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ECOFLEX

D4.2 Front end applications for charge scheduling

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Abstract for dissemination (PU)

This deliverable outlines the concept and approach used in the development of a front-end application designed for the smart scheduling of electric vehicle (EV) charging algorithms. The application serves as an interface between end-users and the charging infrastructure, facilitating both the capture of driver requirements and the consultation of real-time and historical data. By integrating user preferences with advanced charging algorithms, the system enables optimal charging schedules that balance energy efficiency, grid stability, and user needs.

Contents

List of abbreviations and definitions....3

1. Introduction....5

1.1 Summary....5

2. Features of the front-end application....6

2.1 Basic features....6

2.2 Custom features for ECOFLEX....7

3. Communication between different platforms....10

3.1 Connection between Jedlix and LMS....10

3.2 Connection between Jedlix, Pluginvest, and VUB....10

4. Pilot site at Pluginvest offices (Vanbreda building)....11

4.1 Hardware installation....11

4.2 Smart charging configurations for charging points....13

5. Testing and Feedback Mechanisms....13

6. Conclusions....14

6.1 Challenges:....14

6.2 Lessons Learned:....14

6.3 Achievements and Added Value:....15

7. Bibliography....16

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List of abbreviations and definitions

API	***Application Programming Interface***: A set of protocols and tools that allow different software applications to communicate with each other. In the context of this project, it facilitates the real-time transfer of data between Jedlix, Pluginvest, and VUB.
BigQuery	A serverless, highly scalable, and cost-effective Google-cloud data warehouse. In this project, Pluginvest uses BigQuery to store and process the real-time data received from Jedlix before pushing it to VUB.
Chargecard ID	A unique identifier assigned to each EV driver through an RFID-enabled chargecard. This ID links the driver to specific charging sessions and charging points, allowing the system to accurately track and manage individual sessions.
EV	*Electric Vehicle*: A vehicle that operates using electric power instead of, or in addition to, fossil fuels. EVs are central to the ECOFLEX project, as they represent a major flexible energy asset that can be managed to balance grid demand.
JSON	***JavaScript Object Notation***: A lightweight data-interchange format used to structure data for easy sharing between applications. It is the format used by Jedlix to send user preferences to Pluginvest in real time.
LMS	***Last Mile Solutions***: Provider of backend system that connects and manages charging points of Pluginvest. LMS communicates with charging points and processes data such as chargecard IDs.
MQTT	***Message Queuing Telemetry Transport***: A lightweight messaging protocol often used in IoT environments for real-time data sharing. In this project, MQTT is used to transmit user preferences and other data to VUB for smart charging optimization.
MODBUS	A protocol used for transmitting data over serial or network connections. In this project, a Socomec MODBUS is used to track energy demand and production at Pluginvest's site to inform smart charging decisions.
OCPI	***Open Charge Point Interface***: A protocol used for communication between the charging point back office platform (in this case LMS) and the Pluginvest systems.

RFID	***Radio Frequency Identification***: A technology that uses electromagnetic fields to automatically identify and track tags attached to objects. In this context, RFID is used to link chargecards with individual users at charging points.
Smart Charging	A system that optimizes EV charging by adjusting the charging process based on variables like grid demand, energy prices, and renewable energy availability. It helps minimize energy costs and reduce stress on the energy grid.
UTP	***Unshielded Twisted Pair*** (cable): A type of network cable commonly used for communication between devices. UTP cables were installed at Pluginvest’s site to connect charging points and the hardware controller to VUB's cloud-based system.

1. Introduction

This deliverable outlines the concept and approach used in the development of a front-end application designed for the smart scheduling of electric vehicle (EV) charging algorithms. The application serves as an interface between end-users and the charging infrastructure, facilitating both the capture of driver requirements and the consultation of real-time and historical data. By integrating user preferences with advanced charging algorithms, the system enables optimal charging schedules that balance energy efficiency, grid stability, and user needs.

The front-end application (developed by Jedlix) includes a user-friendly interface for EV drivers to input their charging preferences, such as departure times and energy needs, which are then shared and processed to schedule charging sessions. APIs and real-time data connections were developed to facilitate seamless interaction with the underlying charging systems, while the visualization interface offers insights into charging behavior, costs, and system performance. This combination of real-time and historical data enables both end-users and operators to monitor and analyze site elements, ensuring a dynamic and responsive charging experience that supports both energy optimization and customer satisfaction.

In addition, a real-world pilot site was set up at Pluginvest's parking lot to test the solutions developed in the project. This test site enables the validation of the smart charging algorithms in a live environment, incorporating feedback from actual EV drivers and real-time energy consumption data. With dedicated hardware installations, such as UTP cable connections, metering infrastructure, and a smart controller, the site supports the integration of grid balancing strategies, ensuring that the system's feasibility, scalability, and user adoption will be thoroughly tested under realistic conditions.

1.1 Summary

The 'Easily Charged App' developed by Jedlix, plays a critical role in the ECOFLEX project, by enabling real-time control over electric vehicle (EV) charging sessions. This application not only facilitates seamless user interaction with EV charging processes but also contributes to grid balancing by optimizing energy consumption based on various factors such as cost, renewable energy availability, and user preferences (see Figure 1). Key features include:

- **User Preferences**: input from the user to have the constraints to be used in the Smart Algorithm or sent to the VUB controller: Chargepoint ID, User ID, leaving time and preferred SoC.

- **User Interface (UI)**: the app allows users to view insights into their charging sessions, helping them understand their charging behavior. Users can track how much money they have saved through smart charging decisions and adjust their preferences according to their charging needs (e.g., time to departure or amount of energy required).
- **Smart Algorithm**: the app incorporates a smart algorithm designed to:
    - Minimize energy costs by choosing optimal times for charging, such as when electricity prices are lower.
    - Maximize the use of renewable energy sources, prioritizing charging sessions during periods when renewable energy, such as solar or wind power, is most available.
    - When the VUB controller pushes a charging profile to the chargepoint, the smart algorithm from the app will be overruled.

While for the integration capabilities, the app can connect directly to the user's (i) EV, (ii) charging point, and (iii) the Last Mile Solutions (LMS), which is the back-office platform that monitors and manages the charging points. These integrations enable seamless control over the charging process while optimizing the distribution of electricity across the grid.

In the context of the ECOFLEX project, the Easily Charged App has been tailored with custom features to gather user preferences from EV drivers. These preferences are then shared automatically with Vrije Universiteit Brussel (VUB) through MQTT messaging, where Pluginvest acts as the intermediary for the real-time data transmission.

2. Features of the front-end application

2.1 Basic features

The app offers several core features:

- **Smart Charging**: Automatically adjusts the charging time and power based on factors such as electricity prices and grid demand, ensuring cost-effective charging.
- **Solar Charging**: Integrates with local solar panels (where available) to prioritize the use of solar energy during charging, reducing dependency on grid electricity and increasing the use of renewable energy.

- **User-Friendly Interface (fig xx)**: The app is designed with an intuitive UI/UX, enabling users to easily access insights, set preferences, and manage their charging sessions.

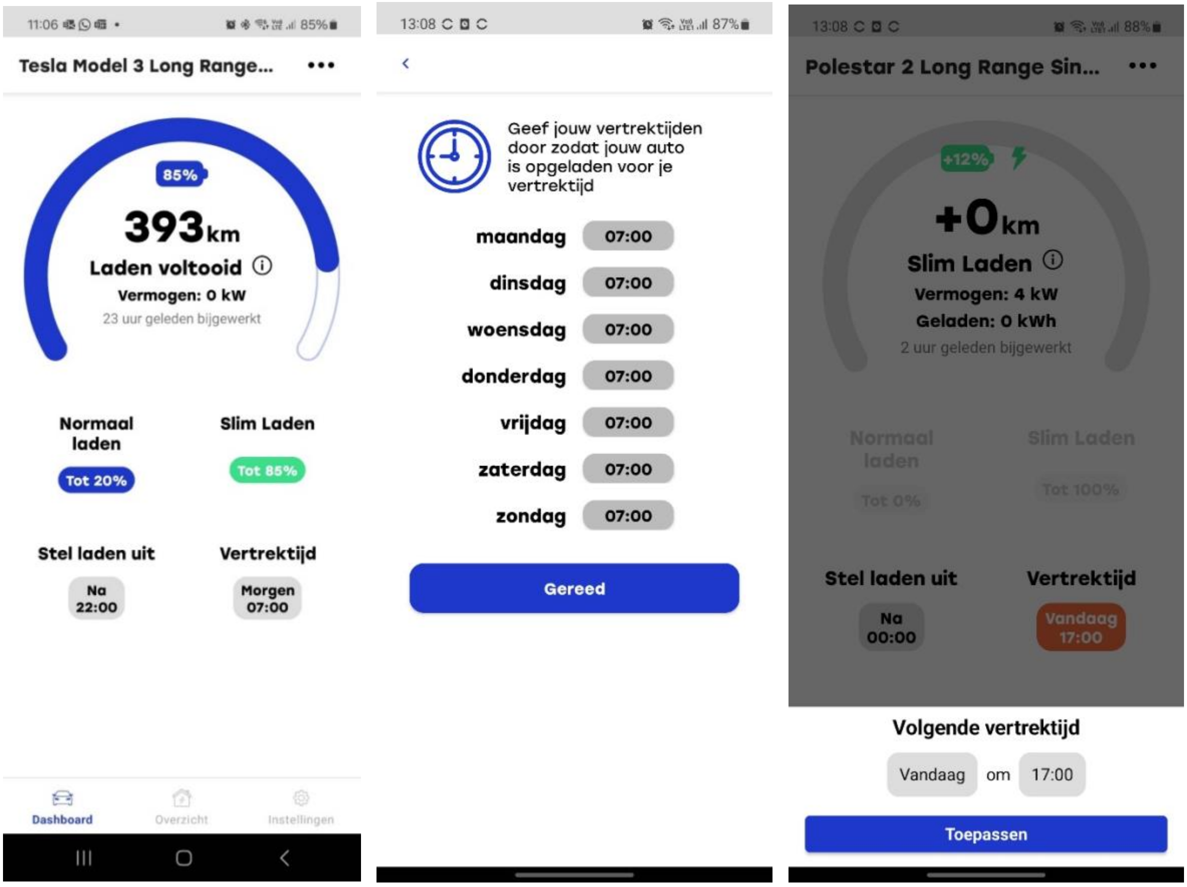

Figure 1: Screenshot of home screen of the Easily Charged app

2.2 Custom features for ECOFLEX

In order to adapt the Easily Charged App for the ECOFLEX project, several custom features were developed. First an integration with LMS Backend was required, a critical connection between Jedlix's backend and the LMS backend was established to ensure that the system can identify which charging point is being used for a given charging session. This allows the system to track which Chargecard ID (linked to the user) corresponds to the specific charging point in use, ensuring accurate data transmission.

Second, custom APIs were developed to enable Jedlix to share user preferences in real time to Pluginvest. These preferences, which include (i) departure times and (ii) required energy levels, are then processed by Pluginvest and shared with VUB in a JSON format for optimization purposes (Figure 2). The data is sent via MQTT to ensure low-latency, reliable communication.

```
{
  "nr":"1",
  "ID": "1xxx123",
  "Time": 120,
  "Target": 100
}
```


Figure 2: Format of JSON response that is shared with VUB

In order to link the user(s) to a charging session on a specific charging point, users are required to fill in their Chargecard ID into the app. The Chargecard ID is used as a unique identifier for the user. This feature is especially important for the pilot phase, where the system needs to accurately track charging sessions at the Pluginvest office. The complete overview of the process, ranging from data retrieval of user preferences from the Easily Charged app towards the sharing of the data to the LMS platform is displayed via a sequence diagram in Figure 3.

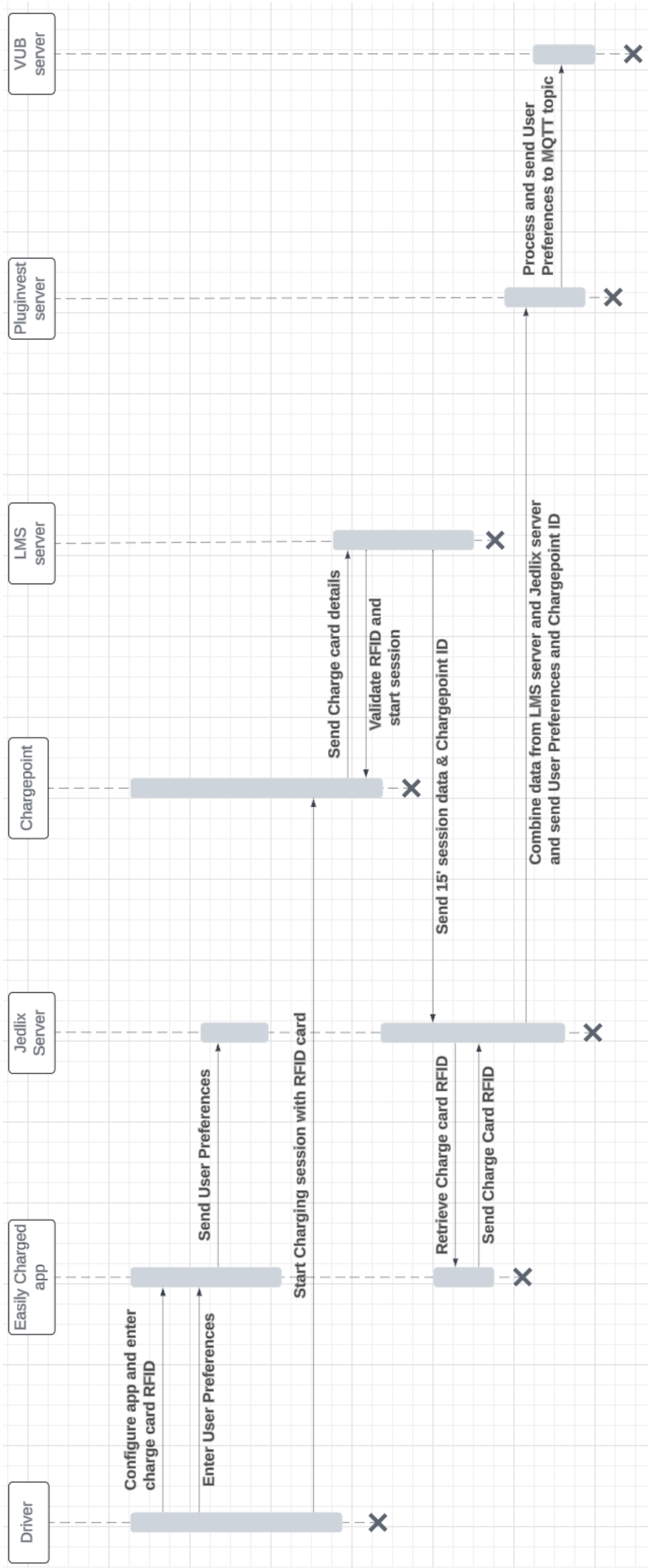

Figure 3: Sequence diagram of the data gathering and sharing process

3. Communication between different platforms

3.1 Connection between Jedlix and LMS

The main reasons for which the integration between Jedlix and the LMS backend is crucial, are the following: (i) charging point data integration, (ii) smart charging profiles and lastly (iii) the user identification. In terms of data integration, the connection allows Jedlix to access data with respect to the charging points that cannot be controlled directly by the app. This ensures that even non-controllable (no direct integration with chargepoint possible) charging points can still be monitored and optimized using the smart charging algorithm. This is of particular importance since in practice, a lot of charging points are currently not controllable (no direct integration with chargepoint possible). By having a direct connection between the backend of the app with the backend of LMS, these chargepoints become controllable without direct integration. Therefore, the provided solution aims to valorize the developed tools and helps with the scalability.

Besides the data integration, setpoints must be send towards the charging points in order to adjust the charging in a smart manner (i.e. smart charging). To this end, the integration between both Jedlix and the LMS backend enables Jedlix to send the optimized smart charging profiles to the corresponding charging points. This, based on the data it received from the Chargecard ID and the LMS backend thus, ensuring the system is aware of the charging point in use and can adjust accordingly the charging parameters/setpoints.

Finally, when users enter their Chargecard ID in the app, the latter will be transmitted to the LMS backend. There, it is used to start a charging session on a specific charging point and via this way allowing the system to identify which charging point is being used, facilitating accurate data collection and charging profile optimization.

An OCPI connection is created between LMS and Jedlix. In this way, data from active sessions is being pushed every 15’ to the systems of Jedlix. This allows Jedlix to combine all required information and send this to a Pluginvest endpoint.

3.2 Connection between Jedlix, Pluginvest, and VUB

One of the major challenges in realizing the aforementioned smart charging strategies, is the real-time control of the assets. To facilitate real-time optimization of charging sessions, a data-sharing pipeline was developed between Jedlix, Pluginvest, and the VUB (shown in Figure 4). This connection enables real-time communication of user preferences and charging data, which is critical for optimizing the grid load and reducing energy costs. Different communications are established:

1. *Jedlix to Pluginvest*: User preference data (e.g., departure time, charging needs) are pushed to Pluginvest in real-time through an API. The data is sent in JSON format to Pluginvest's endpoint in the Google Cloud infrastructure, where it is processed and stored in BigQuery.
2. *Pluginvest to VUB*: Once the data is processed, Pluginvest forwards the information to VUB via MQTT. This real-time data flow allows VUB to access user preferences instantly and use this data to optimize charging sessions. The system adjusts the charging profiles based on multiple factors, such as local energy production, demand, and cost.

Figure 4: Real-time data connection between Easily Charged app (Jedlix), Pluginvest and the Vrije Universiteit Brussel

4. Pilot site at Pluginvest offices (Vanbreda building)

4.1 Hardware installation

Within the ECOFLEX project, three pilot sites have been selected for real-life testing of the proposed solutions. One of these pilot sites is the Pluginvest offices (Vanbreda Building). However, to be able to support the ECOFLEX project and thus to validate the smart charging solutions in a real-word environment, some additional hardware setup was installed at the Vanbreda Building, namely: (i) UTP cables were installed, (ii) additional metering infrastructure and (iii) a controller to steer the controllable assets.

(i) High-speed UTP cables were installed to connect the charging points with the onsite controllers. These cables facilitate real-time communication between the charging points and the smart charging system.

(ii) A Socomec MODBUS system was installed to monitor local energy demand and production. This device tracks the energy consumption of the building, as well as the output from any onsite renewable energy sources (e.g., solar panels). The data collected is critical for the proposed smart charging optimizations.

(iii) Hardware Controller: A hardware controller from VUB was installed onsite to manage the charging points. This controller is responsible for applying smart charging profiles based on real-time data from the VUB cloud infrastructure.

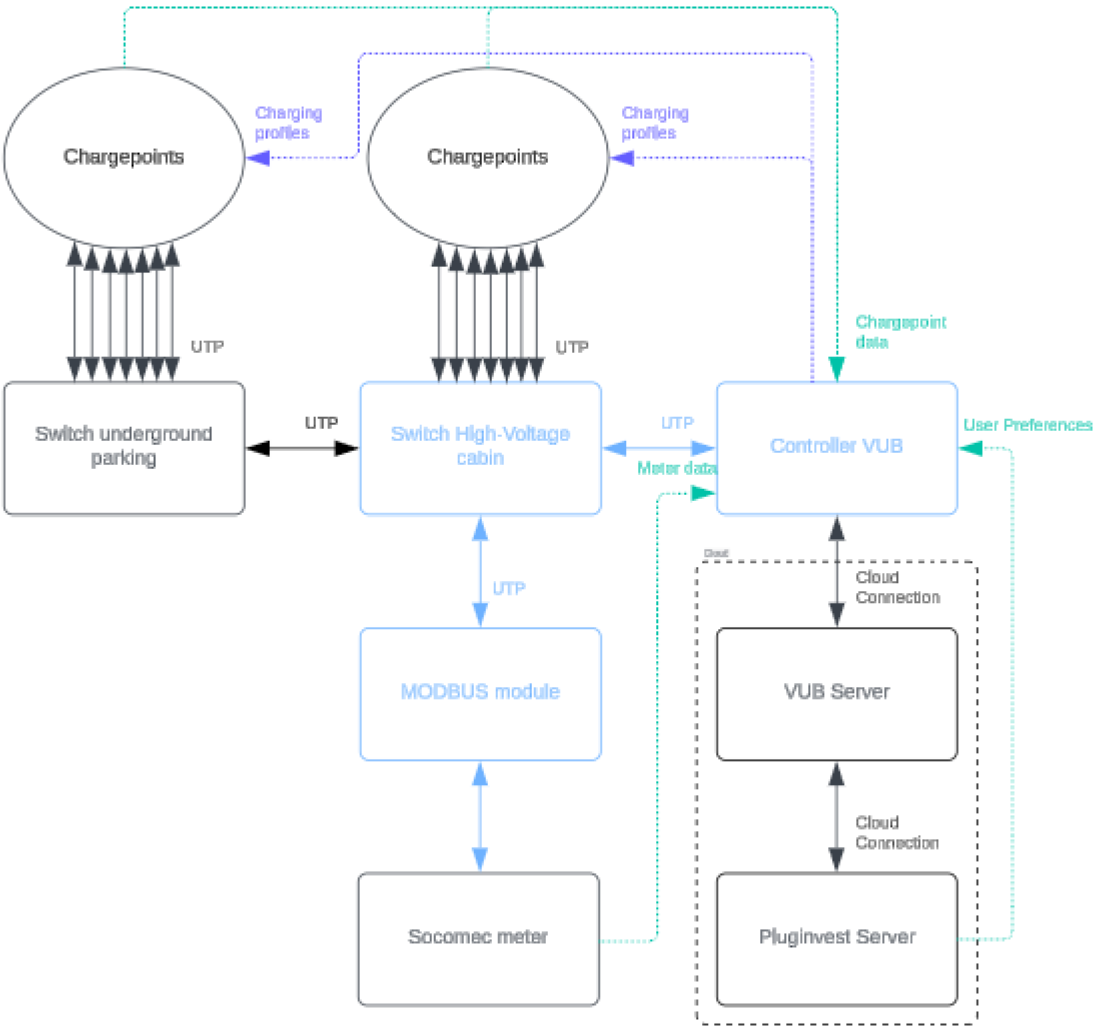

Figure 5: Hardware setup at Pluginvest pilot site, with the extra hardware installed for the project (blue). Dotted lines show the most important data flows. Input data going to the VUB controller. Charging profiles as output from the algorithm going to the chargepoints.

4.2 Smart charging configurations for charging points

In order to implement the smart charging profiles developed for the project, each charging point (Alfen chargers) needs to be equipped with a smart charging license. This license, priced at €125 per charging point, is crucial to enable the charging point in receiving and applying the optimized charging profiles. Unfortunately, smart charging cannot be activated without a license, making this a barrier in the setup process and scalability of the solution.

Another essential item with respect to the smart charging process is the controller. This controller, operated by the VUB plays a crucial role in the ECOFLEX targets and was installed directly at the Pluginvest offices, connecting all charging points via UTP cables and interfacing with the VUB cloud system. The role of the controller is threefold, as:

- It receives the user preferences as well as the energy data (i.e. local energy demand of the site), to create optimized charging schemes.
- It sends the optimized charging instructions, i.e. setpoints, to the charging points and ensures that the charging sessions are aligned with the broader energy management strategy defined within the project.
- It integrates seamlessly with a larger system infrastructure. Since the controller does not communicate directly with Jedlix or Pluginvest, it relies on data stored in VUB systems.

5. Testing and Feedback Mechanisms

As part of the project, Pluginvest's pilot site at the Vanbreda Building serves as a critical testing ground for both the technical feasibility and user adoption of the smart charging solutions.

- User Interaction: The primary method of gathering user feedback is through the Pluginvest Smart Charging app, where users can input their charging preferences and interact with the system. This data is then used to optimize their charging sessions.

- Real-world Data Collection: Although there is no formal feedback mechanism, real-world data collected from the chargepoints, user preferences, and local energy demand will inform the project’s ongoing development.

6. Conclusions

6.1 Challenges:

1. **Technical Setup at the Pilot Site:** Installing the necessary hardware at the Pluginvest parking lot, including UTP cables and metering systems, proved to be a complex process. Ensuring that the charging points were properly connected to the VUB controller and able to communicate in real-time posed logistical and technical challenges.

2. **Real-Time Data Transmission and Integration:** Establishing a reliable and low-latency data pipeline between Jedlix, Pluginvest, and VUB required overcoming challenges related to real-time communication. The MQTT protocol had to be configured to handle large volumes of data from multiple users while maintaining consistent performance across systems.

3. **Limited User Feedback Mechanisms:** Although the app successfully gathered user preferences for charging sessions, there was a lack of formal feedback channels for real-time responses from drivers. This limitation affected the ability to fine-tune the system based on direct user feedback during the pilot phase.

4. **Maintaining Data Privacy and Security:** Handling sensitive user data, such as Chargecard IDs and personal preferences, required strong security protocols. Ensuring that this data remained protected throughout the transmission between the app, Pluginvest's infrastructure, and VUB was a constant concern.

6.2 Lessons Learned:

1. **User-Centric Design is Critical:** The development of the UI for the Pluginvest Smart Charging app emphasized the importance of a user-friendly interface that allows drivers to easily input preferences such as departure times and energy needs. Simplified, intuitive designs can improve user adoption and engagement, essential for gathering accurate data to optimize smart charging profiles.

2. **Importance of Real-World Testing:** The test site at the Pluginvest parking lot provided valuable insights into the real-world application of smart charging solutions. Testing in a controlled yet operational environment highlighted the need for precise

hardware setup, smooth data flow, and robust infrastructure to handle real-time adjustments.

3. **Flexibility in User Preferences:** Allowing users to input and adjust their charging preferences in real-time proved crucial for balancing individual needs with overall energy optimization goals. The ability of the system to dynamically adapt to varying user demands while prioritizing cost and renewable energy use was key to the project's success.

6.3 Achievements and Added Value:

1. **Creation of a Tailored User Interface:** Pluginvest successfully developed a user-friendly front-end application that allowed drivers to input their preferences for charging sessions. This UI was integrated with the overall smart charging system, providing real-time data to VUB for optimizing grid demand and energy use.

2. **Pilot Site Success at Pluginvest Offices:** The Pluginvest parking lot served as a vital testing ground for the smart charging system. Real-world data collected from users and the local energy demand demonstrated the system's capability to adapt and optimize charging in a real environment. This successful validation at the pilot site proved the feasibility of the developed solution for larger-scale applications.

3. **Effective Real-Time Data Flow:** Despite the challenges, the real-time data pipeline between Pluginvest, Jedlix, and VUB enabled instant transmission of user preferences to inform charging decisions. The system ensured that preferences were considered alongside energy costs and renewable availability, making the charging process both cost-effective and environmentally friendly.

4. **Integration with Existing Infrastructure:** The integration of the Pluginvest Smart Charging app with the LMS backend and the VUB controller added significant value to the project. This setup allowed the system to function smoothly within existing energy management infrastructure, making it adaptable for future scaling and use in other environments.

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