Begonia

# USE CASE 4:

# AI-driven price-based methods applications in cross-border EV charging strategies

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## Use case identification

*Table 1. Identification of the use case 4.*

| ID | Name of Use Case | Geographical scope | Cross-sector domains | | | Interoperability layers |
|---|---|---|---|---|---|---|
| | | | Electric | Mobility | Data | |
| BEG.04 | AI-driven price-based methods applications in cross-border EV charging strategies | ☐ Local<br>☒ Regional<br>☐ National<br>☒ Cross-border<br>☐ Outermost | ☒ Customer<br>☒ DER<br>☒ Distribution<br>☐ Transmission<br>☒ Generation | ☒ Customer information<br>☒ Vehicle<br>☒ Energy station<br>☒ Infrastructure<br>☒ Traffic and logistic | ☐ Edge<br>☒ Fog<br>☒ Cloud | ☒ Component<br>☒ Communication<br>☒ Information<br>☒ Function<br>☒ Business |

## The scope and objectives of the use case

*Table 2. Scope and objectives of use case 4.*

| Scope and Objectives of the Use Case | |
|---|---|
| **Scope** | This use case is designed to address the complexities of scaling up EV charging infrastructure across national borders, with a focus on infrastructure scalability, mitigating the grid impact, refining cost and pricing strategies, and leveraging RESs. As EV adoption surges, the demand for a robust, cross-border charging network becomes crucial, posing challenges for the existing electrical grids, especially during peak charging periods. This initiative aims to develop a smart, sustainable, and scalable EV charging solution that not only facilitates seamless cross-border mobility for EV users but also incorporates smart charging technology and renewable energy to alleviate the strain on electrical grids supported by state-of-the-art artificial intelligence (AI) solutions. Additionally, the project intends to develop standard user profiles by analyzing patterns in historical user behavior data. By implementing dynamic pricing models based on the amount of renewable energy produced and the standard charging profiles, the project intends to make cross-border EV charging accessible and economical, thus fostering greater EV uptake. Emphasizing renewable energy integration ensures that the expanded charging network supports the transition to a low-carbon transport sector, aligning with global sustainability goals. |

| | |
|---|---|
| **Objective** | The main objectives of the use case are as follows:<br>• Develop a smart, sustainable, and scalable EV charging infrastructure that enhances mobility for EV users, using smart charging technology and renewable energy to reduce the strain on electrical grids,<br>• Propose a digital platform that facilitates the coordination of EV supply equipment (EVSE),<br>• Develop weather-based AI methods to predict future production levels of renewable energy systems,<br>• Implement dynamic pricing models based on the availability of renewable energy to make EV charging more affordable and promote greater adoption of EV leading to better utilization of surplus renewable energy,<br>• Integrate renewable energy sources into the EV charging infrastructure to reduce the carbon footprint and support the transition to a low-carbon transport sector,<br>• Crafting adaptive charging frameworks that adjust to real-time grid conditions and renewable energy availability, optimizing charging schedules based on data-driven insights,<br>• Analyze historical user behavior data to create standard user profiles, improving the efficiency and user experience of the EV charging process,<br>• Support the expansion of the EV charging network with a focus on renewable energy integration, facilitating a shift towards a more sustainable and low-carbon transportation sector in alignment with global sustainability objectives. |
| **Reference country(ies)** | Austria, Hungary |
| **Related Business Case** | EV charging, renewable energy trading |
| **Possible stakeholders** | EV charging points, RESs, EV owners |

## Narrative of the use case

A significant percentage of people living in border settlements frequently commute between countries. In 2020 more than 700.000 Austrian workers commuted abroad. This cross-border commuting necessitates a cross-region, bilateral infrastructure to support the daily routines of commuters in terms of transportation. In recent years the adoption of EVs in commuting has gained a large momentum. In 2023 50.000 new EVs were sold in Austria, which shows an exponential growth during the years. This poses several challenges including the increased demand put on the electrical grid. Ensuring reliable and efficient access to charging stations to support commuters using EVs is essential in terms of economics, health, and environmental goals.

Establishing cross-border EV charging solutions would facilitate a more sustainable model for commuting by fostering closer cooperation between neighboring countries. Integrating renewable energy sources into the EV charging systems can reduce the carbon footprint and promote the use of green energy, making a significant contribution to the fight against climate change. Providing reliable charging options even for cross-border commuters can encourage them to transition from fossil fuel vehicles. However, besides these advantages, there are also unique challenges that need to be addressed.

One of the most pressing problems is the intermittency of renewable sources such as wind turbines and photovoltaics (PVs). Solar and wind energy are the primary renewables used in charging infrastructure. They are relatively cheap and efficient, but they highly fluctuate based on weather conditions and time of day. This intermittency can lead to periods where the available renewable energy does not align with the charging demand from commuters, particularly during peak times or unfavorable weather conditions, potentially straining the grid or necessitating reliance on non-renewable backup sources. If cases of surplus energy production aren't handled optimally it can lead to significant wasted energy. One way to address this issue is to build advanced energy storage systems to store excess renewable energy when production exceeds demand and release it during periods of high demand or low renewable generation. However, maintaining, scaling, and building these energy storage systems can be very costly and difficult, especially in cross-country cases. They also might have a significant environmental impact. The proposed use case provides a distributed solution that facilitates better and more efficient utilization of renewable energy while providing solutions to the difficulties mentioned above. A generic framework for the proposed use case is illustrated in Figure 1 The *framework of the proposed platform*.

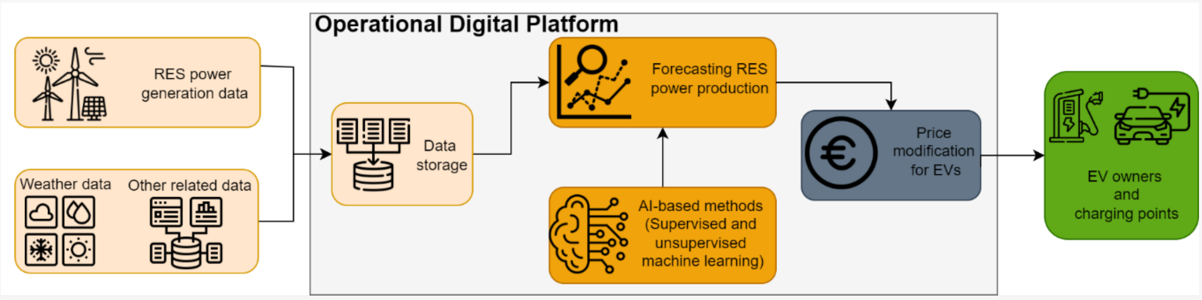


*Figure 1* The framework of the proposed platform

The proposed system observes the factors affecting the production (like weather) and consumption (like peak hours of commuter traffic) of energy. The use case implements state-of-the-art supervised and unsupervised machine learning algorithms to predict the effects of these factors. Using these predictions, EV supply equipment providers can speculate on the price of the energy based on the amount produced.

The companies can use this information to offer dynamic pricing encouraging optimal consumption by customers from both sides of the border. This solution can alleviate the stress put on the grid, thus increasing the user experience of using EVs. It also leads to a lower amount of wasted energy which reduces the carbon footprint of the collaborating countries.

By leveraging predictive analytics, the system can not only forecast energy production from renewables but also anticipate the demand for EV charging.

The proposed system represents a multi-stage cross-border ODP that

- **Analyzes the charging behaviors of commuters** gaining actionable insights from the processed data. This is done by cutting-edge machine learning-based profiling algorithms,
- **Provides relevant and effective recommendations to optimize the charging behavior** according to the commuters' travel patterns along domestic and long-distance routes while ensuring consistency of service for EV owners in different member states,
- **Helps to ensure the balancing of supply and demand across different jurisdictions** minimizing the impact of renewable energy's intermittency on a larger scale. This includes calculating EV charging schedules that ensure efficient utilization of surplus RES production,
- **Enables communication between different actors** using advanced communication technologies and the Internet of Things (IoT). These technologies facilitate the real-time exchange of data between EVs, charging stations, renewable energy producers, and grid operators located within the EU,
- **Includes the impact of the specific mobility and energy transfer conditions** across different EU borders, e. g. available transfer capacity, through historical and real-time data analysis.

By harnessing the power of machine learning for predictive analytics, encouraging dynamic pricing to manage demand, and improving communication and collaboration across borders, this solution not only mitigates the intermittency of renewable energy but also promotes the adoption of EVs, contributes to grid stability, and advances the transition towards a more sustainable and interconnected energy future. The machine learning models can also identify and forecast anomalies (shortages, overgeneration) in the energy generation processes, these should be shared with the providers, so they can react on time. The effect of these anomalies could be mitigated by proposing different charging points for the users or by adjusting the pricing to it.

### Diagram of the use case

The diagram of the use case 4 is presented in Figure 2. The description of actors and scenarios descriptions are provided in Tables 3 and 4.

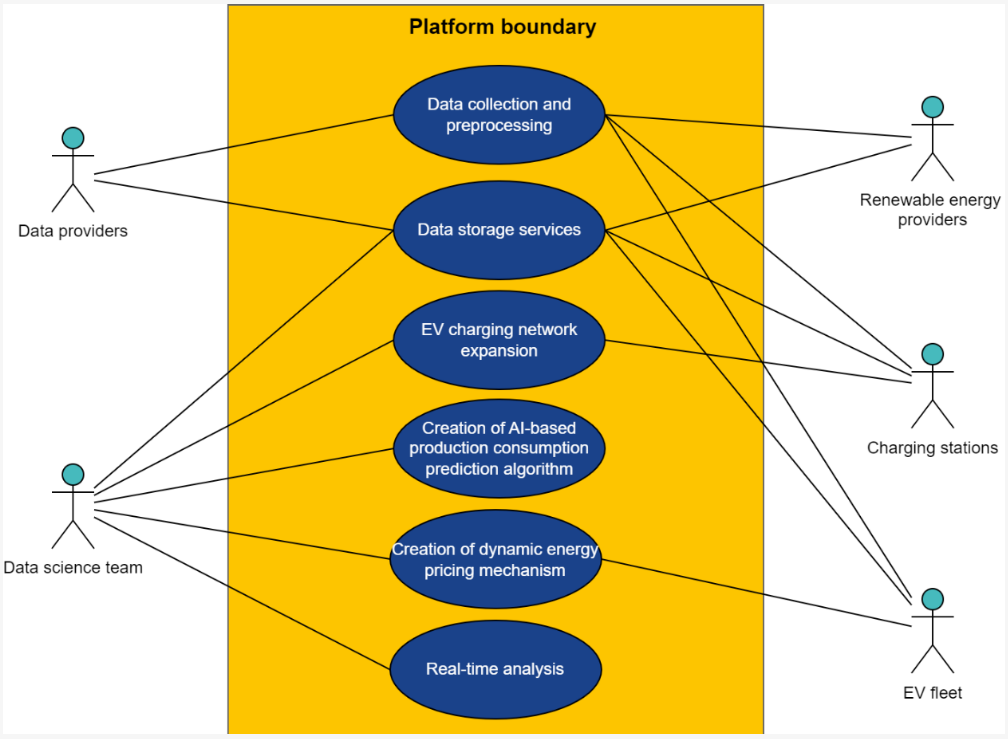


*Figure 2. Diagram of the use case 4.*

## Actors of the use case

*Table 3. Description of the actions of use case 4 actors.*

| Actor Name | Actor Type | Actor description | Actions | Standards |
|---|---|---|---|---|
| Data providers | Role | Data providers are research institutes, industry associations, and sometimes different consultancy companies which are paid by different companies to supply data to eco-invent. | Collect and supply the necessary additional information such as weather and price to the ODP, in compliance with the data science team's needs. This data is used by other ODP services in conducting testing and validation of data-driven models and price modeling. | No |
| Charging stations | System | Physical equipment consisting of one or more charging station controllers and one or more electric vehicle supply equipments managing the energy transfer to and from EVs. | Communicate in real-time with an ODP to monitor usage and performance, supplying data to real-time analysis and data processing services. Charging stations also receive dynamic prices from the ODP. | No |
| Data Science Team | Role | Group of data scientists analyzing, implementing, testing, and deploying data-driven solutions. | Define requirements for data collection, develop, validate, and test in real-time the AI-based forecasting algorithms and pricing mechanisms. | No |
| EV Fleets owners | Role | Businesses, governments, or organizations that own and operate groups of EVs | Collaborate with other stakeholders to test the ODP in specific member states and cross-border conditions | No |

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| | | for various purposes, including delivery, transportation services, and employee commuting. | ensuring the robustness of the developed algorithms and price calculators. Send location data to the ODP and receive price options in different charging stations of member states at different hours. | |
| Renewable Energy Providers | Role | Companies or organizations that generate electricity from sustainable sources such as wind, solar, hydroelectric, and biomass, offer cleaner alternatives to fossil fuels. | Providing information about renewable energy production. | No |

## Scenarios

*Table 4. Description of use case 4 scenarios.*

| S.No | Scenario Name | Triggering Event | Scenario Description | Primary Actor |
|---|---|---|---|---|
| BEG.04.S1 | Data collection and preprocessing | Continuous, when new data is generated by RESs, charging stations EVs and data providers | Data is recorded by smart meters and sensors in the RESs and charging station locations or by data providers | RESs, charging stations and data providers |
| BEG.04.S2 | Data storage service | Continuous, by receiving data from RESs, charging stations, EVs and data providers | The data received from RESs, charging stations, EVs and data providers are preprocessed and stored to be used by the data science team. | Data science team. |
| BEG.04.S3 | AI-based energy production and consumption prediction | The algorithms are updated continuously | Implementing and validating machine learning to forecast the production and consumption of renewable energy. By using these predictions, EV supply equipment providers can speculate on the price of the energy based on the amount produced and expected consumption. | Data Science Team |
| BEG.04.S4 | Dynamic energy pricing | Continuous, when power production and consumption forecast is updated | Development of a dynamic energy pricing scheme to balance the supply and demand across different jurisdictions, minimizing the impact of renewable energy's intermittency on a larger scale. | Data Science Team |

| | | | | |
|---|---|---|---|---|
| BEG.04.S5 | Real-time analysis | Continuous | The Data Science Team continuously monitors the power balance condition in member states and the performance of the pricing and prediction algorithms to improve them | Data Science Team |
| BEG.04.S6 | EV charging network expansion | When optimal placement for a new charging station is needed | Considering the historical data, optimal locations for installing new charging stations are obtained and informed to investors. | Data Science Team |

## Policy and digitalisation needs

*Table 5. Description of use case 4 policy and digitalisation needs.*

| | |
|---|---|
| **Policy needs** | The main policy concerns for this use case concern data sharing and EV-specific regulations, in particular,<br>• Data-sharing agreements must be made with renewable energy producers, EVSE, and mobility fleet owners or traffic operators, considering general data protection regulation (GDPR) both domestically and between member states. It should be stated from the beginning that personal data will not be acquired, stored, and processed, only aggregated energy consumption, generation, and mobility data,<br>• There are concerns about whether the companies are willing to share their internal data such as energy produced, the energy consumption from EVSEs, and the daily route of their EVs. The quality and quantity of the acquired energy generation, consumption, and mobility datasets can alter the accuracy of predictive analytics models,<br>• Imbalances brought on by RESs must be balanced in the balancing market. New regulations are required to allow EVs to be directly involved in mitigating these imbalances,<br>• Support from local regulations is needed to apply price adjustments. Different energy market conditions may preclude RES-generation-based tariffs,<br>• Building and maintaining the necessary infrastructure for cross-border EV charging, including charging stations, energy storage systems, and communication networks, requires significant investment. We could foster the efficient deployment of the infrastructural elements, by providing detailed insights and analysis about the user consumption and mobility patterns for the providers. |
| **Digitalisation needs** | The platform needs<br>• Access to real-time and historical data of the renewable energy suppliers, EVSE and mobility fleet owners,<br>• Communications channels to EV users (like the fleet's or traffic management's mobile apps),<br>• Identify and agree on requirements for data quantity and quality with the data provider to be able to test and benchmark the AI algorithms. |