customer's assets, but customer chooses requirements/settings (within limits).

Concept is currently in trial stage, targeting people with own detached houses, that have EVs, PVs or batteries. The customer receives limitations on use of their assets (e.g. EV has to be plugged in from 6. to 12.) for which the they are compensated (e.g. operator disables EV charging and the customer gets compensated).

Rationale for managed automation

"There isn't a role for customer to single-handedly participate in flexibility trading, as they would be overwhelmed. Operator managed automation is necessary. However, it's imperative that the customer retains ultimate control (have a system override mode), to honour the state of ownership.

There might be 5% of people who want to do everything themselves ("play with the system"), to be able to see all that is going on, and designing for them is important, but they are only a small percentage of the whole customer base.

On the other hand, there's around 15% of those who want to only achieve specific goals, and if the system allows them to do that, the automation is ok."

– SWW representative

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Openness to flexibility

Flexibility SWOT analysis

Strenghts

Resident interest
According to a municipality representative around 1/5 of residents are interested. However, past engagement efforts have shown varying results.

Brand
High trust in a municipality owned brand with longstanding reputation in resident beneficial efforts.

Cost reduction
Flexibility allows for overall decrease in energy expenses. However, it's important that the community is rewarded for them.

Grid reliable green energy transition
The unpredictability of sustainable sources is mitigated for by flexibility's auxiliary potential.

Low impact on appliance operation
Most modern energy efficient appliances can offer decent amount of flexibility with almost unnoticeable impact on performance.

Weaknesses

Complex topic
It's difficult to give people a sense of the whole topic as they rarely engage with it, sporting a 'when I need electricity, I get it' attitude.

Limited engagement
Previous projects have shown that the people's behaviour can only be influenced twice – the first time and then trough a reminder/ teaser. People are prepared to go through the process once, and then wish to not touch it anymore. This can serve as another argument for automated systems and contracting.

Low familiarity
The topic of flexibility is less familiar and harder to imagine than other energy services, due to lower tangibility (e.g. people are eager to adopt district heating as they can see the pipes and infrastructure, which the heated water comes from.)

Slow research efforts
Oftentimes research projects run for several years without any hope of implementation.

Limited cost incentive
There are concerns that the cost itself might not be a sufficient and societally beneficial incentive.

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Opportunities

Energy communities
Communities could help better engage residents in energy related topics. They would also allow P2P trading, ensuring that the money remains in the community. However, members would still need to operate as a single entity, as it's unfeasible for the system operator to trade flexibility sizes of individual consumers.

Price as a pragmatic plug'n'play driver
Most consumers will likely be convinced by price reductions on their energy bills. For such, the design should require as little user interaction as possible, allowing them to simply 'plug-in' to the system via a contract (taking on a role of an 'interface') and immediately start earning rewards.

Threats

Restrictive regulation
Offering flexibility in Germany requires a status of a BRP (balancing responsible party). SWW will become complaint with this starting Jan 1st 2025. In regards to P2P trading, such regulation is yet to be introduced in Germany.

Misinformation
Circulating unfounded misinformation which questions costs, effectiveness and invasiveness of sustainable sources is having a hampering impact on solutions that work towards the green energy transition.

Digital dependency
The extensive digitalization of the energy system will make it more vulnerable to system failures and digital attacks.

Cost of entry
The cost of assets required to meaningfully participate in energy flexibility might for many be too expensive.

Exclusive transition
Many households, such as renters or employees with inflexible working hours, might be unfairly barred from participating. This exclusion not only cuts them out from rewards but possibly also makes energy more costly for them.

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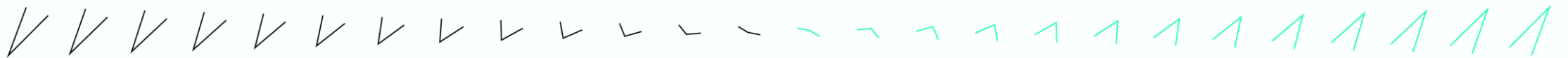
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User insights

Analysis & Categorisation

The user interviews have been processed through various rounds of analysis and synthesis.
The insights are presented through the following categorisation, which reflects the structure of the interview questions:

Energy attitude
- Energy awareness
- Motivation & goals
- Flexibility & automation

Energy systems & behaviour
- Setups
- Behaviour
- Barriers

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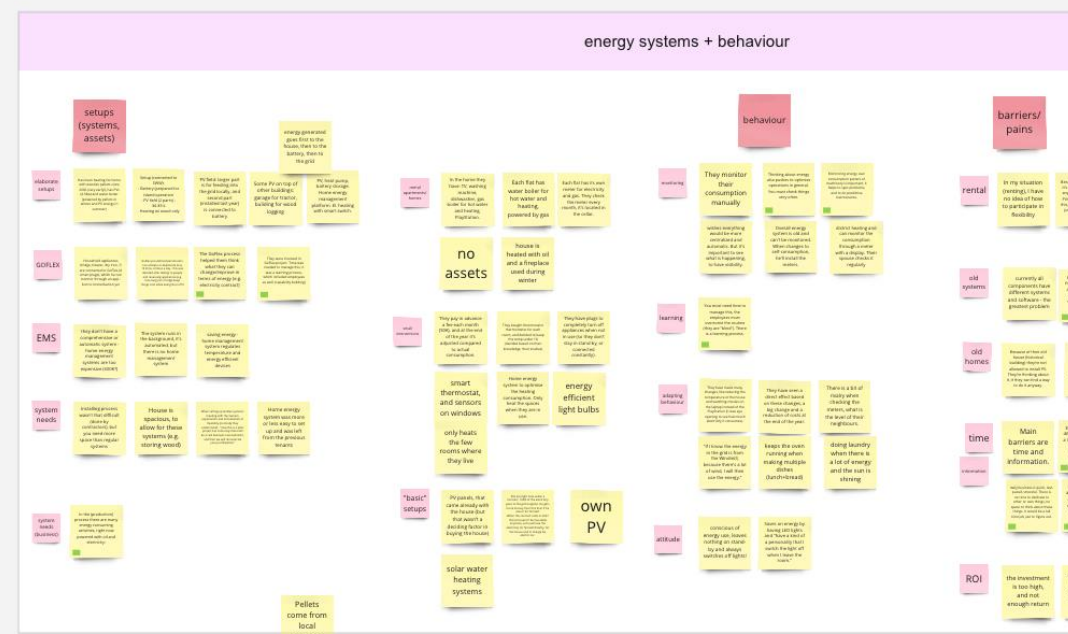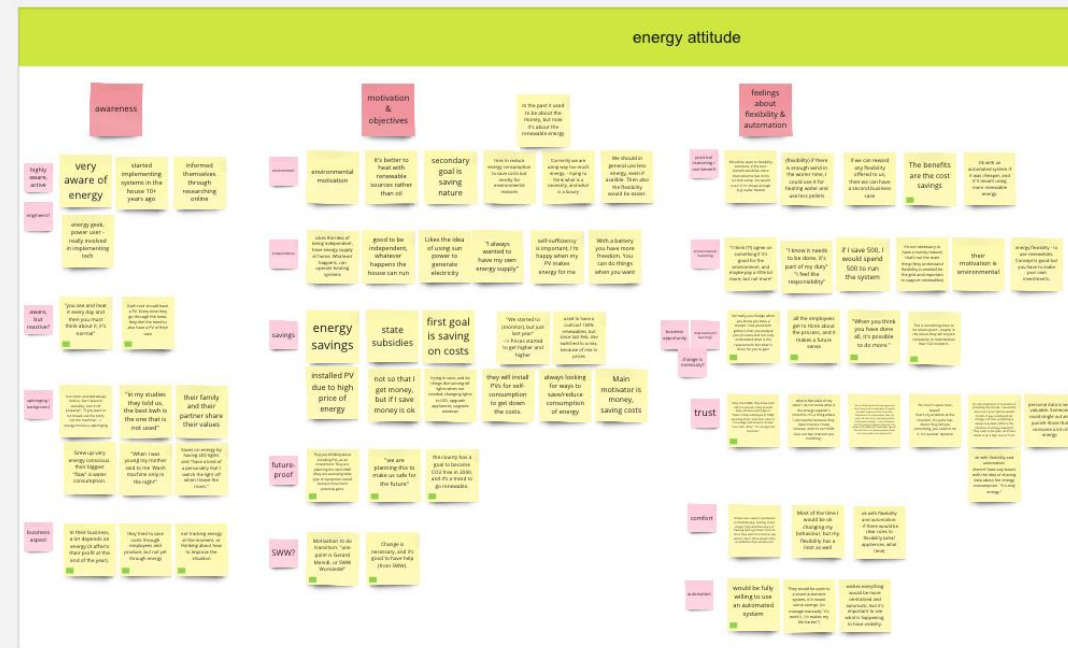
Energy attitude / **energy awareness**

In general, awareness related to the topic of energy was high among interviewees. Some aspects contributing to this were the highly "active" context (Wunsiedel and SWW), global events (war in Ukraine), and people's personal history and attitude.

Furthermore, in the case of small businesses, energy is in general an important topic as it can greatly impact profits.

- Participants were generally aware of the role of energy in their lives, some even more so since the start of the war in Ukraine last year.
- Awareness is catalysed by the context, in which adoption of renewables is normalised.
- Many share an overall conscious attitude towards energy.
- Energy is a critical aspect of business.

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Energy attitude / **energy awareness**

Participants were generally aware of the role of energy in their lives, some even more so since the start of the war in Ukraine last year.

A large number of participants was aware of their energy consumption and needs, with some (particularly prosumers) being highly aware and active in self-informing. Some in the prosumer group have already been implementing energy systems in their homes for over a decade.

Furthermore, the war in Ukraine has been a major factor in bringing the topic of energy to the forefront for many, even motivating some to take action (e.g. monitoring, switching contracts).

Awareness is catalysed by the context, in which adoption of renewables is normalised.

– "You see and hear it every day and then you must think about it, it's normal."
– "I'm going through the streets, and I'm counting the roofs (...) in my opinion each roof should have PV."

Living in and around Wunsiedel, most participants seemed to be aware of the topic of renewable energy from their surroundings.

Solar panels are especially present, boasting visibility of the topic in the everyday life of residents. Generally, renewable energy solutions were discussed as a "normal" and relatively widespread option.

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Energy attitude / **energy awareness**

Many share an overall conscious attitude towards energy.

– "Our mom and dad always told us, don't leave it in stand-by, turn it off properly!"

In terms of values and behaviour, many participants reported having an energy-conscious attitude and habits, which sometimes stemmed from their upbringings.

Examples included always turning off the lights when leaving a room or trying to avoid using energy-consuming appliances unnecessarily.

Energy is a critical aspect of business.

– "Our whole business depends on energy"

For small businesses, energy is a crucial aspect of their activities. Energy costs can greatly affect profits at the end of the business cycles.

However, despite energy costs being very impactful, not all are currently able to manage, monitor and improve their situation as they wish.

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Energy attitude / **motivation & goals**

Among participants there was variation in terms of motivation and goals related to energy.

The main recurring objective was cost saving, with reducing environmental impact coming up as a close second. Sometimes these two were equally important, but other times one would prove to be a priority over the other. Among prosumers, another identified goal (partly related to savings) was to be as self-sufficient and independent as possible.

For businesses, energy attitudes were also a matter of future-oriented investments and being reactive to the operational environment.

- <u>Saving costs</u>: lowering economic cost of energy as much as possible
- <u>Environmental impact</u>: reducing own impact on the environment
- <u>Autonomy and independence</u>: being self-sufficient and resilient to outside changes or events
- <u>Future-proofing</u>: doing smart investments and preparing for future scenarios

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Energy attitude / **motivation & goals**

Savings and reducing energy spending

Lowering energy costs was the most common goal among participants. There was a general shared opinion of energy costs being too high, especially since the events of February 2022.

Reducing energy spending was a big motivator for those who had installed PV panels already. These instalments were partly incentivised by the state subsidies in Germany.

At times, the financial needs were intersecting with the environmental motivation. In some instances, negatively, such as needing to make compromises (e.g. switching from 100% renewables to mixed sources, due to rise in prices); other times positively, for example taking measures to reduce consumption, which both saves costs and reduces carbon footprint.

Environmental impact and responsibility

– "I know it needs to be done, it's part of my duty!"

– "If I know the energy in the grid is from the windmills, because there is a lot of wind, then I will use the energy."

For some participants, the main motivation behind their choices towards energy was related to the environment, and trying to do what is best to reduce negative impact. For some, this was expressed as "saving nature", or a preference towards renewable energy rather than oil. For others, it was also about trying to optimise and reduce consumption overall, as they felt their current energy consumption was in general too excessive.

Among those with environmental motivations, there was a sense of societal responsibility towards the collective, beyond the individual gains.

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Energy attitude / **motivation & goals**

Autonomy & independence

– "I always wanted to have my own energy supply."

Especially for prosumers with their own homes, the concept of self-sufficiency regularly reoccurred when discussing motivation and goals. Some wished to have an independent energy supply and storage, knowing that regardless of what happens outside (e.g. rising prices, or a blackout event), the house and systems connected to it will run.

Participants appreciated the idea of being less dependent from the grid, for example having a battery connected to a PV system, as it meant having more freedom to use the energy as they pleased.

Future-proofing a business

– "We are planning this to make us safe for the future."

Business also saw the move to renewable energy as a future trend. It motivated them to make investments in order to stay ahead of the curve.

A small business owner mentioned that they sensed how the country goals were pushing towards net-zero consumption. They perceived that the government might in the future introduce a requirement for businesses to declare their carbon footprints. For these reasons they were investing in new energy solutions, as it made "future sense".

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Energy attitude / **flexibility & automation**

Most interviewees were not familiar with the concept of energy flexibility. However, when discussed, there was a general positive and open response.

On the topic of automation, most were also positive, however doubts towards costs versus benefits, the importance of retaining control and visibility, and trust between service provider and customer (e.g. data privacy, profit goals) did surface in conversations.

- Many are open to automated solutions to energy and (potentially) flexibility, if they are economically more advantageous than the current situation.
- For some, if there is a clear environmental value, economic benefits cease to be the key aspect.
- Automation makes life easier, at the same time, some want to retain control and visibility.
- Flexibility is a complex and unfamiliar topic, but people seem open to it.
- For some, trust is a dealbreaker.

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Energy attitude / **flexibility & automation**

Many are open to automated solutions to energy and flexibility, if they are economically more advantageous than the current situation.

When approached with the topic of automation of energy systems, and the potential of flexibility, many responded in a positive and possibilistic way. However, the new or additional system would need to be cheaper, or have a better cost-benefit ratio, over their current situation.

For seasoned prosumers, who already have a level of automation in their systems and know how to manage them, there would need to be a clear advantage in a new solution. A few participants mentioned that the current cost of EMS are too high for the benefits they would bring.

For some, if there is a clear environmental value, economic benefits are not the key aspect.

– "If I spend 500, I would spend 500 to run the system."
– "If it's good for the environment, I'd maybe pay a little bit more, but not (much) more."

If the participant expressed a strong environmental motivation, the economic aspect became less critical. Provided that they would be assured of the positive environmental impact of the solution, a monetary reward is in their opinion not fundamental.

However, even if they understood the concept of flexibility as being positive for the environment, they still perceived cost to it. The system would need to be financially sustainable for households in ordered to be considered.

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Energy attitude / **flexibility & automation**

Automation makes life easier, at the same time some want to retain control and visibility.

– "(To manage things manually) it's work! It makes my life harder."

Overall, automation was perceived in a positive way. Many would be willing to use automated systems (if it meant savings and/or positive environmental impact). They saw the potential of making everyday life easier, compared to adjusting systems manually. However, some brought up a need to being able to establish clear rules and boundaries.

Moreover, while many experienced prosumers would like everything to be more centralised and automatic, some still found important to have visibility on what is happening.

Flexibility is a complex and unfamiliar topic, but people seem open to it.

Although many participants were not aware of the concept of energy flexibility, they were open and interested to learn more through our conversations. They often made to day/night tariffs, with which they were more familiar.

Some considered flexibility as an interesting concept for consumers to take part in sustainable energy transitions, while others saw potential to be more aware of their energy consumption and possibly be empowered with more information and tools to monitor it.

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Energy attitude / **flexibility & automation**

For some, trust is a dealbreaker.

– *"(Sharing data) is a thing where I am careful, because (energy suppliers) have interest, I have interest, and I'm not 100% sure our two interests are matching."*

– *"I do not believe that the energy supplier's intention is to power the people by renewables, I guess the intention is to power people at as low cost as possible and make profit."*

A few participants raised concerns around data privacy, for example mentioning that automation would be acceptable only if the data collected was anonymous and safe. Generally, trust in the service provider was seen as a key aspect, not only in data collection but also around the goals and operations. It seemed, however, that in Wunsiedel, many trust SWW, as a local and known institution.

– *"Most of them are employees of SWW, we know them in person, here in the village and around, and we trust each other."*

The role of SWW as a trusted actor seemed to be an important enabler for renewable energy solutions and activities in Wunsiedel. One interviewee, when asked about their motivation to invest in energy technologies, started their answer with: "one point is SWW Wunsiedel." This was a recurring theme; SWW being instrumental for facilitating change. Impression was that the local company is well-known and trusted, even the name of the CEO was familiar to many. Despite being a private company, SWW is owned by the municipality and is bound to serve its citizens above profit goals.

It's also important to note that the pool of interviewees was gathered by SWW, therefore a good level of familiarity and trust was expected.

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Energy systems & behaviour **/ setups**

Assets and setups varied considerably. Among prosumers, some had elaborate setups comprised of multiple components, while others had more simple systems, mainly PVs. Although setups could be elaborate, we found very little use of EMS.

On the opposite end, consumers had very little assets. Many were limited in their choices by their living situations (e.g. rentals, historical or old homes). Despite this, we found people still devised ways to affect their energy consumption through changes in behaviour and small interventions.

Finally, a few participants were already a part of another EU project related to flexibility, therefore they had some previous experience and equipment.

- Prosumers' home setups vary from very elaborate to simple and low maintenance.
- People living in rental apartments and homes have limited agency but can still find ways to improve energy use.
- Energy management systems are not being used.
- Some people were already participating in a previous flexibility project (GoFlex).

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Energy systems & behaviour / **setups**

Prosumers' home setups vary from very elaborate to simple and low maintenance.

The more experienced group of prosumers generally had very elaborate home setups, composed of various components. For example, PV panels, batteries and pellet heating. They all had some form of automation and were able to monitor their use and production regularly. The evolvement of the setups seemed to be related to the possibility of gaining more financial returns, compared to the current situation.

Another group of prosumers had less involved setups, usually comprising solely of PVs and a few solar water heating systems. They seemed to have less visibility and control over the systems.

People living in rental apartments and homes have limited agency but can still find ways to improve energy use.

Participants living in rentals pointed out how they were limited in making choices related to energy in their situation. At the same time, some had still found ways to reduce energy consumption.

Solutions ranged from more simple interventions such as installing plugs with "off" switches and energy-efficient light bulbs, to more sophisticated ones like smart thermostats and window sensors.

Many people were taking some measures to reduce energy consumption, in the way they could – even just by slightly reducing their house temperature. Oftentimes, these changes seemed to be a reaction to the price spikes of the previous year.

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Energy systems & behaviour / **setups**

Energy management systems are not being used.

Among the group we interviewed, EMS were not common. While prosumers' assets can be set up to run in the background, with automated settings, in most cases these weren't connected to each other and there was no centralised home management.

Interviewees mentioned that such software can be expensive, and it might not be worth the price. Moreover, it would need to cater to multiple different devices, which don't always have standardised protocols.

Some people were already participating in a previous flexibility project (GoFlex).

SWW has already been involved in many flexibility projects, one of which called GoFlex. A couple of interviewees who participated have already installed smart plugs, which can steer assets to activate or deactivate, 4 times a day for 15 minutes. This parameters were defined in the project after assessing the participants' needs. The assets connected to the plugs could be monitored through an app.

One involved business owner mentioned how the process took time and it had a learning curve, which included employees as well. However, it did help them think about their situation, how they could change or improve in terms of energy. Throughout this process they were greatly supported by SWW.

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Energy systems & behaviour / **behaviour**

Generally, interviewees reported monitoring their energy use in various forms, however mostly manually. For many, checking the bills is a way to stay on top of it.

Some also adjusted their behaviour in response to current energy production, for example doing energy-intensive household chores when the sun was out (prosumers) or trying to optimise or reduce use of appliances (consumers).

- Most participants regularly monitor their energy consumption but mainly manually.
- Many prosumers with PVs adapt their behaviour to the performance of the system.
- On top of "passive" adjustments, some have changed their habits to reduce consumption.

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Energy systems & behaviour / **behaviour**

Most participants regularly monitor their energy consumption but mainly manually.

Whether they had energy production capabilities or not, many participants reported checking on their energy use regularly and in similar frequency .

Many had meters with displays as interfaces, located in cellars, basements or other locations in their homes/ apartment buildings. They manually checked the numbers and some even recorded them in files on their computers. Others monitored their energy use through bills that came at regular intervals throughout the year.

A business owner with a production line mentioned that the importance of monitoring lied in spotting problems with machinery and doing predictive maintenance.

Many prosumers with PVs adapt their behaviour to the performance of the system.

To maximise their investment, prosumers who had PVs without storage, reported adjusting their behaviour to make most of the energy produced. For example, if they saw the sun shining outside, they knew more electricity was being generated that day, therefore they would take that chance to do laundry.

This behaviour seemed partly driven by the fact that selling energy back to the grid was not seen as profitable. As sell prices were considered too low, at the moment, the most desirable scenario for prosumers was to use most of the energy produced themselves.

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Energy systems & behaviour **/ barriers**

We identified some barriers to the uptake of energy-related technology solutions. First of all, the topic is complex and is not easily accessible to many. In the cases where it was more understood, there was still a need for better clarity in terms of value and benefits.

Then there are barriers related to infrastructure and living conditions. Old and historical homes are especially challenging, together with old and varied systems and components. Finally, for the many living in rentals, the possibilities of engagement was very limited, or perceived to be.

- The topic of energy is complex and has a steep learning curve.
- The return of investment might be perceived as unclear or not very significant.
- It's challenging to adopt new technologies in old and historical homes.
- Systems and components vary in terms of age and compatibility.
- For those living in rentals, they are very limited in what they can do, as landlords lack incentives to make changes.

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Energy systems & behaviour / **barriers**

The topic of energy is complex and has a steep learning curve.

In general, we found that those who were familiar with the topic of flexibility, or who had more elaborate energy systems at home, shared a connection to the energy field, either in their study background (engineering, environmental sciences) or in their professions.

For others, the understanding around these issues was somewhat limited. Some shared views that learning about energy solutions and monitoring their use can be "like a second job." Time and information seemed to have been the main barriers in engagement.

The return of investment might be perceived as unclear or not very significant.

The whole group of interviewees was generally positive towards renewable energy solutions, likely due to the manner of gathering participants.

However, there were cases in which some scepticism was expressed. Concerns about the high initial investment were brought up. Moreover, many prosumers mentioned how, in their opinion, the price of electricity sold back to the grid was too low.

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Energy systems & behaviour / **barriers**

It's challenging to adopt new technologies in old and historical homes.

Quite a few interviewees happened to live in old and/or historical buildings, which the area we visited seemed to have plenty of. This created problems in implementing adaptations, such as improving the energy efficiency of the house or installing solar panels.

Some issues arised from the construction of the buildings, running on old systems and requiring roof renovation before being ready for PV installation. Other barriers came with regulation, if the building was deemed to have historical value. In such cases, there were limits to what could be changed or added (e.g. PVs) for the sake of conservation.

Systems and components vary in terms of age and compatibility.

When thinking about monitoring, software and integrating different components into one energy system, a recurring issue was the variety of assets and their software. Not only that different components might run on different software, but might also be of different version/age, adding to the complexity in compatibility.

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Energy systems & behaviour / **barriers**

For those living in rentals, they are very limited in what they can do, as landlords lack incentives to make changes.

For consumers who are not home-owners, becoming a prosumer is challenging. Some struggled to see how they could even participate in flexibility, if they couldn't do significant interventions in their homes.

The landlords didn't have any incentive to make changes, as the electricity and energy costs fell on the residents, not the owners. However, some did see interventions like installing PVs and batteries as an investment that would be tied to the house.

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3
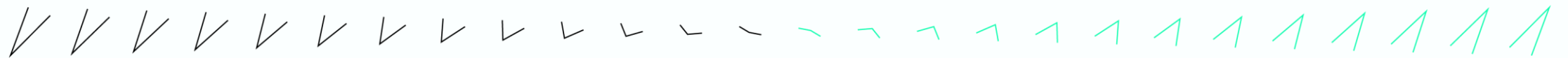
User archetypes

Consumers & prosumers (B2C)

4 archetypes

Based on the previous user insights, we created four B2C archetypes. It should be however noted that these are based on a small pool of participants and are therefore not comprehensive, so they should be considered as such. Nevertheless, they can help us summarise valuable insights and understand consumers through a few parameters.

We decided to consider two key aspects: the amount of assets a consumer has and their knowledge and engagement with the energy topic. As the group of interviewees was generally favourable towards the topic, a notable missing perspective is the neither neutral nor positive one (i.e. sceptics or critics).

Low engagement

Low assets

High assets

High engagement

Unfamiliar / unaware consumers 2

Early majority/ Pragmatists 4

Familiar / aware consumers 2

Early adopters/ Energy geeks 3

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1 Interviewees per archetype
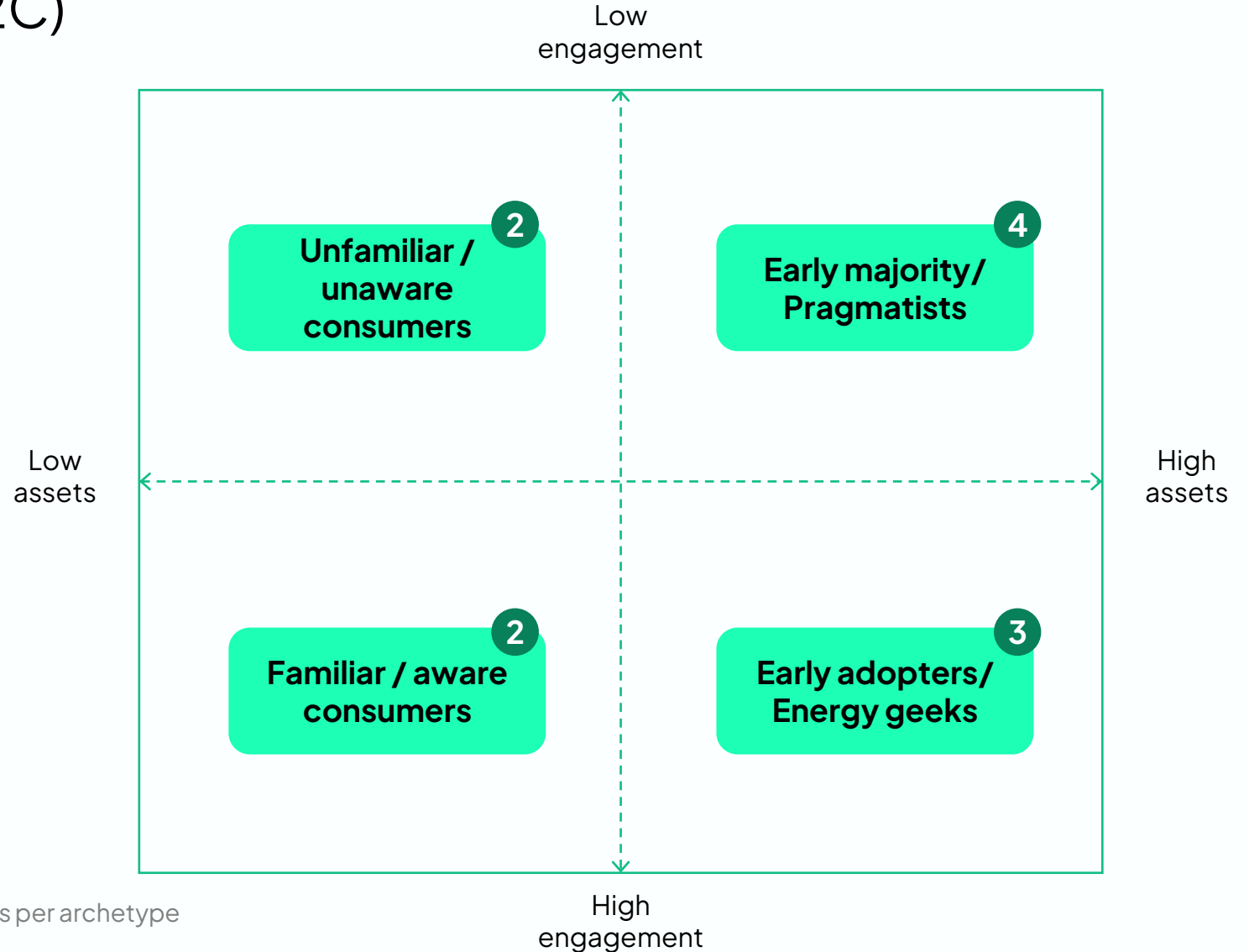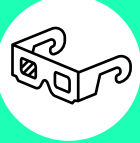
Early adopters/ energy geeks

age range

20 — 30 — 40 — 50 — 60 — 70
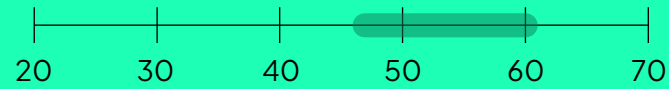
background
- Home-owner, large property
- Engineering/energy background
- Interested in technology
- DYI attitude, proactive
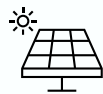
assets & setup — HIGH

engagement & familiarity — HIGH

motivation & objectives
- Independence, self-sufficiency
- Energy savings, lowering costs
- Environment is on their radar, but not the primary motivation

barriers & pains
- Components differ in age and software
- The benefits from selling electricity back to the grid aren't substantial

energy setup
- Elaborate setups with multiple components (PVs, batteries, pellet heating systems, EVs)
- Have been implementing these systems for 10+ years
- There is a level of automation, but different parts might not be connected

monitoring & behaviour
- They monitor their consumption/ production regularly
- They try to optimise their own system (e.g. home temperature)
- They keep themselves informed and up-to-date on energy topics

feelings about flexibility & automation
- Positive and supportive of automation, but prefer visibility
- System upgrades need to make financial sense, (cost-benefit vs current system)
- Further automation has limited value as they can already easily operate their own systems

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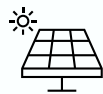Funded by the European Union

Early majority/ pragmatists

age range

20   30   40   50   60   70
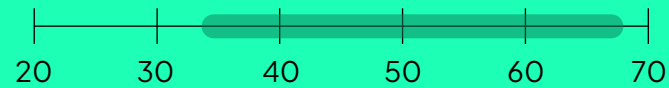
background
- Home-owner, large property
- Various professions/retired
- Not interested in technology itself, but in the benefits of it

assets & setup — **HIGH**

engagement & familiarity — **LOW**

motivation & objectives
- Main motivation is saving money
- Installed PV due to high energy prices and available government incentives
- Additionally motivated by having independence and autonomy

barriers & pains
- Loss of favourable PV contracts
- The benefits from selling electricity back to the grid aren't substantial
- Want to maximise their self-consumption (make most out of their PV investment)
- Wish to add storage to get more out of their PVs

energy setup
- Simple PV systems

monitoring & behaviour
- They occasionally monitor usage/production by reviewing their energy bills
- They adjust their behaviour to make the most of PVs (e.g. do laundry when sunny)
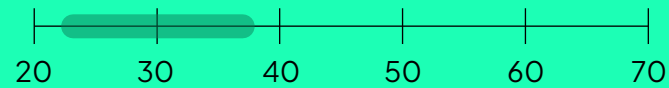
feelings about flexibility & automation
- Limited knowledge of flexibility
- Supportive of the concept if there is a financial benefit

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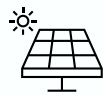Funded by the European Union

Familiar/ aware consumers

age range

20 — 30 — 40 — 50 — 60 — 70

background
- Rental homes
- Work/background related to energy
- Interested in sustainability
- Energy-conscious

assets & setup — **LOW**

engagement & familiarity — **HIGH**

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motivation & objectives
- Strong environmental motivation
- Feeling of responsibility
- Need to make ends meet

barriers & pains
- Need to make compromises between financial costs, environmental sustainability, and comfort
- Wishing to limit their use only to sustainable sources
- No incentive for landlords to do anything substantial
- Concerned about privacy and trust, they don't feel like companies share same interests
- Managing systems manually

energy setup
- No energy production assets
- From zero to little automation in the homes (e.g. smart window sensors)

monitoring & behaviour
- They monitor and try to change behaviour in order to reduce energy consumption
- Regularly looking at energy bills and energy meters

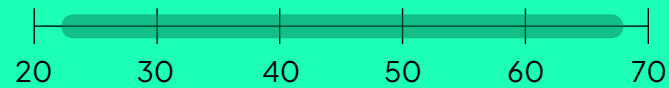## feelings about flexibility & automation
- Somewhat aware of flexibility
- They see financial value, as well as value at large for the grid
- They are open to automation, but trust and data privacy need to be addressed
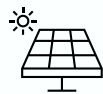- Flexibility systems could also help them learn more about their energy use

Unfamiliar/ unaware consumers

age range

20 30 40 50 60 70

background
- Both rental homes and homeowners
- Have limited idea of energy tech based on what they see & hear around them (e.g. neighbours with PVs)

assets & setup — LOW

engagement & familiarity — LOW

motivation & objectives
- Pragmatic motivations (running the household, saving costs when possible)
- Possible environmental sensibilities

barriers & pains
- Low knowledge and information about a difficult topic
- No time in daily life to dedicate to learning about the topic
- Limited investment potential (e.g. historical homes, rentals)

energy setup
- No energy production assets
- Conventional systems (e.g. oil heating)

monitoring & behaviour
- They occasionally monitor usage by reviewing their energy bills
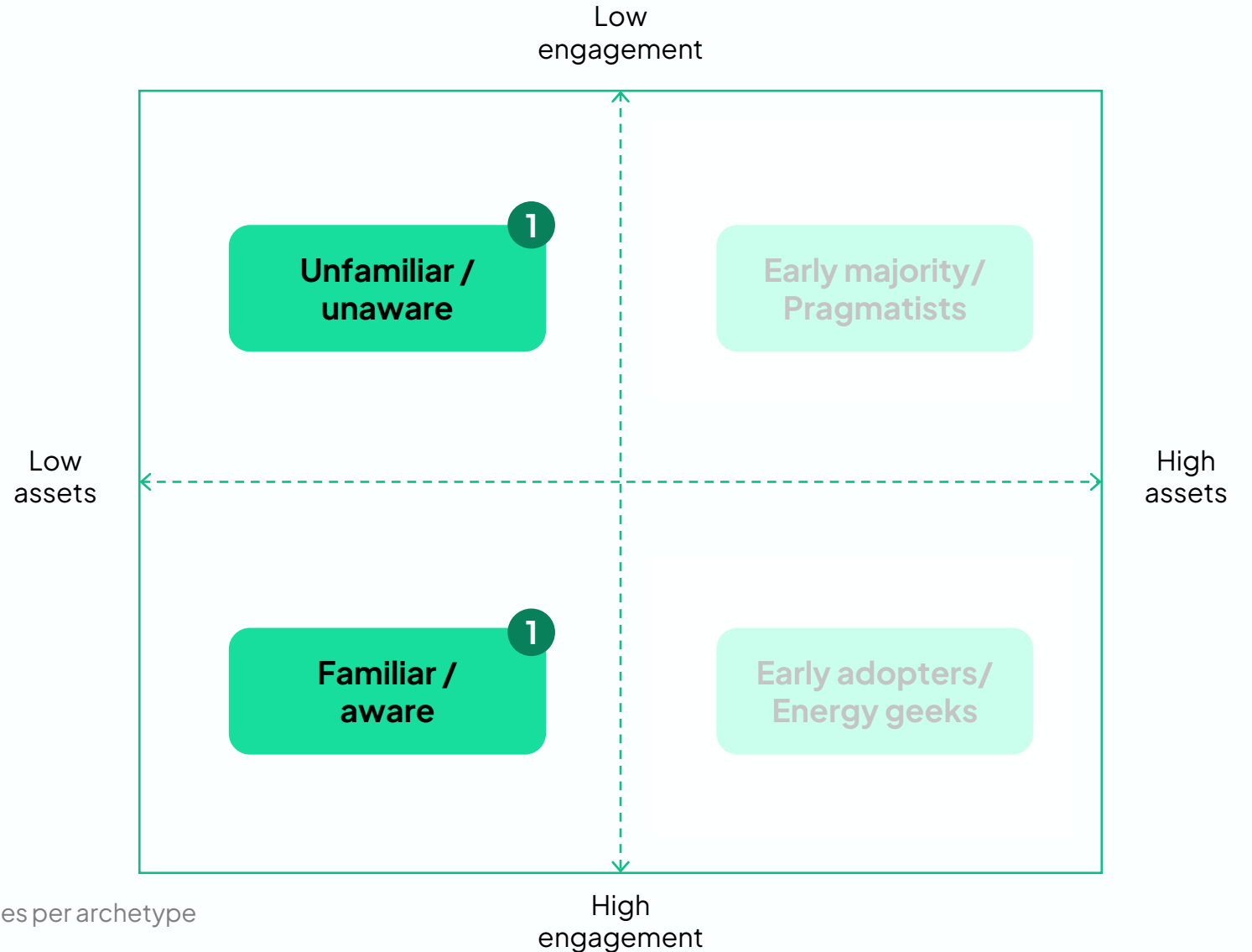
feelings about flexibility & automation
- Very limited knowledge
- Open to possible automated flexibility services

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Small businesses (B2B)

2 archetypes

We only interviewed two small business owners, therefore these two archetypes stem from them. None had substantial assets in use (e.g. PVs or batteries), however one was very engaged with the topic, while the other very unfamiliar. Despite being limited by the number of sources, they can be use useful in thinking about different perspectives in terms of B2B users.
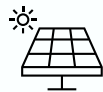

Low engagement

Low assets

High assets

Unfamiliar / unaware 1

Early majority/ Pragmatists

Familiar / aware 1

Early adopters/ Energy geeks

High engagement

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1 Interviewees per archetype

Familiar/ aware

background
- Production of goods
- Need to meet business goals and customer needs, manage employees
- Day-to-day is dynamic and diverse
- Longstanding relationship with SWW, aware of energy tech possibilities

assets & setup — **LOW**

engagement & familiarity — **HIGH**

motivation & objectives
- Optimise costs and operations (energy greatly affects profits)
- Evolving with the sustainability trend (foresee carbon footprint declarations) and investing in the right technologies to future-proof their business

barriers & pains
- Custom flexibility solutions take time to implement
- It's not possible to do it alone
- Machines are all differ in age and software

energy setup
- Custom flexibility sockets from the previous project
- Production machinery

monitoring & behaviour
- They check machines once a month and log data into excel files
- Monitoring energy use/ consumption patterns of machinery is important, as it helps to spot problems and to do predictive maintenance

feelings about flexibility & automation
- Flexibility shouldn't impact core processes
- Custom, monitored automation
- Need for visibility

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"Change is necessary, and it's good to have help"

Unfamiliar/ unaware

background
- Service sector
- Need to meet business goals and customer needs, manage employees
- Daily business is diverse, fast-paced and stressful
- Understand the impact of energy but haven't done much on the topic
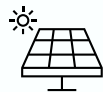
assets & setup — **LOW**

engagement & familiarity — **LOW**

motivation & objectives
- Pragmatic (running the business, saving costs)
- Do what is best to satisfy customers
- Environmental sensibilities (would be happy to do something eager for the environment)

barriers & pains
- Complexity and time: energy management is difficult, it takes a lot of time and information
- Energy needs change frequently and are hard to adapt to
- Daily routines make it hard to reserve "space" to think about how to improve the situation

energy setup
- No energy production assets
- Substantial flexibility potential (equipment, heating)

monitoring & behaviour
- They don't track energy at the moment or think about how to improve the situation
- The adjustments they make to reduce consumption are more "gut-based" rather than data-driven

feelings about flexibility & automation
- Flexibility shouldn't impact core processes
- Change is difficult
- Possibly open to automation

"Tracking and managing energy would be like a full-time job, beside my job"

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Desktop research

Feedback

Feedback systems have showen to have little impact on user behaviour

Studies included in our research [1,2,3,4] found that the feedback from energy metering applications had very little impact on energy use. Apps did raise user's understanding of consumption, but didn't lead to any substantial change in behaviour. They usually remained in use only up until the user ascertained their consumption patterns, but were then quickly dropped as users failed to implement adjustments that would leave noticeable impact. Studies thus concluded that the apps should've provided more relevant, meaningful, and actionable information tied to each user's case.

The insights from our Wunsiedel study expend on these findings. Participant metering behaviour reflected the referenced studies – they familiarized themselves with their energy consumption by checking their energy meters and implemented necessary changes. They didn't have trouble identifying adjustments, but they mostly completed a single adjusting cycle. They explained they were satisfied with lowered costs, lesser consumption in comparison to their neighbours and deemed they achieved the highest level of compromise in their comfort.

Participants also perceived the back and forth metering to be very tedious, suggesting that could've also acted as a demotivating factor for further adjustments. When asked about automation, they were open to it, as long as they could maintain control of the severity of adjustments. Such perspective could suggest that:

The feedback of flexibility interfaces should focus less on metering on more on controlling comfort levels.

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Incentives

There is deep intertwine between financial and environmental reasons, yet cost savings remain the main driver.
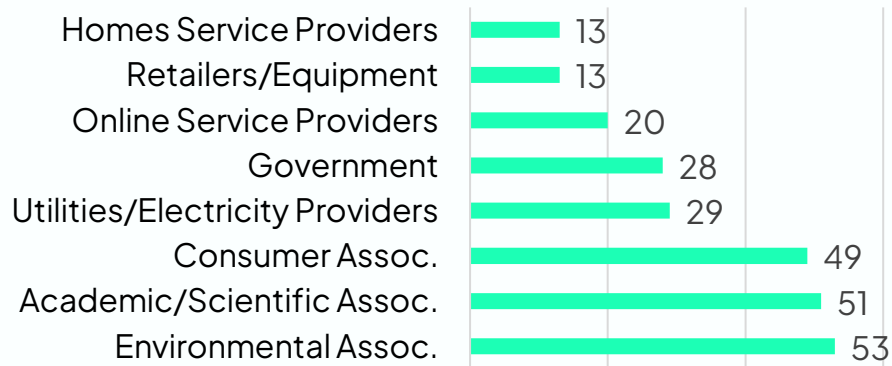
The insights from Wunsiedel showed that user motivation might be more intertwined as it might first seem. Instead of separating the financial and environmental[5], resident attitudes build on the notion that the financial gains are used as an argument to underpin another aim, such as becoming self-sufficient or reducing emissions[2]. Yet again, the commitment to these goals was not always clear, as most residents ran financial calculations before switching or investing in their system, to ensure they wouldn't incur any losses. Similar stance was also discovered in previous studies, where despite the intention to limit environmental impact, the main driver remained personal cost savings[1].

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Trust

A survey[6,7] of 9000 consumers has shown that only 16% would allow electricity providers to control and limit the use of household appliances, without an overwrite option and a considerable discount (at least 10%). Reasons for apprehension involved expectation of higher energy bills (46%), provider profiting on energy they themselves saved (41%) and access to personal consumption data (32%).

The survey also measured (%) if constumers trusted offered consumption advice from various sources:

Source	%
Homes Service Providers	13
Retailers/Equipment	13
Online Service Providers	20
Government	28
Utilities/Electricity Providers	29
Consumer Assoc.	49
Academic/Scientific Assoc.	51
Environmental Assoc.	53

A comparatively high level of trust of SWW consumers could be ascribed to the multiple trust layers the company is positioned in

In contrast to the survey, all participants in the Wunsiedel study expressed a high level of trust in SWW's operations and were highly inclined for the company to automate their households. SWW's position seems to address most apprehensions raised in the survey – their flexibility concept includes fixed discounts and a 'turn-off' functionality, as municipally owned entity the profits are returned to residents and the data control remains regulated with public official oversight.

As a separate entity with research institute characteristics, they also successfully fall under the trusted category of an academic association.

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Barriers

Barriers expressed by Wunsiedel study participants compared to previous studies[1,5,8]:

Barrier	Description	Occurrence in Wunsiedel
Economic	Economic non-affordability of devices and services	Participants often expressed the high cost of flexibility supporting systems. Even those with existent intricate builds were reluctant to expend due to costs.
Communication	Exclusionary discourses and communication.	Amongst participants, none expressed they felt excluded. We suggest that the municipal ownership might have played a relevant role.
Literacy	Limited knowledge and skill to use smart grid and smart home services and products	Many participants found the electricity system to be complex and difficult to understand. They also expressed the need for guidance on how to adopt set-ups and participate.

Barrier	Description	Occurrence in Wunsiedel
Interest	Limited interest or voluntary non-use of smart grid services	Most of participants had ties with previous flexibility projects, so they all expressed interest. Relevant stakeholders confirmed this, stating that a big part of residents showed interest in flexibility. At the same time, many weren't involved due to scepticism, unfamiliarity or lack of time.
Practices	Limits tied to inflexibility of everyday practices	Some participants expressed trouble adopting flexibility as they were often working from home. Some also perceived troubles in coordinating with other household members.
Infrastructure	Limited infrastructure access	Lack of space necessary for set-ups (large basements, roofs) and limitations related to rentals and historical protection were commonly brought up by participants. Fortunately, we didn't notice any limitations pertinent to IT or similar services.
Design	Limited usability or incompatible design	Most limitation stemmed from the need for extensive set-ups to participate in flexibility. However, the piloted smart plug solution shows great potential in addressing this barrier.

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5

Conclusion

Design **Drivers**

We have collected design drivers that emerged throughout our study. They present factors which a flexibility solution should include to best align with user wants and needs.

Reducing costs seem to be the most desired incentive for consumers. Many also value environmental impact which they can perceive. Transparency and fairness is one of key prerequisites for the implementation of automated control.

Solutions must be non-demanding for user to install and should allow customizability based on desired comfort and stable operability. The required user participation should be kept to a minimum, while still allowing for the users to make adjustments and opt-out.

Finally, flexibility holds the potential to achive a higher level of community cohesion.

- Cost reduction
- Tangible environmental value
- Transparency & Fairness
- Frictionless installation
- Custom configuration
- Invisible operation
- Opt-out automation
- Community Action

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Design Drivers / **motivation**

Cost reduction

User financial incentives seem to be strongly tied to reducing the cost of energy. When investing into new set-ups or signing up to new energy system arrangements, users expect to spend less or at least break even.

Tangible environmental value

Users value the environmental impact they create. Clear tangible insights should be provided to empower users in their actions.

Transparency & Fairness

To participate in flexibility, users need to trust the operators that their interests are advocated for. Operators should transparently educate users and provide clear financial calculations. Flexibility gains must be shared fairly and data management should be done with diligence and user oversight.

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Design Drivers / use

Frictionless installation

Flexibility installations should be made as frictionless and simple as possible. Users should be clearly guided through the process. Many find the topic very complex and should thus also be provided clear information about what they are signing up for.

Custom configuration

Users consumption practices differ considerably, thus flexibility participation should be able to adapt to their need. Households seek compromises on comfort, while business pursue stable operability.

Invisible operation

Flexibility participation shouldn't be time consuming and require limited user input. Configuration process (comfort/operability adjustments) should be done once and expect very sparse user initiated nudges afterwards.

Opt-out automation

Automation show enticing potential for non-obtrusive flexibility participation. However, as new externally controlled technology, it also brings a lot of scepticism and concerns. Users thus need to be reassured they can always adjust its operation and easily opt-out if the system doesn't align with their expectations.

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Design Drivers **/ sustainability**

Community Action

Flexibility services have the potential to create higher community cohesion by uniting users under a common cause. Collective action makes monetary and especially environmental impact further amplified.

Operators can also benefit by supporting communities. Creating co-ownership programs and reinvesting earnings into community beneficial projects can bolster higher trust and loyalty amongst consumers.

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Design **Barriers**

We have compiled design barriers that were brought up among the participants of our study. They present hurdles that a flexibility solution should overcome to ensure inclusion and usability.

Energy flexibility is a very complex topic and requires a high level of energy literacy. Varying access to capital and availability of space considerably limit participation in flexibility. Different are also user expectations of control and automation, making it hard to consider everyone.

Distrust in data is also prevalent, prompting the solution to either bolster trust or operate with limited data.

Lastly, scaling flexibility might put users, who aren't able to participate, in an unfair disadvantage.

- Literacy
- Access to capital
- Home ownership
- Differing expectations of automation
- Limited data sharing
- Cost of non-participation

Design Barriers **/ motivation**

Literacy

The novelty and complexity of energy flexibility can limit interest and even deter users. Clear and inclusive communication should be used to educate and reassure consumers.

Access to capital

Involvement in flexibility requires substantial asset investments. Diverse means of participation, with varying degrees of cost, complexity and commitment should be provided, to allow for a truly inclusive adoption.

Home ownership

Many users' living situation might restrict them in implementing more complex flexibility set-ups (such as a lack of a roof or large basement). There are also those, who are limited by historical protections on their buildings. Flexibility solutions should be introduced that enable non-intrusive installation.

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Design Barriers **/ use**

Differing expectations of automation

Certain users prefer to participate in a very limited manner and are fully willing to entrust operations to an automated controller in order to save time and effort. Yet, others wish to retain a high level operability, so they can 'look in the box' and tweak the system to the highest level of efficiency.

Limited data sharing

Users can be reluctant in sharing their data. Considerations should be made on how to either reassure the user that the data is respected and managed fairly or find ways of operation with only limited available data.

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Design Barriers **/ sustainability**

Cost of non-participation

Certain users might not able to participate in flexibility due to limitations in capital, assets, infrastructure or inflexible routines. As flexibility scales these users might unfairly find themselves in a serious disadvantage and be forced to pay substantially more for their energy.

Party that manages flexibility should commit to advocate for and find ways to aid users unfairly harmed in the flexibility transition.

Open questions

- **How might we educate consumers on energy flexibility without overwhelming them?**

- **How can we incentivise users in a viable way that caters to all?**

- **How can we adapt flexibility to include needs of multiple users? How should these alternate versions look like?**

- **How can we achieve an inclusive flexibility system that allows everyone to participate?**

- **How might we bolster energy system trust amongst the consumers?**

- **How can we motivate community cohesion in our flexibility services?**

- **How can we aid those that might be left out of the flexibility transition?**

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Key takeaways

Motivation

Reducing energy costs seems to be the main driver for consumers. It is used to argue for self-sufficiency and reducing environmental impact. However, a fair assumption can be made that the younger generation – the future prosumers, might value sustainable actions over monetary benefits.

Barriers

Energy flexibility is a really complex topic, requires high "energy literacy", needs to cater to various differing needs, and may not be equally available to everyone (access to capital, homeownership, physical space). Different levels of participation are necessary to cater to various levels of flexibility potential.

Flexibility & automation

For most, automated 'invisible' solutions are ideal, but some it's important to retain a higher level of control and visibility. Data-privacy also remains a concern for some.

Trust

Trust in SWW is the key driver in Wunsiedel developments. A presence of a motivated actor with strong community relationships and a will to work closely together with residents and businesses resulted in rapid technological evolution in the region.

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Wunsiedel study: Insights Summary Report

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