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atelier
Positive Energy Districts

AmsTErdam BiLbao cItizen drivEn smaRt cities

Deliverable 7.5:
Citizen Science Experience: citizen's own perspective, trajectory and outputs

WP7, Task 7.4

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Author(s):	UDEUSTO (Roberto Garay, Ainhoa Arriazu-Ramos, Cruz Borges, Muhammad Talha Siddique) Waag Society (Thomas van Dijk, Julia Jansen, Simone van der Burg)

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DoA	This task establishes, executes and evaluates an accessible (entry level) citizen science program based on service learning methodology. The program will include three modules: A) basics of energy and smart systems, B) mapping the energy landscape, C) processing and sharing results and insights. Workshops take place both at community centres and outdoors and will be launched in M6 and promoted through local, city and project channels. This task contributes to providing data (linked to WP9) with respect to participation, happiness and well-being, promotion of social cohesion, etc. Through consumer research and the use of behavioural psychology, AUAS will gain insight in the effective way to promote behavioural changes in relation to PED implementation.		

Date	Version	Author	Comment
30/04/2025	0.1	UDEUSTO	First draft of deliverable. Structure, general sections and activity in Bilbao.
29/04/2025	1.0	UDEUSTO	First complete version, Incorporating input from activity in Amsterdam.

Disclaimer

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1. Introduction

This deliverable is part of ATELIER WP7, which focuses on the role of citizens (residents, local communities) and other key stakeholders (entrepreneurs, property owners, developers, public services, officials, and knowledge centres) in the project's Positive Energy Districts (PED). It examines their role both as end users of the PEDs and in their capacity for co-decision-making, co-implementation, adoption of measures, and behavioural changes for the energy transition.

One of the tasks of the work package is to encourage citizens and key stakeholders to change their energy and mobility habits. This will be done by working directly with stakeholders and citizens in the pilot cities, following a citizen science approach.

Many definitions of citizen science have been offered. The European Commission uses a definition from the Oxford English Dictionary, saying very generally that it is: scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions. It also notes that 'Citizen Science is often linked with outreach activities, science education or various forms of public engagement with science' (European Commission 2016, p. 54). The original concept of citizen science was coined by Alan Irwin to refer to a paradigm where research goals were collaboratively determined by professional scientists and the public in the UK (Irwin, 1995), but since then many varieties of citizen science have evolved. There has especially been a lot of discussion about the level of involvement of citizens, following the line of academic discussions about broad themes of public engagement in science policy, discourse, and research, which have in the past years taken a 'participatory turn' (Jasanoff, 2003). Figure 1 offers an insight into the different levels of participation of citizens.

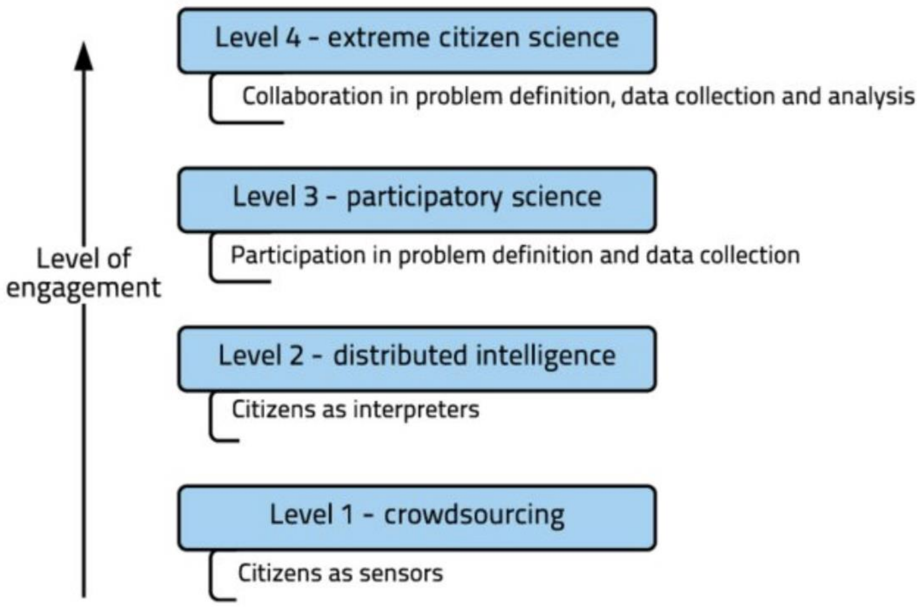

Figure 1. Levels of citizen science (Haklay 2013)

In this context, deliverable D7.5 focuses on documenting the methodology and the results obtained from the citizen science activities conducted in dwellings in the two pilot cities (Bilbao and Amsterdam). For that, first, the general and specific objectives of the task are defined and presented, along with the common methodological framework. Then, considering the specific characteristics of each city and context, the methodology, the level of citizen science implemented, the analysis process, the results obtained, and how these have affected citizens' awareness of their energy habits are presented separately for each city.

2. Aim

The main aim of the citizen science tasks reported in this deliverable is to map the energy landscape, process the data collected and produce insights that help people optimize their energy usage. For that, the specific goals are as follows:

1. **Promote energy education**: Education is essential to any plan aimed at conserving energy, so it is imperative to educate the public about their energy consumption habits and the resulting effects on the environment and economy. This is one of the main aims of this 'citizen science' project. Accessible data on energy usage patterns helps people understand their own consumption patterns and pinpoint areas in which they may make improvements.
2. **Increase awareness of (smart) energy systems and data sharing**: The activity aims to raise residents' awareness about the basics of energy systems, particularly smart energy systems, and the importance of energy data sharing. Participants were expected to gain insights into the electricity consumption and production patterns in their own households and in their neighbourhood.
3. **Encourage the use of energy monitoring tools**: Through the citizen science activity, participants will be introduced to various tools typically used for monitoring electricity (thermal energy is not monitored) consumption. They may choose to purchase these tools in the future to save energy and analyse their own consumption patterns.
4. **Facilitate the comparison of energy consumption patterns among citizens**: As a result of adopting energy monitoring tools, citizens will be able to compare their energy consumption patterns with those of their neighbours. This can further promote collective efforts in energy conservation.
5. **Build active communities for energy conservation**: Creating a community focused on energy conservation will encourage cooperation and support among residents. Projects like ATELIER provide platforms for cooperation, knowledge exchange, and collective action. Involvement at the local level can amplify the impact of individual conservation efforts, helping to develop a culture of sustainability beyond isolated actions.
6. **Empower residents to realize the energy transition**: The activity contributes to empowering residents to actively collaborate in the energy transition process within their neighbourhoods, particularly in the development of PEDs. This collaborative effort helps shape the future of sustainable urban energy systems.
7. **Identify major energy-consuming appliances in households**: By using electricity monitoring devices, it is possible to determine which appliances and activities use the most energy. Citizens can then designate locations for conservation efforts based on an analysis of consumption trends. For example, home appliances like refrigerators, washing machines, and HVAC (heating, ventilation, and air conditioning) systems, frequently account for a sizeable amount of energy use. People can significantly reduce their overall consumption by focusing on these areas.
8. **Reduce energy demand during peak hours**: It is well-known that energy usage varies throughout the day or week, and demand peaks at specific times can put stress

on the energy system and increase inefficiencies. Incentives to shift energy use to off-peak times can help ease this burden and save money. By implementing an awareness campaign (like citizen science), we can encourage load displacement and more effective energy use among participants.

9. **Foster collaboration among residents to reduce CO_2 emissions**: The activity aims to increase awareness about how energy connects neighbours through the electricity grid, opening possibilities for collaboration to reduce CO_2 emissions in their neighbourhood. This could help avoid net congestion and promote joint action towards a more sustainable energy future.

3. Methodology

The general methodological approach is based on *citizen science* techniques, ensuring that the interventions are tailored to the needs and expectations of the project, as well as the involvement of the inhabitants of the dwellings.

However, in each city (Bilbao and Amsterdam) a specific methodology adapted to the local context has been developed, considering the social, urban, technical and energy characteristics of each one.

4. Bilbao

4.1. Context Bilbao PED

[Status update:

In April 2025, significant progress has been made in the development of the citizen science initiative: the activity has been fully designed and the IT systems have been successfully developed, tested, and replicated to ensure its implementation in the final dwellings.

Currently, efforts are focused on facilitating access to households, a crucial step for the implementation phase. This process is expected to be completed by June 2025.

Once access is secured, the next phase will involve the implementation of the citizen science activity within the participating households.]

[To be developed when recruiting the dwelling and householders involved]

4.2. Methodology

4.2.1. Approach

In Bilbao there is a medium level of participation (level 2), called 'distributed intelligence` (see figure 1) in which the citizens participate as interpreters. The implementation of this citizen science project in Bilbao will be done with a multi-pronged approach: data collection (energy consumption per dwelling and electricity price) and energy monitoring (specific energy consumption in different devices per dwelling.)

This approach will help identify citizens who may be using more energy than the average consumer, while the electricity price data will be combined with the consumption patterns from the monitoring devices. This will enable the correction of energy consumption behaviours that could be leading to high costs and increased load on the grid.

4.2.2. Householders selection criteria

In the first phase, neighbourhood associations and district centres will be contacted through the Bilbao City Council, with the aim of identifying volunteer households interested in participating in the study.

Subsequently, the volunteer households will be evaluated according to three inclusion criteria: i) availability of certain resources in the home, necessary for the proper functioning of the monitoring equipment; ii) access to data from the electricity distribution company; and iii) verification of regular use of the dwelling (i.e., that it is regularly occupied).

The dwellings that meet these three requirements will be included in the study.

4.2.3. Structure of the process

For the development of the methodology, a process structured in 4 phases is proposed: i) intervention (energy data collection and electricity data monitoring); ii) data analysis and insight extraction; iii) sharing information with citizens; and iv) conclusions.

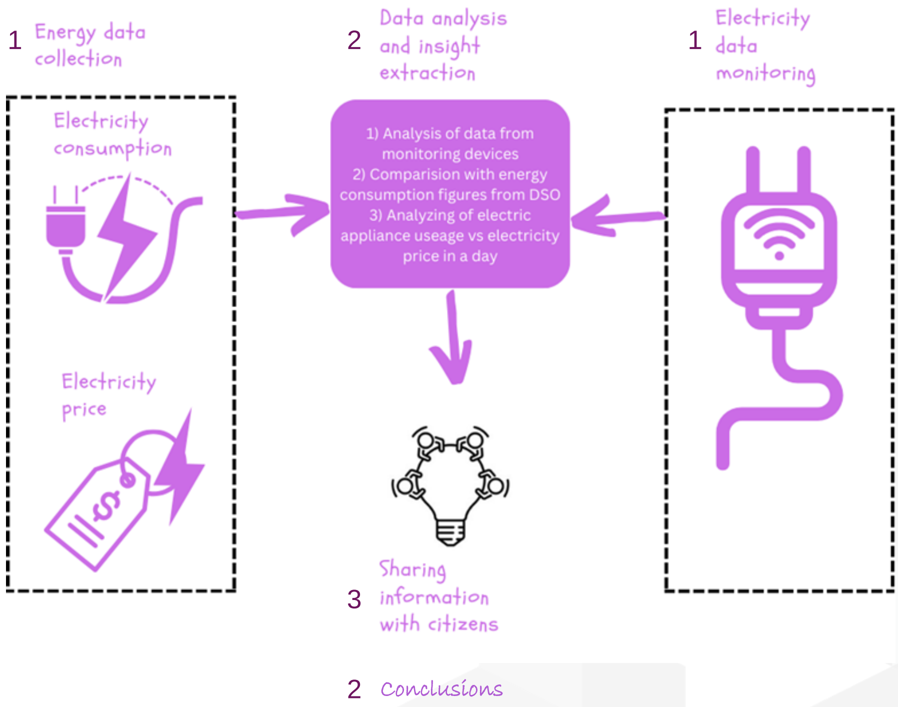

Figure 2. Approach for the citizen science project

4.2.3.1. Pre-intervention

The purpose of the pre-intervention phase is to assess the technical and logistical issues in dwellings, ensuring that all requirements are met before proceeding with the installation and configuration of the measuring devices. Conducting these checks in advance helps prevent potential complications and optimizes system performance.

To ensure the correct function of the system, certain technological requirements must be verified: the household must have a Wi-Fi router; ensure that it has at least one available Ethernet port and provide the administrator password for proper configuration; and access to electricity contract information and to the Distribution System Operator (DSO) platform. Besides, the accessibility to install meters in key appliances will also be confirmed, including the refrigerator, washing machine, TV, electric water heater (if applicable), and at least two or three additional locations within the home.

Once these verifications are complete, an appointment will be scheduled for the technical survey and installation of the monitoring system. This structured planning ensures that the process is carried out efficiently and tailored to each household's needs while anticipating potential issues before the intervention phase.

4.2.3.2. Intervention

Energy data collection: data of energy statistics

To gather comprehensive insights for the citizen science project, an array of energy statistics will be sourced from publicly available databases. These datasets are instrumental in elucidating consumption patterns, pricing dynamics, and regional variations in energy usage. The following points outline the key sources and their respective contributions to the project's data acquisition and analysis:

1. Energy statistics will be sourced from publicly available databases.
2. 'Esios' serves as a primary data portal for the Spanish national grid, offering hourly energy price data among other metrics.
3. The hourly energy prices from 'Esios' will facilitate decision-making regarding the optimal usage of electric appliances during periods of high electricity prices.
4. Another data source is 'Datadis', functioning as a neutral information hub for electricity supplies in Spain.
5. 'Datadis' provides both private and public information, including aggregated daily energy consumption data for residential households at the regional level.
6. The publicly available data from 'Datadis' is typically consolidated with approximately a three-month delay.
7. Despite the delay, reasonable assumptions can be made to utilize data from the preceding year, enhancing the robustness of the analysis.

Energy data collection: data of energy supply

The second source of data is the supply. This will come from two places, the DSO and the invoices. In Bilbao, the DSO that covers the entire city is IBERDROLA DISTRIBUCIÓN

ELECTRICA (I-DE). This information can be found on the online portal[1] and it requires authentication. The data available from the portal is:

1. Hourly consumption data for up to 1 year (Consumption and invoice).
2. 5-minute data for up to 1 week. Needs to be explicitly programmed in advance .

Another source available from the DSO is via using an API[2]. The DSO provides the capacity to retrieve data from the web portal via an API. This requires authentication and that the user is defined as "advanced". The available data is:

1. Sub-hourly time series on electricity consumption in the recent past (i.e. ~24-48 h).

Data can be retrieved through a House Assistant integration. This is set so that data deliveries are made available every ~3-6 h.

Energy retailer invoices can also be used to collect data. In Bilbao, a large share of consumers is covered by two companies which sell electricity: IBERDROLA CLIENTES or IBERDROLA COMERCIALIZADORA ULTIMO RECURSO (CURENERGIA). The information available from the invoices are as follows:

1. Monthly data.
2. For each tariff period:
   a) Contracted power.
   b) Consumed electricity.
   c) Unit costs for power and consumed electricity.
3. Fixed costs & taxes.

Electricity data monitoring

Deusto will deploy localized monitoring units in each dwelling. These will be composed by a Central system (RaspberryPi) with Home Assistant (OS) and several smart plugs.

The data monitoring activity will yield data of energy consumption pertaining to various electric appliances in the household. Once the monitoring equipment is setup, it will be left for about 4 weeks (1 month) to allow for data to be collected. The data obtainable from these monitoring devices is as follows:

1. 1-minute or better over the monitoring period.
2. Data from smart plugs (electricity).
3. Typical installation points (household dependent):
   a) Water heater (if electric and located inside the dwelling).
   b) Fridge.
   c) Washing Machine.
   d) Dishwasher.
   e) Other small appliances in the kitchen (grouped in 1-2 plugs).
   f) Computer/office.
   g) TV & home leisure.
   h) Up to 10-15 plugs per apartment.

[1] https://www.i-de.es/consumidores/web/guest/login
[2] https://community.home-assistant.io/t/iberdrola-distribucion-i-de-energy-monitor-custom-integration-released/326602/7

From these three data sources mentioned above, some interesting data can be collected, listed below:

1. Share of energy consumption per household appliance.
2. Share of parasitic energy consumption.
3. Comparison of energy consumption against typical dwelling(s) in the area.
4. Load shifting potential & cost impact (laundry & water heating).
5. Rise of Energy-Awareness.

Questionnaire

The occupants of monitored dwellings will complete two questionnaires: one before the monitoring and another one after it (once the results of the study have been shared with the participants).

The first questionnaire includes general questions related to knowledge of electricity consumption in the home, the contracted tariff, the energy efficiency of devices, and their usage habits.

The second questionnaire focuses on specific aspects of how the results obtained have influenced (or not) the users' habits related to the use of household equipment.

4.2.3.3. Data analysis, insight extraction and sharing information.

Once the data is collected, the monitoring equipment will be removed from the houses and data analysis will begin. As mentioned previously, the monitoring data will aid in determining if the consumer choices of using electric appliances are energy efficient or not. This will be done by comparing the electricity prices throughout the day with the energy consumption of monitored appliances. The insights drawn from this analysis will finally be shared with the participating citizens.

4.2.4. Deployment and testing monitoring process

Before starting the monitoring process, a field test of the system was carried out. For this purpose, two dwellings were selected in Bilbao, each one with a specific objective:

- Dwelling 1 (B_01): to verify the proposed monitoring technology and devices.
- Dwelling 2 (B_02): to evaluate the validity procedures defined for the deployment of monitoring devices.

In addition, the results obtained in both dwellings were analysed in order to identify inefficient behaviours or appliances which energy consumption was higher than expected, and recommendations were provided to optimize the consumption of the dwellings.

4.2.4.1. B_01

In this dwelling, a family of four members (two adults and two children) lives. With the aim of verifying the functionality of the proposed methodology, energy consumption was measured for the following devices: computer, TV, fridge, microwave, device for music, washing machine, and small appliances. Besides, the total household consumption was recorded, which led to the creation of an additional analysis category (miscellaneous) that grouped the remaining devices and outlets that could not be monitored.

Starting the exploratory analysis, the box plots (Figures 3,4,5,6,7,8,9 and 10) are used to get a sense of total energy consumption for each appliance. The results show that there is a moderate consumption (range from 0.5 to 1 kWh) and low consumption appliances (up to 0.20 kWh).

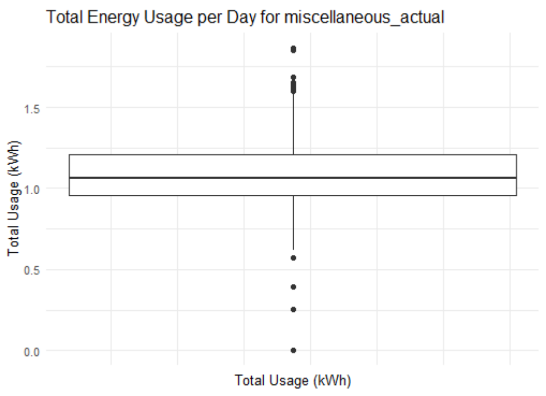

Figure 3. Total energy usage per day for miscellaneous category

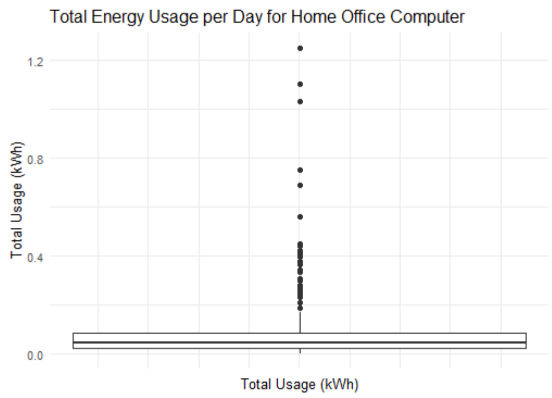

Figure 4. Total energy usage per day for computer

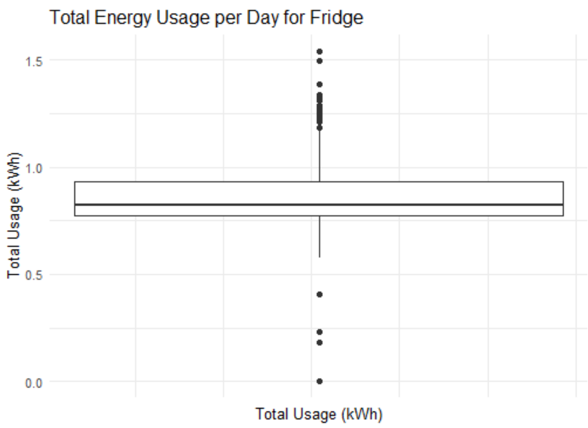

Figure 5. Total energy usage per day for fridge

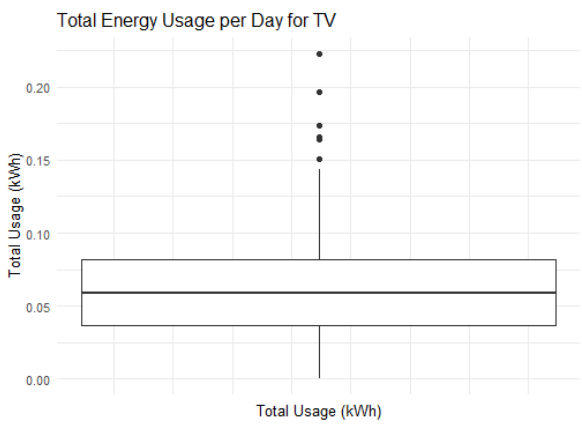

Figure 6. Total energy usage per day for TV

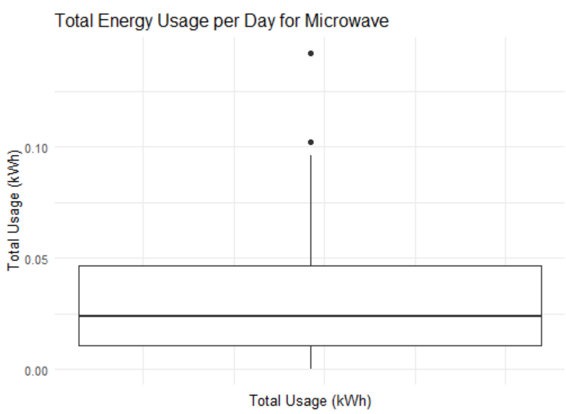

Figure 7. Total energy usage per day for microwave

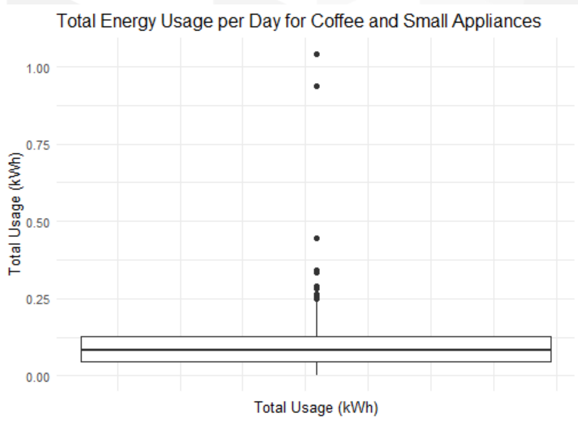

Figure 8. Total energy usage per day for small appliances

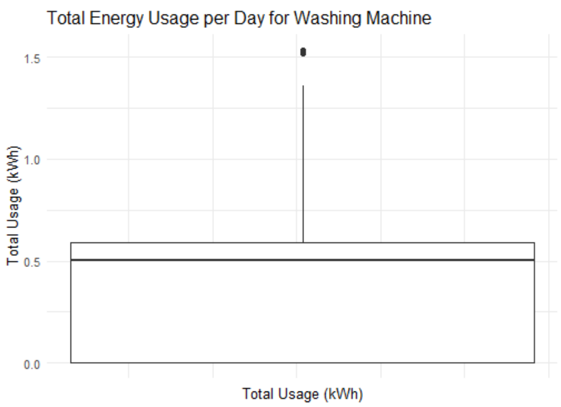

Figure 9. Total energy usage per day for washing machine

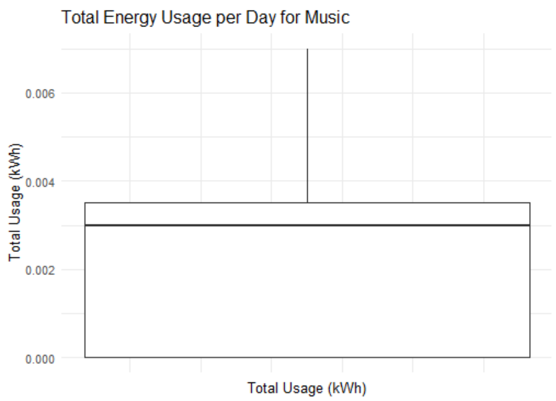

Figure 10. Total energy usage per day for Music

Figure 11 shows a pie chart of all the appliances, where the highest consumption is produced by the miscellaneous (40,5%), the fridge (32,1%) and the washing machine (16,6%).

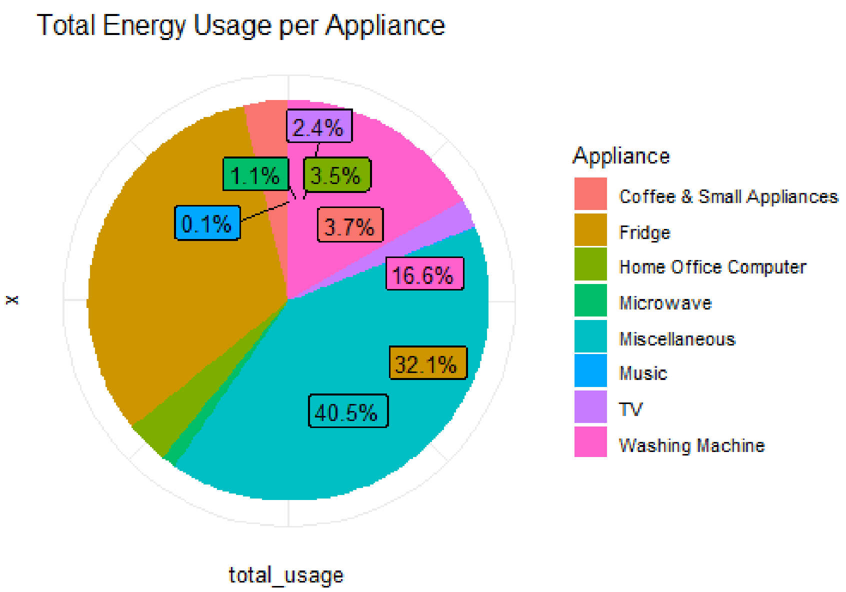

Figure 11. Total energy usage per appliance (pie chart)

Figure 12 reveals that the highest load is in produced during peak tariff period. 1 In Spain, electricity prices are organized into three time periods: peak, flat, and off-peak. The peak period, with the highest prices, runs from 10:00 to 14:00 and from 18:00 to 22:00; the flat period, with intermediate prices, runs from 8:00 to 10:00, from 14:00 to 18:00, and from 22:00 to 00:00; and the off-peak period, with the lowest prices, runs from 00:00 to 8:00. These schedules apply from Monday to Friday on working days, while Saturdays, Sundays, and national holidays are considered off-peak throughout the entire day.

Figure 13 depicts the contribution of each appliance to the total energy load (kWh). Like in the previous figure, 'moderate consumption' appliances are also the main contributors.

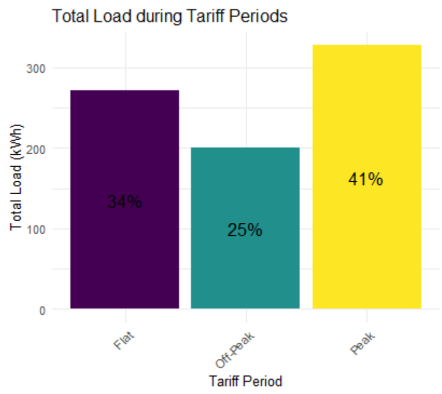

Figure 12. Total load during tariff periods

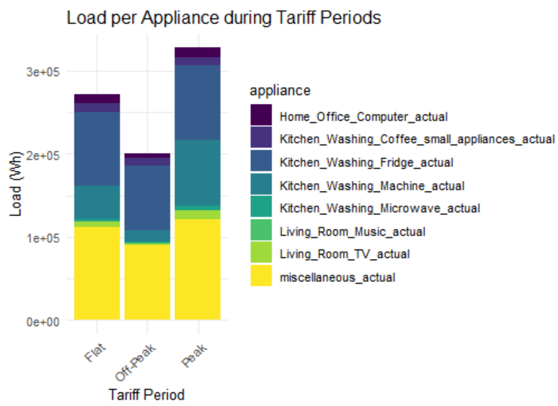

Figure 13. Load per appliance during tariff periods

4.2.4.2. B_02

In this dwelling, different adults live together in a shared apartment. For the objective of assessing the replicability of the methodology, the energy consumption was measured for the following devices: microwave and small appliances.

Exploratory analysis of the data collected is performed in order to get insights from the data. For each appliance following plots are made to get an understanding of the data, compare in terms of costs and, eventually, produce recommendations.

Starting the exploratory analysis, Figure 14 presents a pie chart showing that small devices consume nearly 75% of the energy.

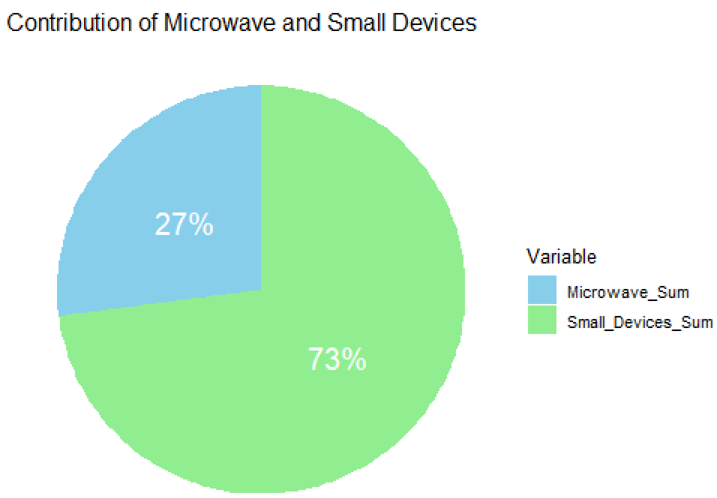

Figure 14. Total energy usage per appliance (pie chart)

Figure 15 reveals that the highest load is produced during peak tariff period. Figure 16 depicts the contribution of each appliance to the total energy load (kWh). Like in the previous figure, 'small devices' are also the main contributors.

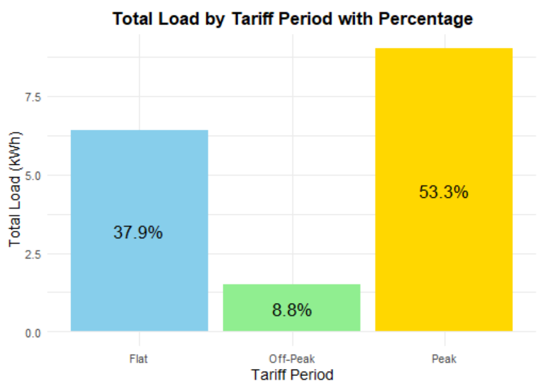

Figure 15. Total load during tariff periods

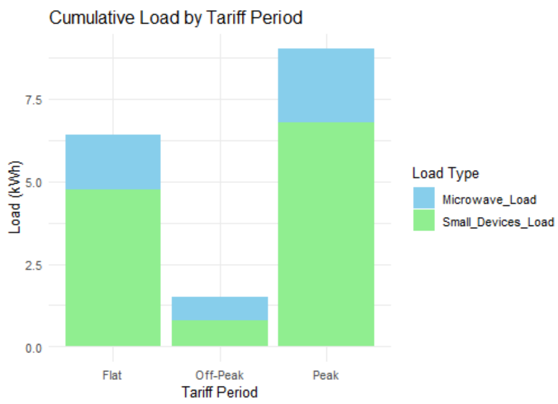

Figure 16. Load per appliance during tariff periods

4.2.4.3. Recommendations

The discussion on the results obtained from the analysis of the energy consumption data from the house hold is organized in three sections. Starting with high consumption appliances, it is important to highlight these as they contribute the most and improvement in this area leads to greatest cost saving opportunities, which is the second section and, lastly, some discussion on behavioural changes from the occupant side.

A) High consumption appliances

It is clear from the box plots that the frequency of moderate devices consumption is much higher than the low consumption appliances. This is simply because it is used more often and therefore has a higher energy consumption.

B) Cost saving opportunities

In order to determine the cost saving opportunities, the highest consuming appliances are analysed against tariff periods. From the obtained results it is evident that fridge, washing machine are utilized more during the peak period compared to the off-peak and flat periods. This opens up an opportunity for improvement.

C) Behavioural changes

Based on the identified cost-saving opportunity, one possibility for the occupant in B_01 could be to shift the use of the washing machine to off-peak hours. Modern washing machines offer scheduling options, allowing them to be loaded in advance and programmed to operate during off-peak times. This would help reduce both energy consumption and electricity bills. Regarding usage in B_02, shifting the use of small appliances (such as a PC) to off-peak hours could be more difficult, as it may be related to working from home or leisure activities.

4.3. Dwelling selection for monitoring

The target audience is defined as private households in Bilbao, with particular interest in areas close to Zorrotzaurre.

Given currently low population in Zorrotzaurre, this neighbourhood is aggregated with neighbor areas in Deusto and San Inazio. All these areas are of particular interest.

Access to the target audience is being facilitated by the municipality of Bilbao through the district-level council (mixed council, with representatives of the City council and local associations).

The citizen science activity is scheduled to be presented to the city council in May 2025. Here, associations in the district will be contacted, and the access to end-households is expected to be facilitated.

The actual citizen science activity is expected to be deployed after the summer break, with about 20 households meeting the inclusion criteria previously described, which will be monitored for about 1 month each in the September 2025 to March 2026 period.

4.4. Results

No results are available yet, as the monitoring process has not started due to the lack of access to the dwellings.

5. Amsterdam

5.1. Context Amsterdam

In Amsterdam, the citizen science activities were originally planned to take place in the PED sites. However, we eventually moved them to a different part of the city. The buildings of the PEDs in Amsterdam were slow to be built and residents in Republica did not arrive until 2024 with Poppies expected to occupied in late Spring 2025. After they had moved there, residents were asked to take part in a lot of research activities from the various ATELIER WPs, which was overwhelming to residents. Besides, the leaders of the cooperation 'in-the-making' in the PEDs resisted ATELIER activities as they were afraid to overburden residents. Waag Society therefore decided together with Amsterdam University of Applied Sciences and the coordinator of the ATELIER project, that it would be better to move some of the activities to a different district of Amsterdam: IJburg. This concerns specifically:

- Cocreation of energy data commons, which demands engagement in a cycle of activities leading up to the design of requirements and possible ways to respond to them in design (T7.1).
- Citizen science, which demands involvement in several workshops, as well as looking for answers to the measuring questions in one's own house (T7.4).

IJburg is a 20-year old district built on a couple of islands in the river IJ, just north of Amsterdam (hence we speak of our activities *on* IJburg, as the district is built on islands). Residents from IJburg set up an organization, Natuurlijk IJburg, and aim to make IJburg more environmentally friendly. It is this organization that wanted to work with us as they were interested in turing their neighbourhood into a PED. As the community on IJburg is able and willing to take the time and do the effort to get together for the cocreation and citizen science workshops and engage in the required activities at home, we decided this was a good place to do the citizen science activities.

Participants were recruited in a variety of ways. Next to our advertisement on the district's online platform 'Hallo IJburg' and through community centers, local shops, café's and libraries, leaders from Natuurlijk IJburg helped to bring together a group of neighbours to explore their interest in forming an energy community and explore possibilities to develop a PED on IJburg's islands in the river IJ. ATELIER's citizen science activities were a way for them to get their neighbours to engage in a conversation about this. Our purpose with the citizen science activities related to this: we wanted to engage residents who are not yet living in PEDs in the energy transition.

5.2. Research questions of citizen science activity

In order to realize the aims of the citizen science activity, we formulated the following research questions.

1. Does the technology contribute to knowledge and awareness of electricity consumption and production, in individual households and the neighbourhood?
2. What did citizens learn from the activity (with respect to their own research questions)?
3. What requirements does the energy monitoring technology have to fulfil for residents to use it and appreciate it?
4. What is the contribution of citizen science to the empowerment of residents to collaborate jointly around realising the energy transition in their neighbourhood and develop towards a PEDs?

5.3. Approach

In this project we understand the term 'citizen' broadly: it includes all inhabitants of the neighbourhood connected to the same electricity grid and interested to collaborate around electricity.

In Amsterdam we choose a high level of participation (level 4), called 'extreme citizen science' (see figure 1), as we aim for intrinsic as well as extrinsic benefit. This means we do not only give citizens a role as data collectors (extrinsic benefit), which are subsequently analysed by professional researchers who use it to develop scientific knowledge (intrinsic benefit) based on the data which is at the end shared with the community in the form of learnings or communications (Wildschut 2017). Instead, we want to involve citizens not only in data collection but also in their interpretation. It is only when citizens have a role in information interpretation that they will be able to understand its meaning, which will enable them to engage with data and use them in decision making in their own households and in the development of an energy community in their neighbourhoods.

In this way, citizen science can **enhance social capital**; we want people to get motivated and stay involved. According to literature on citizen science in the context of other environmental topics, this motivation most likely comes about when citizens are actively involved in seeking answers to questions that they themselves experience as problems, using the data that they collected (Ebitu et al 2021). Or, as Pino et al (2022) state, when citizens are enabled to ask the research questions themselves, this contributes to their 'ownership' of the problems that they seek an answer to. Also, it allows citizens to gain more agency over their environments as they are involved in finding the answers to their own questions, and this enables them to act as knowledgeable and skilled actors who can contribute to solving their own environmental problems, such as their energy problems.

5.4. Methodology

To describe the method we adopted, we need to separate between: i) design of the citizen science activities; ii) recruitment of participants; iii) selection of the technologies to carry out these citizen science activities; and iv) the methods to monitor, describe and assess the effect of these citizen science activities on the awareness and knowledge of residents and on the contribution of these activities to empowerment of residents to turn their neighbourhood into a PED.

5.4.1. Design of citizen science activities

A lot of citizen science activities engage citizens in the collection of data, which are subsequently analysed by professional scientists. In these projects, citizens serve professional science. But our citizen science activity had a different aim: we wanted to help citizens to acquire knowledge about the energy transition by themselves, which would allow them to govern their own energy transition. It was therefore more a type of 'public research': the research carried out as 'citizen science' is done by citizens and serves to answer the questions that they have themselves.

While recruiting participants for our citizen science activity, we talked to many residents in different districts in Amsterdam and we noticed there is a large difference between people who know a lot about the energy transition and those who know very little. We also noticed that most people (both with and without knowledge) tend to reflect on the energy transition in an individual manner: they reflect on their own decisions (for ex. to buy photovoltaic solar panels, a heat pump or an electric car), but almost never reflect on the dependence on their own individual choices on an electricity grid with limited capacity.

To enhance awareness and knowledge of all participants and empower them to move forward, we decided to have two separate phases in the citizen science activities:

1. Individual monitoring (Local).
2. Collective monitoring (Energy community).

Three workshops were organized, and between them we asked participants to carry out monitoring activities in their own households. The workshops were:

1. **A kick-off** during which: i) we explained the purpose of the activity during a presentation; ii) handed out the smart-meter measuring devices (the dongles) and explained how they needed to be installed; iii) engaged participants in setting up 'measuring questions' to which they would have to find answers during the first measuring period (between workshop 1 and 2); and iv) gave them a logbook in which they could note the answers to their measuring questions, based on their monitoring activities at home.
2. **A second workshop** focused on: i) comparing the answers that participants found to the measuring questions which were noted in the logbook in subgroups; ii) exchanging lessons learned; iii) we introduced the collective monitoring phase with a presentation during which we showed the community platform and how it is able to represent assembled data from the neighbourhood; iv) we asked participants to shape measuring questions about the assembled energy data of the entire community in subgroups; and v) asked consent from participants to collect data on the collective platform.

3. **A third workshop** during which: i) we provided insight into the graphs on the community platform representing the shared data of the participants on their electricity production and consumption; ii) talked about what people saw and/or what surprised them; and iii) answered the collective measuring questions which they listed during workshop 2. In the end we reflected with the group on what they could do with these data, and whether (and under what preconditions) they would like to collaborate with the purpose to eventually realize a PED.

5.4.1.1. Timeline of the citizen science activities

The citizen science activity in Amsterdam took place from spring 2023 until winter 2024.

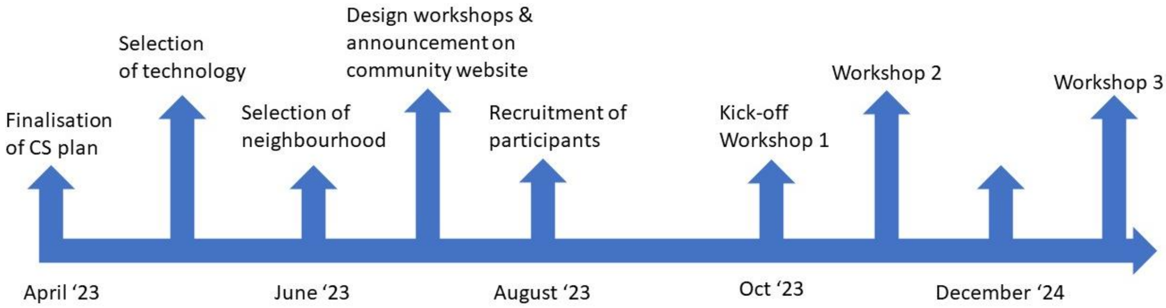

Figure 17. Timeline of the activity.

5.4.2. Recruitment of participants

For the citizen science initiative, our target was to involve 50 households. Our recruitment strategy involved engaging key members of a local sustainability community called Natuurlijk IJburg. These were our linking pins to recruit other residents using a snowballing approach through both online and offline channels.

In addition, we engaged in other recruitment activities. We made posters and flyers, which we attached to the wall in community centers, local libraries, a community 'living room', supermarkets and café's.

Figure 18. The poster/flyer of the event

We also wrote an announcement for the community platform *HalloIJburg*, which is widely used in this neighbourhood, and which contains a kind of 'activity newsletter'. Here we posted an announcement about the citizen science activities, and invited citizens to participate. On this community platform, we also created a page where we shared updates about the project, further program announcements and updates (see: https://halloijburg.nl/project/9783/energiemeent--ijburg). Furthermore, a local neighbourhood meeting space played a role in spreading the word about the project via social media and also offline, by disseminating flyers with information about the activity within the meeting space itself. All workshops related to citizen science and data commons happened in this same meeting place, creating a cohesive and centralised experience for the participants.

Eventually 55 people showed an interest. Of those 55 people, 40 residents actually went to the community library to collect a dongle that we provided to measure energy, and a smaller group also decided to join the meetings. During the three workshops there was a steady group of 15 participants, and during every meeting there was a group of between 3 and 8 'extra' people joining. These extra participants participated actively in the workshops, but they did not participate in the whole sequence of activities.

We don't know why people who initially showed an interest (by subscribing to the group meetings and collecting the dongle) eventually did not show up. We never actually met them and therefore were not able to ask. But the people who were part of the flexible circle of attendants provided different reasons for not attending to all of the meetings. They gave reasons like: lack of time to join, or other commitments. Furthermore, some of them said they expected to have to be able to invest in photovoltaic solar panels, but lacking the money to do so; some also mentioned their lack of knowledge about the topic (it is perhaps 'too difficult' for me), or some said they did not know whether the topic would be relevant for them, given that they live in an apartment building where there is little room to decide for oneself about energy, or having a rented house and knowing that decisions about energy are not theirs to take. Someone in the core group who joined every time also had his own explanation: 'People in IJburg want to feel free, they come when they feel like it and cannot be forced in any way.'

The core group was composed primarily of men with ages varying between 40 and 80 and one woman (70+). The majority had a higher education (university or applied university), but there were also 4 participants with middle education levels (secondary vocational education). Across these various education levels some people knew a lot about energy, and others did not. In the flexible group that joined only sometimes, 8 more women joined as well as 12 men of varying education levels.

5.4.3. Selection of technology

The citizen science initiative aimed to enable individual monitoring of electricity consumption and production and it facilitated a comparative analysis of energy behaviours at the group level. To realize these ends, Waag chose to work with: i) a combination of an open source dongle which could be plugged into the P1 portal in the smart electricity meter; and ii) a (cooperative) platform for sharing of energy data within energy communities.

5.4.3.1. Open-source

In a citizen science activity, citizens learn by doing. To do this we decided to use open-source technologies. Open-source means that the source-code is visible and the entire solution could be rebuilt without permission of the initial developers and contributors. The software and hardware architecture is transparent. By using open-source technologies individual citizens and communities obtain the possibility to understand, control, own and manage the technologies used within the community. Technical support can still be outsourced.

In theory, there are several benefits from using open-source, which is that it:

- Prevents that individuals reinvent the wheel, as solutions can be freely shared once developed and tested
- Increases digital participation, as everybody can join and see how it works
- Can decrease security risks as errors can be found and solved faster
- Improves interoperability as connections with other solutions can be made faster when the source code is available.

The choice to use open source technology seemed to fit best with the purpose of citizen science, which is to empower citizens to engage actively in the energy transition. Open source technology allows to engage actively also with data collection, storage and display of results.

5.4.3.2. Selected technologies and platform

We started with technologies that only disclosed data locally. Then we moved to a community cloud where the data of the participants would come together.

Figure 19. Starting from local monitoring, we moved into community monitoring.

Figure 20. Open-source P1-dongle used. All technical information is available on GIThub

Individual monitoring: Open-source P1-dongle

For phase 1, the individual monitoring, we used the open-source dongle from Smart-stuff, that can be found here on Github. We also had contact with another open-source dongle producer in Belgium, which can be found here. But eventually we did not choose that one.

We made a concise and more extensive manual explaining users how to use the dongle and how to install it, which we provided with the dongle in a box specifically designed for the IJburg workshops. We also developed an installation instruction video (in Dutch) which we made available on the community platform *HalloIJburg*, where residents could easily find it.

Many countries have smart meters. The dongle we used is connected through a telephone cable in the P1-port and can be used in different countries. The solution and workshops we held on IJburg in Amsterdam are therefore also usable in other EU countries, such as by other members of the ATELIER consortium.

Once the dongle is correctly installed, the first dashboard can be seen. This is represented below. Especially the real-time character of the monitoring and the ability to see developments each 10 seconds, allows users to see the effect of the use of different devices in the household on the electricity consumption. This real-time monitoring is what enabled participants to experiment with the dongle in their own households: they could turn a device on and see on the dashboard how much electricity it uses.

In addition, the dongle also delivers real-time data about electricity production, which allows to monitor at what moments of the day a lot of clean energy is available. This information allows to make choices regarding when to turn household devices on or off. In figure 3 a P1-dongle dashboard can be seen of a household that delivers power back to the grid ("teruglevering"), generated with roof-top photovoltaic solar panels. On the islands of IJburg, no one uses natural gas, so that was not visible on the dashboard.

Community Platform: EnergyID.

To collect and monitor energy use and supply in the entire neighbourhood, we made a connection with the energyID platform, which did not have a community platform at the time of our citizen science experiment on IJburg (2023-2024). After that, EnergyID developed this community platform, and now when we are writing this report (March, 2025) it is available.

Usually, the data monitored with the P1-dongle is only visible inside the local Wi-Fi network. This ensures that the energy data is accessible by the household. Energy ID keeps the data in a common storage place where data of all their clients are stored, but the clients continue to be in charge of what happens to the data as they automatically become members of an energy data coop. To combine energy data and compare them with each other, we collaborated with EnergyID, because of this cooperative approach to data governance. EnergyID is a cooperative cloud-based energy solution provider, initiated and owned by cooperatives, and is mostly used in Belgium.

Figure 21. Interface on local dashboard of dongle, showing information about the connection to EnergyID platform.

We had the dongle firmware adapted (which was easy, because it was open source) so that a connection could be made with energyID from within the local dashboard.

First, an account on EnergyID had to be created. Then in the dashboard one could login to EnergyID, a secure code would be exchanged between the online account and the P1-dongle and the data would be sent via an API. Technical details of the API can be found here.

The integration to the platform is visible here for those interested to do it themselves. There is also already an integration with an open-source dongle from Belgium.

Waag Futurelab acted as group administrator on the community platform, as it was not yet technically possible to give all neighbours access directly. Waag could see all the different records of the participants, and presented the assembled energy data of all participants during the workshops with the participants. We asked consent from participants to use the data in this way, only for the time of the citizen science experiment. After the end of the citizen science experiment, we deleted all data that we collected and ended the EnergyID community platform that we formed specifically for IJburg.

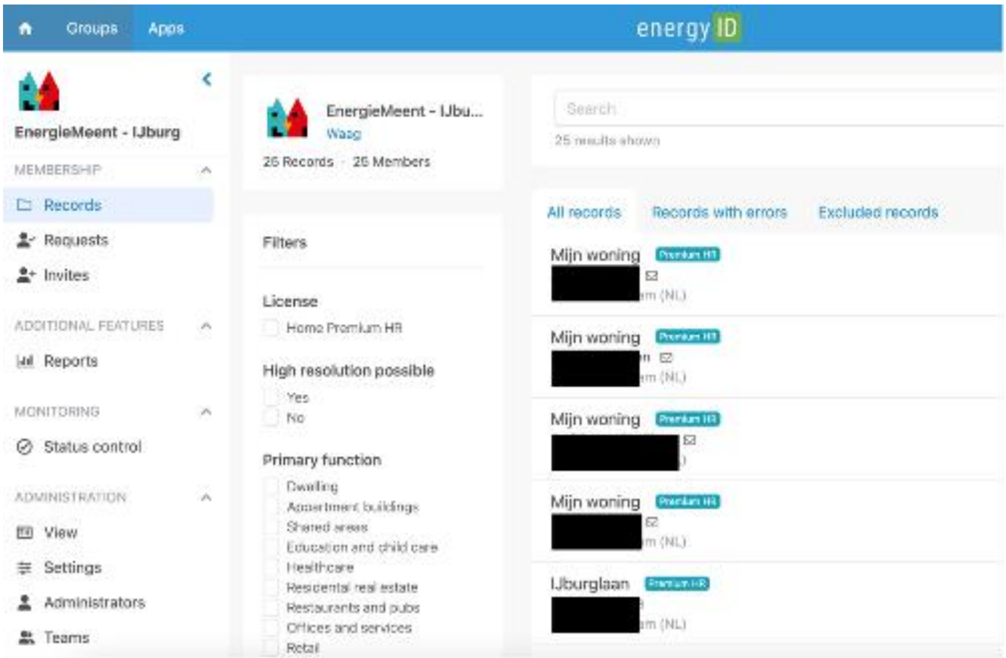

Figure 22. Administrator dashboard of the community platform

5.4.3.3. Methods to monitor, describe and assess.

In order to answer the research questions, we followed two methodologies:

- During all workshops we noted our observations, in as far as they are relevant for our research questions. We also recorded all conversations in the subgroups and listened to them afterwards and used them to enrich our notes. As there were three researchers involved and every researcher had its own notes, based on the conversations of the entire group as well as subgroups that we each led separately, we compared the notes after every workshop and discussed differences between our observations, in order to come to a shared understanding of the workshops. These observations allowed to come to an answer to the research questions.
- After the citizen science activities were completed, we did interviews with 10 participants in order to hear about their experiences. These interviews were recorded and transcribed verbatim, and analysed by two researchers.

The observations, notes and analysed interviews provide the basis for the results of this report.

Figure 23. Pictures of the workshop meetings in the Flex-library on IJburg

5.5. Results

The meetings led to very lively discussions, which allowed to monitor what was happening on various themes related to our research questions. Here we noted the results of our observations.

5.5.1. Satisfaction of expectations

During the first workshop, we asked participants to tell us about their motivation to join the workshops and citizen science activities. In this way we acquired insight into their motivations to join. We discerned six types of motivations. Some participants mentioned only one of these, some mentioned a combination:

- **Curiosity**. Some participants joined because they were simply interested to hear more about the energy transition, or about their own use of energy: '*I am just curious to know more about energy*', or: '*My expectations are not very high, but I'd like to know what I use*', or: '*I am interested to know what I can do to spare energy*.'
- **Learning (even) more**. There were participants who already knew a lot about the assets available and who already had photovoltaic solar panels, electric cars or (in one case) a heat pump and whose primary reason to join the meetings was to learn more about technologies they could employ: '*I hear about solutions and think: hey, that's interesting. So I'd like to learn more about that*', or: '*I've been interested before, but I know there's a lot more to learn, so I decided to join*.'
- **Improving the neighbourhood**. There were participants who joined because they felt particularly connected to the neighbourhood IJburg; they lived there since its beginning, and sometimes even built their own house there, and wanted to turn it into a more environmentally friendly neighbourhood: '*I live here since 2009 (..) I think this neighbourhood is beautiful and I think a collaboration around energy would make it even more beautiful*'.
- **Contribution to a better climate**. Participants joined out of a general feeling that they wanted to prevent that the environment deteriorates and that the climate changes: '*Contribute to the prevention of climate change. That is not only about diminishing CO_2 emissions but also realizing a cleaner living environment*.' Some people also mentioned that doing something together with neighbours made them feel more optimistic: '*Sometimes you feel you cannot do much about the environment (..) and when we do something with the whole neighbourhood, it makes me feel more hopeful; like, we can make a difference*.'
- **Concern about costs**. Some participants joined because they were worried about the increasing costs of energy: '*I don't have solar panels myself, but I get worried sick about my increasing energy bill*', or: '*Saving energy to save costs and to save the environment. The two go hand-in-hand*.'
- **Becoming more sovereign**. Some people wanted to use less fossil fuels, in order to be more independent from countries that produce natural gas or oil, such as Russia or the middle east: '*Current geo-political tensions are an important reason to reduce our use of fossil fuels and become more independent*', or: '*This last year the prices of gas went up so much because of Russia and the war in Ukraine, that I thought: we really need to abandon gas*.'

At the very end of the sequence of workshops and citizen science activities, we asked people whether the workshops and citizen science activities brought them what they had expected, and whether they were satisfied. Participants were predominantly satisfied, but there were also some critical remarks. The positive feedback that participants gave were:

- **Learning about individual energy use**. Many participants said they learned a lot during the citizen science activities about their own energy consumption. Learnings included (a) acquiring general knowledge about electricity, (b) learning about the use of energy by different devices in their house, and (c) seeing options to reduce energy use.

- **Learning from each other.** There were different ways in which people reported that they had learned from each other:
    - **Difference in knowledge/awareness**. Some participants brought forward that they had not realized how big the differences are between those who know a lot about energy and those who do not. The workshops helped them see this difference, and realize that this needs to be considered when realizing an energy cooperation together.
    - **Comparing energy consumption across households**. Many people reported that they learned a lot from comparing the data of the energy use in their households with each other. Differences between energy use of similar households elicited reflection about what they themselves can do to bring their energy use down. Some people also mentioned that it had a 'competitive effect' on them: they wanted to be the one using the least energy in the neighbourhood.
    - **Becoming aware of mutual dependence**. Many people reported that they had not expected that seeing data of the entire community would make them more aware of their dependence on a communal electricity grid. It made them think more of themselves as a member of a community, rather than an individual trying to reduce energy use.
- **Motivation to create an energy community and eventually a PED.** Participants mentioned that they wanted to move forward. They wanted to keep using the technology and involve more people on IJburg in an energy community.
- **Valuable discussion about data sharing.** Many people were interested in the discussion about data sharing, to which the use of the community platform gave rise. They had not expected this to happen. Some people said they expected this to be a technological experiment, and that they were happily surprised to see that the social dimension of the innovation received a lot of attention.

The negative feedback that we received was related to the technologies and the lack of possibility they had to keep using them after the end of the experiment. In addition, some had expected the experiment to really kick-start an energy community on IJburg, and they were disappointed that this was not the case. The reasons why they could not continue were:

- **Immature technologies**. Several participants (but not all) had serious difficulties to use the technologies and needed a lot of assistance. Colleagues from Waag biked around IJburg to help people out but some residents of IJburg also had to help their neighbours.
    - **Install dongle and read out the data**. They did not get the dongle installed or enter the dashboard on which they could monitor their individual energy use.
    - **Sharing data with the community platform**. Some people had trouble sharing their data with the community platform. They needed help to do that.
    - **Only administrator can access the platform**. The platform was not yet ready to allow everyone to see the collected data of the entire neighbourhood. An administrator was the only one having that access.
    - **Information provided on the platform**. Some people commented that the community platform was not user friendly, and that they would prefer to get

another kind of information on that platform: they wanted to see the energy use in every household and compare across similar households.

- **Difficult for people to get engaged**. Because the technologies did not yet work properly, they could not support the continuation and expansion of the energy data common on IJburg.

In the following we will dive a little deeper into these various positive and negative aspects, providing more information on how the workshops unfolded.

5.5.2. Learning about individual energy use

Four colleagues from Waag shaped and conducted the workshops, complementing each other's expertise: an engineer with specialization sustainable energy, an anthropologist specialized in citizen engagement, an ethicist with a focus on data governance and a project manager. During the first workshop we introduced the entire citizen science experiment, we made time to get to know each other, and then we asked participants to list their measurement questions. These questions would mark the beginning of the period during which they would monitor their own energy use. Discussions resulted in the formulation of six measurement questions:

1. How much electricity do different household devices consume? (Or more specific versions of this question: how much electricity do I consume when I am gaming? How much electricity does my phone take when I am charging it? What device in my house uses most energy? Etc.)
2. How much energy do we use at night or when we are not at home? If you turn everything off, what do you still use?
3. At what time of the day are there peaks in energy consumption?
4. Which devices contribute to my own peaks in electricity consumption?
5. When do the photovoltaic solar panels supply electricity?
6. How can I influence in consumption (without getting into an argument at home)?

Each participant went home after the first meeting with a dongle which they had to install into their own smart meter. They had to open the web page and start doing experiments to find answers to the questions they listed. They would describe the answers in a logbook that we gave them. When they came to the second meeting, we asked them for their experiences with the technologies. Some had been able to install them without difficulties, but others had experienced them. Colleagues from Waag, or tech savvy people from the neighbourhood, had helped them out to solve the problems.

List of reported technical problems encountered with the dongle:
- Difficulty finding the P1 port.
- Older smart meters do not have a P1 port (Smartstuff was able to provide an adapter).
- The plug did not fit into the P1 porl (it had to be made smaller).
- Wi-Fi did not work.
- The pop-up screen did not pop up (tried again, several times, and then it worked magically; not sure what the problem was).
- Someone needed a splitter, which Smartstuff provided, and then it worked.

After the first workshop people went home and the first period of measuring started. People noted the answers they found to their measuring questions in the logbook and then returned to the second workshop. During the second workshop we asked people to sit together in subgroups and compare the answers they found to their questions. We observed the following learnings:

- **Different household devices use different amounts of energy**. Participants noticed that some household devices use a lot of energy, whereas others use very little. The water cooker, washing machine, a dryer or dishwasher is immediately visible. Charging the electric car clearly takes up a lot of the available electricity: '*What my car uses is quite enormous, actually*.'
- **High electricity use of some devices**. Some household devices caused high peaks in electricity, whereas people expected these to use very little. '*I have a nice little lamp near the television, which turns out to use a lot of energy. Maybe I should no longer use it*', or: '*What you could see very well in my house, was the elevator. You see a peak when the elevator is starting up, and then the peak goes down again. And it is an elevator with a soft start!*', or: *'I bought a welding machine. First it caused a short circuit. It should function on 220 Watt, but everything just stopped*. *Perhaps on the circuit there were also other devices using electricity and then this welding machine uses energy on top of that, and that was too much'*, or: '*My oven really uses a lot, much more than I thought*.'
- **Low electricity use of some devices**. '*I would think I use a lot of energy in the evening when the lights are on. But I have led lights and they use very little*', or: '*I would think that my freezer would use a lot of energy, but it uses a lot less than I expected. I measured that specifically. When I measured it was only 100 Watt*', or: *'I have an old washing machine and I expected it to use a lot. I wanted to replace it. But as it turns out, it is not using that much. I decided to keep it a while longer.'*
- **Change of devices**. Some people in the team changed devices and saw a difference I their energy use. '*I had a very old dryer and had it replaced. My new dryer uses a lot less energy*', or: "*I saw that my computers use a lot of energy at night. They are stand-by. But then I changed a plug, and now they use a lot less. That was interesting*.'
- **Limited time of electricity delivery**. Photovoltaic solar panels deliver electricity when the sun shines, but people saw that they actually deliver peak energy only during a short period. For some this was between 12:00 and 14:00, others say they have their peak time in the morning. This led to a conversation about whether it is possible to turn one's photovoltaic solar panels. It also led to a conversation about the question why energy is cheaper at night, when there is no solar energy available.
- **Difference in use at night**. The difference in energy consumption of various households at night, when everything is turned off.

The use at night elicited particular discussions between the participants, as people engaged in conversations about what could be the cause of it:

A: 'I use 500 Watt an hour at night, even if I use nothing at all. During the day I use less, but that is because my solar panels are working at that time.

B: That is a lot. My use at night is just 200. How can that be?

A: I have no idea.

B: The 200 at night is just the refrigerator, the freezer, the alarm clock-radio, the pump of the floor-heating

A: My 500 Watt, I don't know what causes it. I have some garden lamps, ventilation

B: Do you ventilate that much?

A: Yes. I have a device which takes air from outside and refreshes the air inside. Apparently, that uses quite some energy. Charging phones, I do that at night. Charging my e-bike. The pump of the floor heating.

B: We also have a pump of the floor heating. So, our households are comparable. How can it be that you use so much more than me? Perhaps those lights in the garden?

A: Quite interesting to look at each other's use. I wonder what I can do differently to reduce my 500 Watt.'

At the closing of the three workshops participants mentioned during the interviews that they learned about their individual use, and they mentioned that having insight into their own electricity use motivated them to bring their electricity use down. Some reported that insight into their own energy use changed their behaviour quite a bit, such as the following quotes from three different participants illustrate:

> *'When I started, I really wanted to know what I am using, you know. And I wanted to know when I have to pay attention; that I turn on the dishwasher and the washing machine at the same time, for example. That causes quite a peak, and I did not know that, and I never really paid attention to that. And now that you asked me to pay attention to that, now I know. I think it is nice that I know that now. But I did not know that there is such a world of technology; it really opened my eyes.'*

> *'I was already paying attention to my energy use. But I never really looked so closely that I could compare the different devices. I thought this was interesting. Now that I could see how much electricity the various devices use, this made me think about how I can diminish my use in a different way. For example, I have the central heating on 18 degrees, and usually I take an electric heater with me in my study, for it is cold when I sit still all the time. But I saw that this uses about 1000 Watt all by itself. Now I bought an infrared panel and put that under my table, which uses not even 100 Watt. This is actually very effective, and it uses a lot less.'*

> *'I would definitely want to continue using this dongle. It provides quite specific information about different devices in the house and that gives us real-time feedback on our behaviour. When I look at what I use regularly, then I think immediately about how I can bring my electricity use down. That goes quite naturally.'*

5.5.3. Communal learning

In the second workshop, we introduced the community platform to the participants, and we asked participants to formulate measurement questions about their energy supply and use as a community. This resulted in five types of questions:

1. What is the difference between the volume of the energy consumption of the community and the volume of the energy that is generated with photovoltaic solar panels?
2. At what time of the day are there peaks in energy consumption in the neighbourhood? (And: What causes the peaks?)
3. Are there surprising variations in either energy supply or use?
4. Are there particular devices in the neighbourhood that use a lot of the available energy from the grid?
5. How can I influence in the consumption of the people in my neighbourhood (without getting into an argument)?

At the end of the second workshop, we asked whether participants were willing to share their data with the community platform for a period of a month. Participants could choose to either join with their own name, or with a nick name. We explained that the data would be shared only during the period of the citizen science experiment, and that after that the membership of the community platform would end and access to the data would stop. Participants consented to participate. After that, we explained what participants had to do to share their energy data with the platform.

List of technical problems encountered with the community platform:
- Difficulty sharing the data with the platform.
- Platform is not yet accessible to every data contributor; it is only accessible to the administrator.
- The data platform provides graphs which represent real-time energy use of all data contributors, and all energy generated by them.
- The platform does not allow to compare energy use across similar households.

During the third workshop we looked at the community platform together with the entire group, and we provided answers to the questions together. It was visible that:

- Participants use a lot more energy than they generate (10% of the energy used was generated by photovoltaic solar panels).
- Peaks in energy consumption were visible mostly in the evenings, when people come home from work or school, turn the lights and the heating, and start using their devices.
- Peaks in energy generation are mostly visible during the day (therefore: peaks in use and peaks in electricity production do not occur at the same time).
- Very high peaks in energy use are visible which result from specific devices, especially electric cars.

These observations elicited a discussion amongst participants during the workshop. Topics that figure in the discussions were: (a) whether it is possible to spread the energy use out more over the duration of the entire day, (b) the possibility of synchronizing energy use and energy supply more in the neighbourhood, (c) whether it is possible to generate more energy from clean sources as a community, also by means of wind mills, and making sure that this benefits the residents of IJburg (rather than placing windmills that benefits the energy providing company) (d) buying a community battery to save energy from sun, (e) the level of 'meddling' of neighbours in your energy use that is wanted/acceptable.

Particularly interesting is during all of these discussions, participants realized that they were connected to each other via an electricity grid. This realization caused a shift in the focus of the discussions. In the first of the three workshops, participants sometimes dreamed of being 'self-sufficient', meaning that they would generate as much energy as they would use themselves. Such an individual focus is illustrated by the following quotes from conversations in workshop 1:

> *F: 'I work at the municipality and I did research, because I wanted to install a geothermal heat pump. I wanted to dig it into my own garden. You have to contract someone who can do that for you. My neighbours also wanted to have it. But you cannot both do it. It is really: who comes first, gets it first.*
>
> *G: That is strange, that you cannot have a geothermal heat pump anymore if the neighbours have one.*
>
> *F: I really would like to be self-sufficient. But if you live in an environment with a lot of holes in the ground, then you cannot do it anymore.*
>
> *G: So that means that if you have it, your neighbours can't?*
>
> *F: I would much rather share it with the neighbours, but I can't.'*

This can be contrasted with conversations in workshop 3, where participants considered the goal of sharing clean energy sources:

> *H: I live in an apartment building with a large empty roof. So much room, you could do so much with it.*
>
> *I: Contact your neighbours. You could place it full of solar panels and serve everyone.*
>
> *H: Yes, but how do you arrange that with Vattenfall [the energy provider]?*
>
> *J: Did you hear of Schoonschip? What they did, they have a common energy connection. All together behind one electricity meter. They said to each other: we want to use 100 Watt max, and we organize together who can use it at what time. They have a physical meter. Imagine we would do that in your apartment building, or a housing block. The energy provider will say; well, that is quite interesting, it you can stay under a particular level of usage.*

In workshop 1 we observed that people talked about achieving more simultaneity between energy supply and use *within their own* households:

> *C: 'I've had my solar panels for a long time. Already for 10 years. Solar panels used to be very expensive at the time. Then I thought: how much time will it take until I earned back the amount I invested in buying them?*
>
> *D: And does it mean that you use now in a different way?*
>
> *C: Yes, I set a timer for my washing machine. Then I turn it on when the sun is shining.*
>
> *E: The future is that each of us has a battery.*
>
> *C: I also think of storage, then you can also use solar energy at night.'*

This can be contrasted with conversations in workshop 3, where participants talk about possibilities that neighbours use the solar energy that is generated in the neighbourhood:

> *B: I already said so… our opportunities to steer our own energy use is so limited. We have so little options to do something with the energy generated by our solar panels.*

E: Yes, and I rent a house, so that is different.

B: Yes, we should work together, we should collaborate, then you have a different conversation.
E: Yes, yes.

B: When my solar panels generate energy and I'm not there, I should send you a message saying: put your washing machine on!

C: Otherwise it goes to waste.

B: It goes to the grid and no one uses it.

In workshop 3, when participants had shared energy data and could see the energy generated and used by all of them, it became very natural to consider collaborating around energy. Participants considered the possibility of reducing CO2 by using the solar energy that their neighbour generates or investing together in photovoltaic solar panels and a neighbourhood battery. But they also considered how this could lead to difficulties, as neighbours might comment on your energy using behaviour:

A: I pay 500 euro a month for warmth, while I have a well-insulated house.

B: That is so much, I only pay 170.

C: I pay 200

B: How can that be?

A: We do take a lot of baths….

C: Yes, that is what is going to happen: we can look into each other's energy use. Then the neighbours will say: are you taking so many baths again?

D: That is what you are going to get, of course.

B: But do you want that? No.

D: You do want to learn from each other: why do you use less than I do? How do you do that? But you don't want people to judge each other for that. That seems to me not desirable.

Different participants brought forward situations in which it is disputable whether neighbours should meddle with someone's high energy use, such as:

1. A participant has a painful leg and takes the elevator, and neighbours might doubt whether his leg really hurts as much as he claims it does. Does his pain justify using the elevator?
2. A neighbour's daughter needs dialysis, which takes a lot of energy. Neighbours who see the high energy use ask for an explanation, thus necessitating this woman to be open about her daughter's condition. Can this still be considered private information?
3. A neighbour uses a lot of energy and neighbours find out that he has a marijuana plantation in his cellar. Are they compliant if they do not tell the police that they suspect the marijuana plantation to be there?
4. Can individuals in the neighbourhood still choose to have a jacuzzi in their back yard if neighbours are responsible for providing the energy?

5. Two neighbours want to charge their electric car: one of them is a physician and could be asked to act in an emergency, the other is just planning a visit to his elderly mother. Who is allowed to charge first?
6. A neighbour has guests and they charge their cars in the neighbourhood. What if the neighbours feel bad about outsiders using their electricity. Do they have a right to be angry?

During workshop 3 these questions were raised naturally, and people joked about them. We 'parked' these problematic situations and invited participants to participate in our commons workshops, where we specifically asked them to consider how they would like their data to be governed (see D7.2 for the results of that discussion about governance). However, at the end of the three workshops, participants mentioned that they particularly enjoyed these kinds of conversations. During the interviews they brought forward that this communal aspect surprised them and taught them a lot:

Interviewer: Are there things you learned from the workshops and the measuring?

> *H: Yes, I acquired new insights. You can also see what others do of course. I would like to focus on that more.*
>
> *Interviewer: And what caught your attention in what others do?*
>
> *H: I am a little…What you try to do, those collective solutions, that is actually quite new for me. For I am more individualistic, working on my own little things. Sometimes collective solutions are actually more…maybe better. It is a little early to judge that, but it is something new that I had not thought of before.'*

Interviewer: And was this project in any way different than you had expected?

> *A: Yes, the energy data common, the sharing of data, was different. It was very much about the social and communicative aspect, more than about the technical aspects. It was about awareness, collaboration, and finding an acceptable way to collaborate around energy and the data. I think specifically the social, communicative, aspect, was really different than in other projects I know of.'*

While most participants were interested in the communal aspect, some were not that motivated by it, such as the following participant explained:

Interviewer: Would you have wanted to continue sharing data?

> *L: Well, not necessarily. It is nice to see, but I am not that fanatic. I'm not going to do my very best, or compare myself with others all the time. It does not motivate me as much as it motivates others. I think that if you use a lot of energy, that you can get inspired to bring it down when you see that others use less. But I don't see significant differences, so I don't, it is what it is. If you use energy in a conscious way then you can always do better. But I think it is good as it is.'*

5.5.4. Motivation to shape an energy community

The citizen science activities led quite naturally to considerations about whether and how to collaborate in an energy community with one's neighbours. We observed two main advantages of the activities:

- Help people with little prior knowledge to get a better understanding, become more aware of their own energy use, steer their own energy use more and acquiring enough knowledge to participate actively in the discussions with others
- Assist participants to understand themselves as a member of a community, rather than (just) as an individual:
    - people with more knowledge about the energy transition took their role and supported their neighbours with less prior understanding.
    - participants compared their energy use and tried to explain differences, which provided reason to adapt behaviour (to many of them).
    - participants started to consider energy supply and use more as a communal affair and considered (a) realising more simultaneity of energy generation and use across households, (b) investing together in photovoltaic solar panels and/or batteries, (c) problems that might occur when neighbours share energy and can monitor each other's data.

At the end of the series of meetings, participants expressed the desire to continue activities and shape an energy community together, including an energy data common. They reported to appreciate the learning they had experienced, but also the fun they had while working together with their neighbours during the meetings. Positive feedback included the following quotes:

> *'I learned. I learned from other participants, as well as from the use of the technologies, and the talking about it. I think I know now better now what I can do to reduce my energy use. And I know now why it is important to work together.'*

> *'I think these gatherings were a lot more fun than I originally expected. I learned a lot, but what was most agreeable to me was that I got to know other residents from IJburg a little better.'*

Some people reported that the large difference in knowledge expertise was an important learning experience for them:

> *'What you see is that some people are still wrestling a lot with the concept of energy. There's a lot of ignorance about it. And there are a lot of opinions. (..) There was someone who did not really know what a Watt is. This person actually does not know what this is all about. At some point somebody brought this forward: that there's a lot of difference in knowledge and expertise, and that some people experience a high threshold to tell that, to say, well I don't understand this. This is my learning experience: if you want to engage people, like family and friends, you really have to keep it simple and explain things very well.'*

Negative feedback expressed disappointment about the lack of maturity of the technologies, which makes it hard to continue building an energy community after the workshops end:

> *'So, it is very disappointing that we cannot continue now and shape this energy cooperative. The technology does not work properly yet, and the membership of EnergyID ends. I would very much like to continue, and had hoped to have the needed technologies to do it after this project. Based on these technologies we cannot involve 200 more people, as they will be frustrated when the technologies do not work properly. If we can make the technologies more mature, then we can continue. That takes some time.'*

Others already knew a lot about different available technologies, but reported liking to see this technology and attending to the discussions:

> *'We use electricity in peaks. We have a morning start, an afternoon-start and an evening-start. I knew that, but I had never really seen it happening real-time. Otherwise I have not seen a lot of new things, I think. But I have to say: that app that you are using, it is really a pity that this is not yet ready for use, for I quite like it. That EnergyID? Yes, I quite liked using that one. It is quite broadly usable and it is user friendly and intuitive. I liked it, and it was interesting to see the discussion it generates among people. We never pay a lot of attention to that, but you cannot do without, actually. So, yes, that was interesting.'*

5.6. Specific conclusions

All in all, we conclude that different participants learned different things which contribute positively to their capacity to continue building energy communities. For some, it meant learning more about energy, and how to reduce energy use. For others it meant learning more about the social aspects of sharing energy and energy data, as well as how to communicate in groups in which people start with very different knowledge and expertise on energy.

Considering the research questions with which we started, we can draw the following conclusions.

1. **Does the technology contribute to knowledge and awareness of electricity consumption and production, in individual households and the neighbourhood?**

   Yes, this is definitely the case within individual households. Different participants reported that insight into their own real-time energy use provided them insight into the energy use of different devices, which allowed them to take measures to reduce their energy use. Many participants reported making such changes within their own household, which ranged between stopping to use certain devices, replacing them with other devices, using them at other times of the day, or turning them off more frequently (and not keeping them stand-by).

   On a community level we also saw that the activities led to more knowledge and awareness, which came forward in a change in the conversations from a focus on the individual level to a community level, for example with respect to investments in photovoltaic solar panels and batteries, or use of available solar energy by various community members. Simultaneous matching of energy supply and use in the neighbourhood became a topic of conversation. Furthermore, many participants were eager to compare their own energy use to that of others, in order to learn more about how to reduce their use.

   What did citizens learn from the activity (with respect to their own research questions)?

   Participants started with different levels of knowledge about energy and technology. Therefore, different people learned different things. Some people knew little about Watt-Hours, and learned the basics. They started to monitor their own use, and try to bring it down, and learned from comparison with their peers.

Others learned to move from a focus on their individual household to a communal perspective, which they had not considered before. They became more aware of their dependence of the electricity grid which they share with others.

Again, others, learned about the social and communicative aspect of data sharing and the sharing of energy, and realized that technology cannot simply be implemented, but needs to be accompanied with a social innovation. For them it was new to hear about the issues concerning solidarity, learning and privacy that people brought forward, and to hear about the various dilemma's that might occur when people start sharing data and energy.

2. **What requirements does the energy monitoring technology have to fulfil for residents to use it and appreciate it?**

   It needs to be easy to install and to put into use. There should be no hiccups, its use should be intuitive and answer questions that people in fact have. In this respect dongle and community platform caused some problems for some of the participants, which demand adaptation of the technologies.

3. **What is the contribution of citizen science to the empowerment of residents to collaborate jointly around realising the energy transition in their neighbourhood and develop towards a PEDs?**

   On this we are very positive. All but one participant was very positive about the workshops and the measuring activities as a way to involve people in the energy transition. They appreciated the careful way in which people were guided to find answers to their own questions, the help they received from the project members as well as from neighbours, the knowledge exchange, the open discussions, and the way in which social issues were recognized and addressed.

6. General conclusions

[To be developed when we have results from Bilbao]

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