Report on best practices and guidelines for user interfaces and user feedback

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Work Package 3 – Market Uptake

Deliverable 3.2

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This document is a deliverable of the FlexSys project (A Flexible electricity System contributing to security of supply) funded by the Energy Transition Fund of the Belgian federal government, managed by the FPS Economy, SMEs, Self-employed and Energy.

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1. Introduction

This document outlines the best practices and guidelines for designing user interfaces and gathering user feedback in the FlexSys project, focusing on the development of the COFYbox.io platform. The goal is to provide actionable principles that enhance usability, accessibility, and user satisfaction, particularly in systems dealing with complex energy data. The scope of the document covers the entire design process, from initial user research to practical implementation, while offering insights that can be applied broadly across similar digital platforms. The methodology combines user-centered design principles, iterative development, and real-world testing in order to create an intuitive and responsive interface that meets the diverse needs of end users. The document is structured to first present key design principles and then demonstrate how these principles were applied in the COFYbox.io platform, concluding with user feedback analysis and recommendations for future improvements.

2. Design Principles for COFYbox.io

This chapter outlines ten user interface design principles that guided the development of COFYbox.io. These principles were essential in ensuring that the platform is intuitive, user-friendly, and capable of meeting the diverse needs of its users. The principles discussed below serve as a foundation for designing a product that balances simplicity with functionality while delivering a seamless and satisfying experience. Where applicable, these principles will be illustrated with practical examples from our design process.

2.1. Understanding Your Users

The first step in designing an effective user interface is understanding your audience. Different users have different needs: some prefer a product that works perfectly straight out of the box with minimal customization, while others want detailed control and customization options.

To accommodate both groups, we provided default dashboards based on templates crafted by experts that work for most users while also allowing for deeper customization. This flexibility ensures that both types of users feel comfortable and catered to, without alienating either group.

Figure 1: Example dashboard

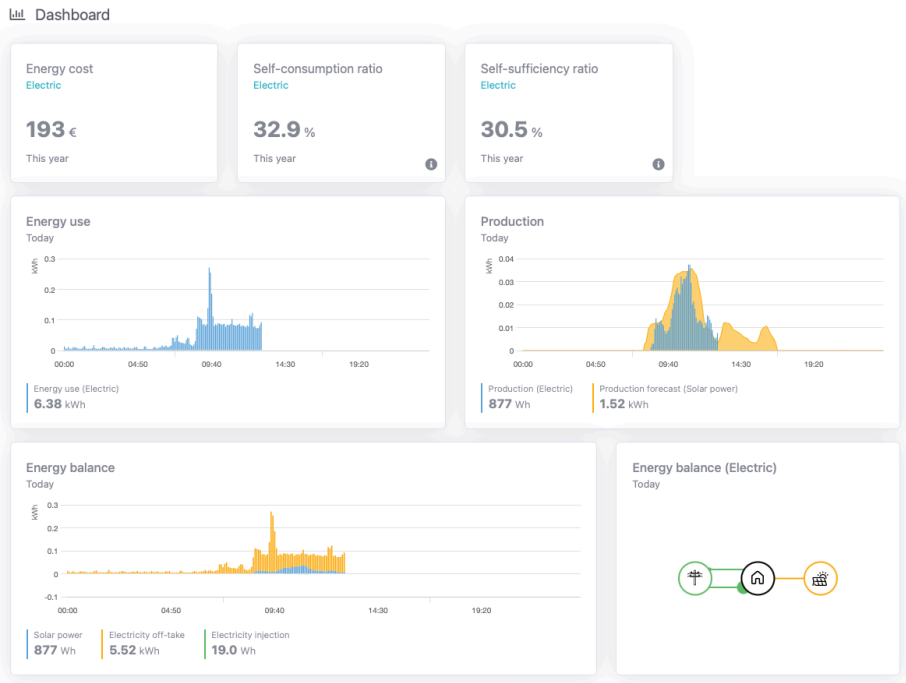


Figure 2: Personalized dashboard

2.2. Simplicity and Clarity

Energy data can be complex, and one of the biggest challenges in designing interfaces for such systems is preventing information overload. Prioritizing what matters most and presenting it in a clear, accessible way is crucial. By focusing on simplicity and clarity, we help users quickly grasp key insights without being overwhelmed by excessive or irrelevant details. Clear visual hierarchy, intuitive navigation, and concise labelling are central to this approach, ensuring that even non-technical users can easily interact with the platform.

These principles resulted in a clear visual language, with soft grey with a clear contrasting soft blue to highlight text of selections:

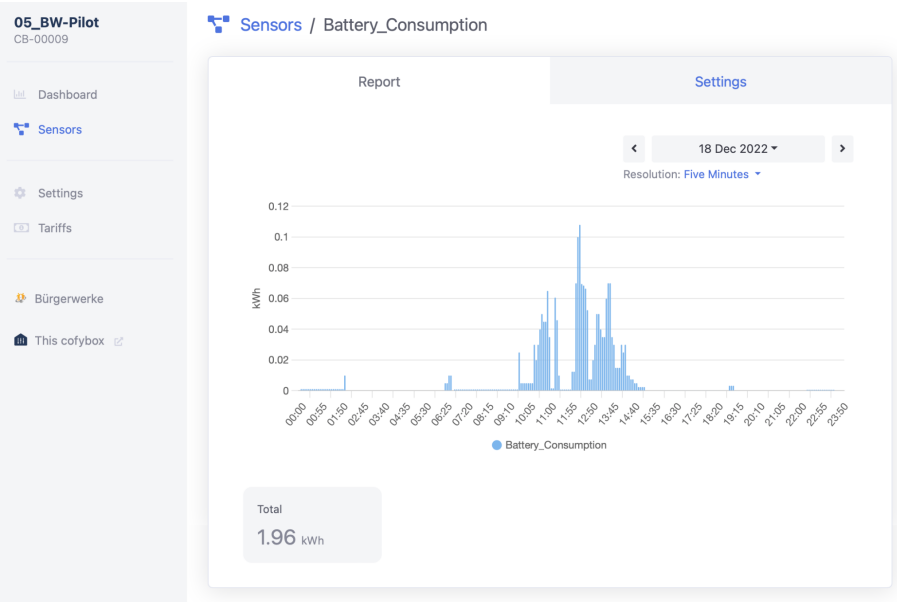


Figure 3: individual sensor report

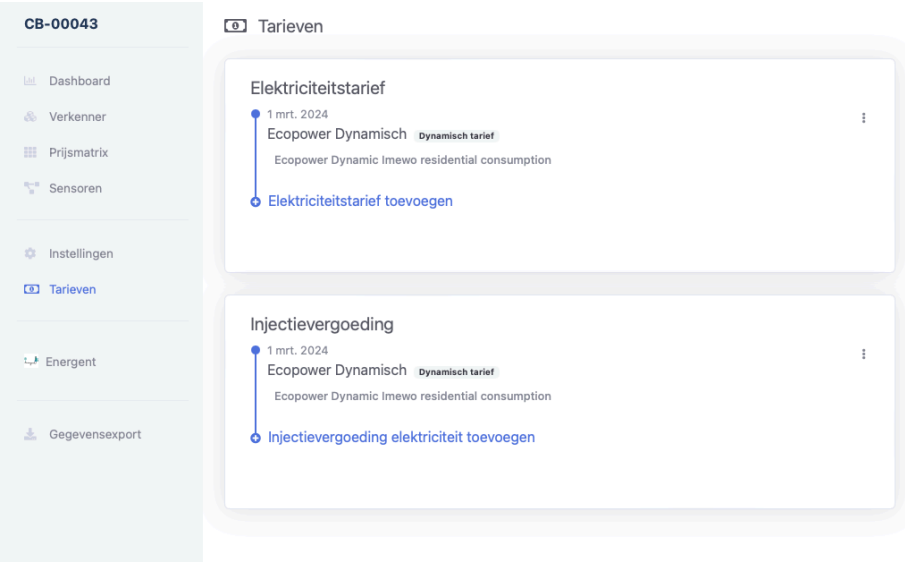


Figure 4: Tariff selection

2.3. Design for Multiple Devices

In today's digital landscape, users expect a consistent experience across various devices, from smartphones to desktops. Ensuring a smooth and visually appealing experience across all screen sizes is crucial. By implementing adaptive layouts, we designed COFYbox.io to be fully responsive. This means that whether users access the platform on mobile devices, tablets, or desktops, they enjoy consistent functionality and readability, ensuring key features and information remain accessible regardless of the device used.

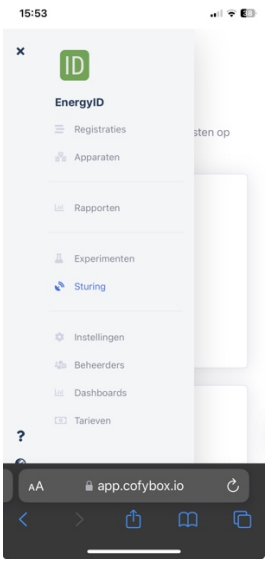


Figure 5: Responsive on mobile phone

2.4. Single Sign-On (SSO)

Users are increasingly reluctant to create new accounts with separate usernames and passwords for every platform. By offering Single Sign-On (SSO) options that allow users to log in with credentials from services they already use, we reduce friction and make access quicker and more convenient. This streamlines the onboarding process, enhances user satisfaction, and encourages engagement right from the start.

EnergieID developed an Identity Server based on IdentityServer4, an OpenID Connect and OAuth 2.0. framework. It enables the following features in the COFYbox applications:

- **Authentication as a Service**
  Centralized login logic and workflow for all COFYbox applications (web, native, mobile, services). IdentityServer is an officially certified implementation of OpenID Connect.

- **Single Sign-on / Sign-out**
  Single sign-on (and out) over multiple application types.

- **Access Control for APIs**
  Issue access tokens for APIs for various types of clients, e.g. server to server, web applications, SPAs and native/mobile apps.

Additional customization was added to support:

- **External logins**
  Support for external identity providers like EnergieID, Powershaper, etc.

- **User management features**
  Common features like password reset, email verification and account deactivation.

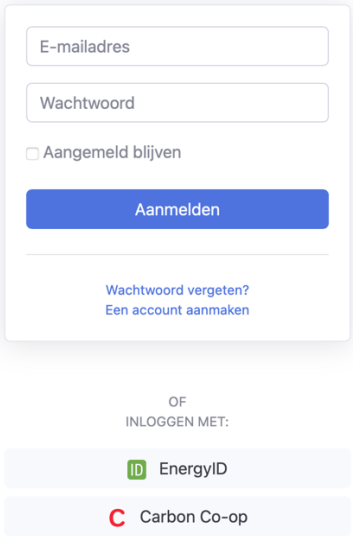


Figure 6: Login with EnergyID or Powershaper

2.5. Streamlined Device Enrolment

For platforms that involve installing new devices in homes, like COFYbox.io, linking those devices to a user's online account should be effortless. A complex or confusing enrolment process can lead to frustration and disengagement. Our approach prioritizes clear instructions, automated steps, and user-friendly interfaces to make the device enrolment process as smooth and straightforward as possible. This ensures a positive user experience from the very beginning.

EnergieID developed a device provisioning service (DPS) that allows COFYbox devices to securely connect to the right data hub for sending telemetry data to the cloud. The DPS enables complete automated provisioning, including both registering the device to the cloud as well as configuring the device.

The Device Provisioning Service is built in such a way to support:

- Zero-touch provisioning to a single IoT solution without requiring hardcoded IoT Hub connection information in the factory (initial setup).
- Automatically configuring devices based on pilot-specific needs.
- Load balancing devices across multiple hubs.
- Re-provisioning based on a change in the device such as a change in ownership or location.

All these scenarios are achievable today through the Device Provisioning Service using the same basic flow (step 1 – 2 – 3):

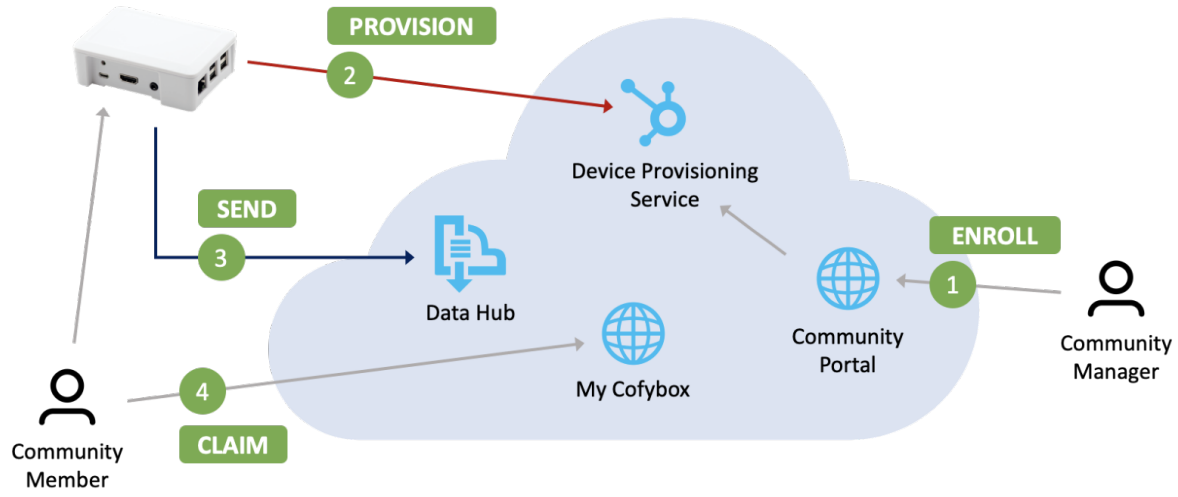


Figure 7: Provisioning overview

Once a device is claimed, a device twin is created in the COFYcloud to:

- Store device state information including metadata, configurations, and telemetry data
- Exchange configuration and settings between cloud and physical device

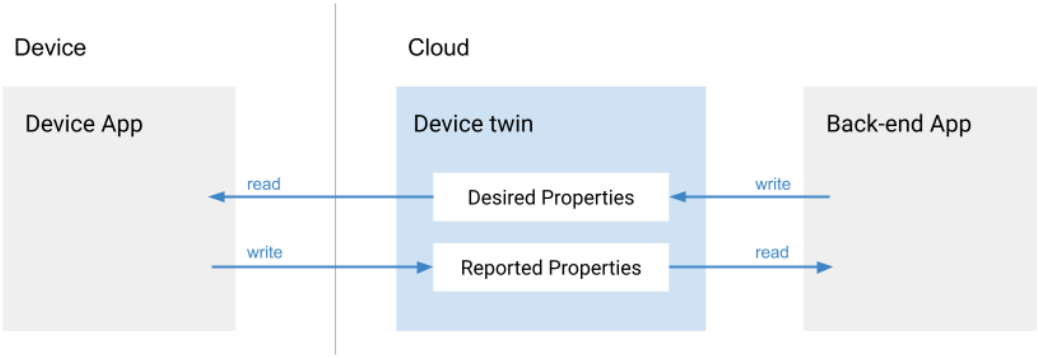


Figure 8: Digital twin

2.6. Responsiveness and Performance

In data-driven applications, users expect quick responses, especially when interacting with real-time graphs and visualizations. However, working with sensors that send data at high frequencies (minute or even second intervals) can pose challenges in delivering this smooth experience. To address this, we implemented back-end services that automatically resample and aggregate data. By pre-processing the data for visualization, we ensure that users experience minimal delays, allowing them to interact with charts and insights almost instantly. This focus on performance is key to maintaining user engagement and satisfaction.

EnergieID developed several back-end processes to efficiently capture, process and store COFYbox telemetry data. The following key concepts were considered:

- **Scalable architecture**
  All data processing services are event-based and can scale out.

- **Partitioning**
  All data is stored in partitions for fast retrieval and high performant queries.

- **Data roll-up**
  All telemetry data is down-sampled into several resolutions to support fast retrieval and high performant queries. For each resolution, a different retention period applies.

- **Data aggregation**
  The back-end services are designed to aggregate data of several COFYbox devices.

Together with big data storage solutions, we managed to create a swift environment to work in.

2.7. Consistency and Predictability

Consistency is key to creating a user experience that feels intuitive and easy to navigate. By maintaining uniformity in layout, interactions, and visual design across different sections, users can predict how to perform tasks, leading to faster adoption and fewer errors. Keeping button placements, color schemes, and navigation structures consistent across devices and features creates a cohesive user experience that is easy to learn and use.

As showed in 2.2, a clear and sober design language was used throughout COFYbox.io. Is also applies to the help section, which is made in a separate CMS (Content Management System). The user is confronted with a simple readable menu structure that is maintained during al navigation:

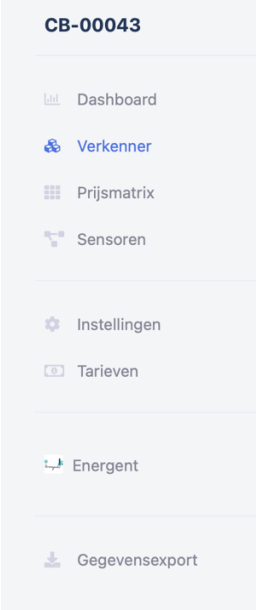


Figure 9: Clear menu structure

2.8. Data Privacy and Security

When designing systems that collect and process user data, especially energy data, privacy and security must be prioritized. Users need confidence that their data is handled securely and transparently. Incorporating encryption, secure authentication methods, and transparent data usage policies ensures that sensitive information is protected while maintaining trust. This principle also aligns with regulatory requirements, like GDPR, enhancing both legal compliance and user confidence.

As an IoT project, use of the cloud is important for the ecosystem and various measures are taken to ensure a secure system, such as access tokens and API keys. The platform also uses a set of security, privacy and data protection models that are used to comply with various data information policies in the context of cloud applications. More particularly, we make practical use of models like identity and access management, role-based access control (RBAC) and client authorization within the COFYbox Portal and Community Tools, a set of cloud-based web applications. In addition, we did a web application vulnerability assessment to identify web application security threats.

In terms of privacy, within the device enrolment procedures, the necessary GDPR consents are embedded on multiple levels. Adding to this, the community, which typically has a co-operative legal form of which the participant is co-owner, acts as a trustable party between a user and the energy market. Even community administrators can only access a COFYbox for support reasons after the appropriate privacy consent is given.

The COFYbox cloud architecture relies on Microsoft Azure (PaaS) services that are all hosted in Europe, more specifically at the West Europe datacenter, located in the Netherlands.

2.9. Feedback and Support

No matter how intuitive a platform is, users may need help or guidance. A well-structured help site with clear explanations and resources is critical. By providing comprehensive support materials, users can find answers to their questions quickly, enhancing their overall experience and reducing the need for direct customer support. Good support features are essential to maintaining user satisfaction and ensuring that users get the most out of the platform.

Therefore, a lot of time and effort was spent on a help section in the local language made available to the users. The style of the CMS was adapted to the design language of the webapp itself.

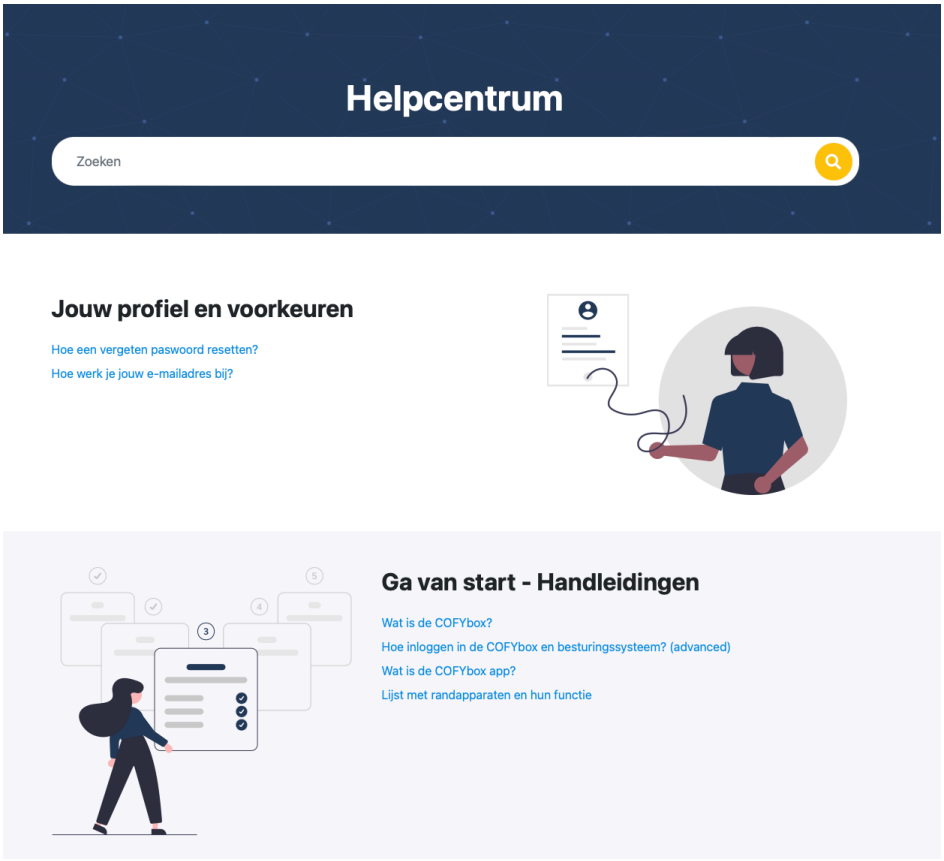


Figure 10: Support site for users

2.10. Iterative Design and User Testing

User needs evolve, and so should the design. Continuous user testing and feedback loops are critical for refining the product. Implementing an iterative design process, where the interface is regularly tested and updated based on real user input, ensures that the platform remains aligned with user expectations. This principle encourages a culture of continuous improvement, where enhancements are driven by actual user behaviour and preferences.

During the project key partners EnerGent and UGent were closely collaboration to adapt the webapp to the needs of the users and the pilot. Lastly, a survey was launched to get final evaluation feedback.

3. User Survey Results

3.1. Survey Questions

1. Frequency of Use:

"How often do you use the dashboard?"

2. Ease of Use:

"On a scale from 1 (very difficult) to 5 (very easy), how would you rate the overall ease of use of our dashboard?"

3. Navigation:

"On a scale from 1 (very inefficient) to 5 (very efficient), how would you rate the ease of finding the functions or information you needed on our dashboard?"

4. Design:

"How satisfied are you with the visual design of our dashboard (including layout, color scheme, font choices)? Rate on a scale from 1 (very dissatisfied) to 5 (very satisfied)."

5. Functioning:

"How would you rate the performance and responsiveness of our dashboard (considering load times, interaction speed, etc.) on a scale from 1 (very poor) to 5 (excellent)?"

6. Relevance:

"How would you rate the relevance and usefulness of the various features of our dashboard on a scale from 1 (not useful at all) to 5 (extremely useful)?"

3.2. Participation Overview

A total of 10 users were contacted to provide feedback on the dashboard. Out of these, 7 users responded and participated in the survey, providing valuable feedback on their experiences with the dashboard. The participants included a diverse group of users with varying levels of technical expertise and frequency of dashboard usage.

3.3. Survey Results

The results of the survey are summarized below, with visual representations provided in the form of histograms.

1. Frequency of Use:

Most respondents accessed the dashboard less than monthly, with some using it monthly and one respondent using it weekly.

2. Ease of Use:

The feedback on ease of use is generally positive, with most respondents finding the dashboard easy to use. However, two users found the dashboard difficult, indicating potential barriers in the interface.

3. Navigation:

Navigation received mixed reviews. While some users found it efficient, others rated it as neutral or even inefficient. This suggests that while certain users are comfortable with the interface, there is room for improvement in terms of making features more discoverable.

4. Design:

Design feedback was largely positive, with most users expressing satisfaction or neutrality. One user was dissatisfied, pointing to potential improvements in visual elements or layout.

5. Functioning:

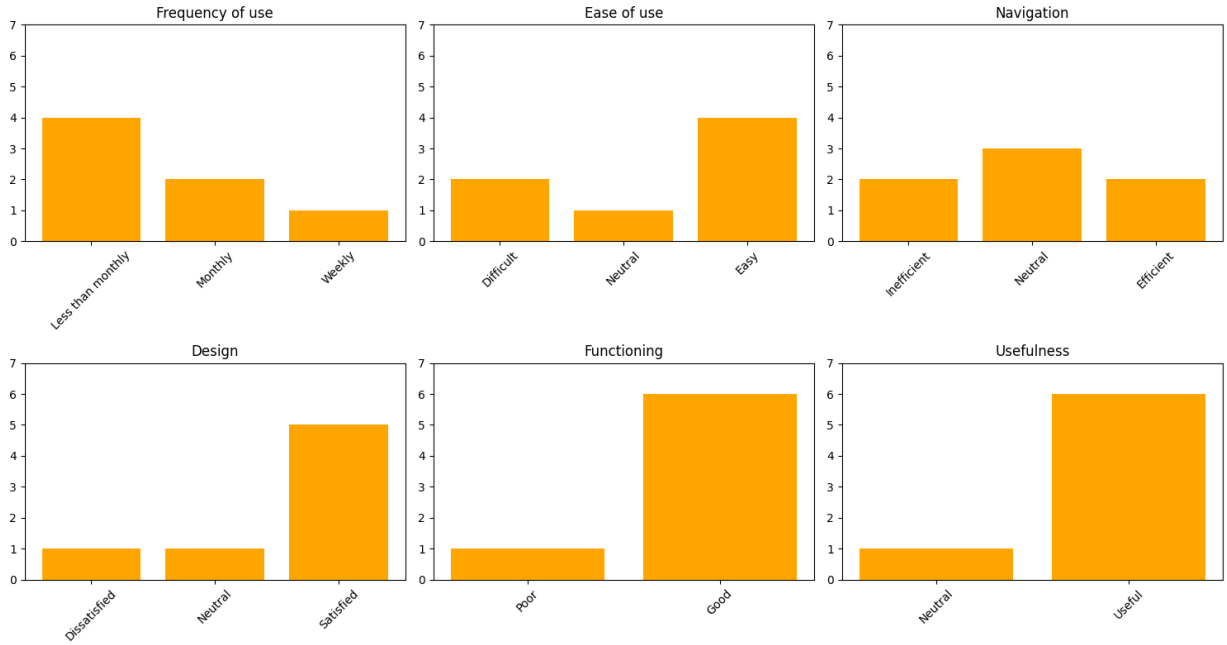
The functioning of the dashboard was consistently rated as good, apart from one respondent who rated it poorly. Most users found the dashboard responsive and fast, indicating that performance is a strong point overall.

6. Relevance:

The usefulness of the dashboard was rated highly by most respondents, with five users finding the features very useful. One user rated it as neutral, highlighting the need to refine or better highlight the most relevant features for all users.

3.4. Visual Summary of Survey Results

Below are histograms depicting the percentage distribution of responses for each survey question:



Based on the survey results, users generally find the dashboard easy to use, responsive, and visually satisfactory. However, the mixed feedback on navigation and occasional reports of difficulties suggests

that there is room for improvement, especially in making features easier to find and enhancing the user experience for those who struggle with the interface.

Moving forward, focusing on streamlining navigation, offering guided tutorials, or improving the discoverability of key features could address some of the challenges highlighted by respondents. Additionally, further iterations of the visual design could be explored to ensure that all users find it appealing and functional.

3.5. Analysis of User Comments

During the 291-day experimental period, the overrule function on the Dashboard was extensively used by participants, with a total of 83 activations across the two heating seasons. The majority of households engaged with this feature, with seven out of ten using the overrule button, although at varying frequencies. For instance, one household used it 19 times, while another used it only three times. Among the three participants who did not use the overrule button, one rated the availability of this option as "somewhat important" and another as "reasonably important" in the post-survey. This feedback, along with the results highlighted above, indicates that participants both understand and appreciate the overrule function.

When overruling, participants were encouraged to specify in a few keywords why they chose to do so. These comments provide valuable insights into their behavior and decision-making processes. The reasons collected show that these processes are complex and that interventions are often overruled because of various factors such as immediate family health issues (e.g., a child being sick), or household schedules (e.g., a child studying for exams or the household expecting visit soon).

However, as expected, most overrules were triggered by discomfort from lowered indoor temperature (e.g. “Te koud woonkamer (18,8 maar feel lager).”) or reduced availability of domestic hot water (e.g., “Te weinig warm water.”). Yet, other comments highlighted issues that could inform the design of large-scale flexibility programs.

First, it is observed that often only one person in a household takes responsibility for managing the overrules. As a result, some interventions were overruled in advance when that person was expected to be absent during the intervention (e.g., "Twee dagen congres, man solo thuis, kan niet ingrijpen in de cofybox, dus vooraf uitschakelen."). This suggest that it is important to ensure easy access to overrule functions for all household members.

Second, several comments revealed technical issues or concerns with the heat pump installation itself (e.g., "Foutmelding (sanitair warm water)", "verwarming springt voortdurend naar 30 graden... ligt dat aan jullie toevallig?"). Although these were sporadic (only seven out of the 83 comments), they underscore two important challenges of flexibility programs: it remains difficult to consistently connect and control heat pumps and it is critical for participants to have a direct communication line with the party managing the flexibility interventions to raise potential issues.

4. Conclusion

4.1. Summary of Key Points

1. **User-Centric Approach Validated**: The project demonstrated how we were adhering to user-centered design principles for creating our user interface. By focusing on understanding users, ensuring simplicity, and providing responsive performance, the COFYbox.io platform was able to meet diverse user needs, offering a balance between functionality and ease of use.

2. **Key Challenges Identified**: User feedback highlighted some areas for improvement, particularly regarding navigation, feature discoverability, and customization flexibility. These insights are crucial for refining the product further.

3. **Importance of Iterative Development**: The iterative design process was key to refining the platform, allowing for continuous improvement based on real-world usage data and user feedback. This approach will remain essential as the platform evolves.

4.2. Future Work

1. **Integration of Advanced Data Analytics**: To provide more valuable insights to users, future work could focus on integrating advanced data analytics and machine learning techniques. This would allow for smarter predictions, personalized recommendations, and more adaptive systems based on user behavior and energy patterns.

2. **Long-term Vision for Flexibility Services**: As the energy landscape evolves, so must the platform's ability to adapt to new flexibility services. Future work will focus on integrating additional energy assets, improving market integration, and enhancing the COFYcloud for broader community use (e.g. energy sharing) and real-time aggregation of distributed assets.

3. **Deeper Integration with Community and Market Platforms**: Future enhancements could involve creating stronger links between COFYbox.io communities and market platforms, enabling dynamic pricing, demand-response programs, and automated energy trading based on aggregated community data.