ElectroCap Project Proposal

Optimizing EV Charging in Residential Buildings: Efficient Usage and Power Management

André Pragosa (106429)
João Martinho (106598)
Vasco Aguiar (106358)
João Ferreira (106734)
João Mação (106220)
Paulo Santos (107510)

TÉCNICO LISBOA

1. Advisors and Mentor

TÉCNICO LISBOA

- Scientific Advisor:
- Scientific Co-advisor:
- Coordinator: Prof. Duarte Mesquita e Sousa
- Mentor: Eng. Vitor Formiga

2. Problem definition (I)

TÉCNICO LISBOA

- With the growing adoption of electric vehicles (EVs), the demand for charging infrastructure has surged, especially in **urban residential buildings**.
- The existing charging points are **often under-utilized or inefficiently distributed** due to limited infrastructure and unclear policies on how to allocate these resources among residents.
- This inefficiency not only **wastes energy** but also leads to **overloading** the building's electrical system, creating power constraints that may **affect the overall electricity supply**.

Fig. 1 – Electric vehicle charging [1]

2. Problem definition (II)

TÉCNICO LISBOA

- Overloading circuits or inefficient use of charging infrastructure can lead to **safety concerns, increased electricity costs, and poor user experiences**.

- Current solutions tend to be **rudimentary**, without the ability to dynamically adjust to usage patterns or predict demand spikes, leading to underutilization or overloading of available resources.

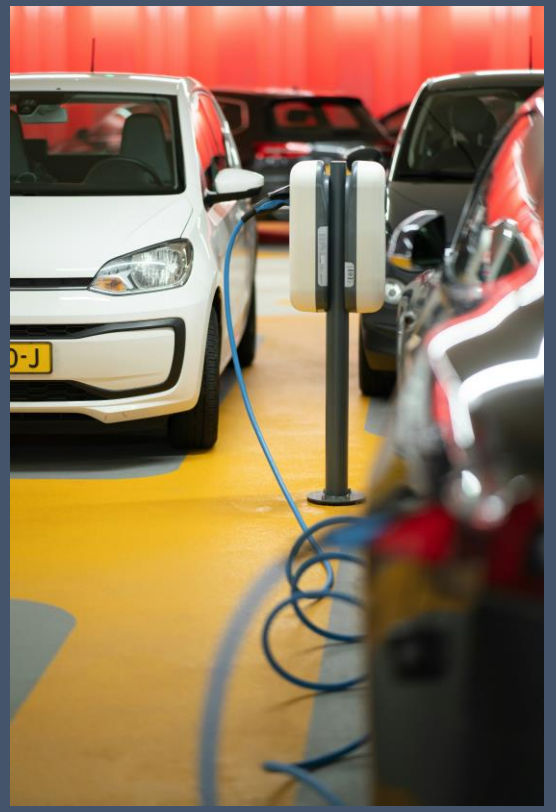


Fig. 2 – Shared EV charging station [2]

3. Solution beneficiaries

TÉCNICO LISBOA

- Residents of multi-family housing who own electric vehicles and rely on shared building electric grids.
- Building administrators responsible for managing the building's energy resources and maintaining a safe and reliable power supply.
- EV owners who require convenient, accessible, and efficient charging options in urban residential settings.
- Electricity companies that benefit from a more efficient management of energy, allowing them to concede a constant amount of energy

Fig. 3 – Residencial charging station for EV

4. Technological solution

1. **Smart Grid Controller**: Our intelligent controller solution will integrate with the electrical grid to **optimize energy distribution**. It monitors power demand and adjusts the charging process to avoid overloading the grid, improve efficiency, and so reduce energy bills, while ensuring a balanced and sustainable energy use in the building. For example, in a situation where two EVs are charging the one with lower energy will be prioritized and receive more energy, to achieve a better energy balance overall.
2. **Battery Energy Storage Systems (BESS)**: The part of the solution uses a battery to **store energy** when there is not a high demand for energy, likely during daytime. It helps smooth out power draw and optimizes charging, ensuring stable and reliable energy supply to the electric vehicle (EV), while reducing energy waste.

5. Competitors and previous work

TÉCNICO LISBOA

- Existing solutions for managing EV charging in residential buildings include **basic charging station installations**, where each resident is assigned a dedicated charger, or simple shared charging systems where users must manually select charging slots.

- However, these solutions do **not consider the power management needs or offer dynamic charging schedules based on demand**. Some buildings may employ time-of-use pricing models, but these are not always integrated with the building's power management system.

- Furthermore, most current solutions do not optimize the overall use of available charging points or incorporate intelligent load balancing, leading to inefficiency.

6. Solution requirements(I)

TÉCNICO LISBOA

- Monitor and dynamically adjust energy allocation prioritizing a branch that require more energy to charge electric vehicles without overloading the grid.
- Autonomy with no regular need for human interaction.
- Real-time data analysis of grid performance.
- This technology can make EV charging faster during high-peak hours.

7. Technical challenges(I)

The integration of an energy storage system, such as a battery, into EV charging infrastructure as a solution to enhance energy efficiency.

•**Battery (BESS)**: Their lifecycle, high power density and susceptibility to degradation over time present challenges.

•**Energy storage systems:** This devices generate heat during operation, needing robust thermal management solutions(battery type). Overheating can reduce system performance, shorten component lifespans, and pose safety risks.

•**Lifecycle**: Designing systems with extended durability and reduced maintenance requirements is essential for long-term viability.

7. Technical challenges (II)

TÉCNICO LISBOA

Creating a controlling system that manages the energy distribution between home facilities and EV charging points can have the following complications:

- **Energy demand forecasting** – Predicting usage patterns to optimize energy allocation.
- **Infrastructure integration** - Ensuring compatibility with existing systems and IoT devices.
- **Real time control** - Monitoring and adjusting energy flow dynamically.
- **Safety compliance** - Adhering to standards and minimizing risks like surges or fires.
- **Cybersecurity** - Protecting against cyber threats and data breaches.

8. Partners

- Currently, we do not have partners however we have the support of our Mentor, who will assist us in identifying potential partnerships throughout the ElectroCap Project.

- Considering the challenges that we may face, our plan is to structure the problem and actively explore companies that can help us. This could involve seeking support for materials, identifying devices like what already exist and collaborate with organizations that would allow us to test our prototype in their facilities.

9. Testing and validation metrics

TÉCNICO LISBOA

- **Charging Efficiency**: The percentage of available charging time that is used productively.
- **Power Utilization Rate**: The proportion of the building's electrical capacity allocated to EV charging versus other uses. Efficient systems should avoid exceeding the building's total power limit.
- **User Fairness**: The level of satisfaction among residents regarding access to charging points. This could be measured through surveys or user feedback.
- **Cost Savings**: Reduction in energy costs for both the building management and the residents by optimizing the charging schedules and avoiding peak demand charges.

10. Division of labor (I)

TÉCNICO LISBOA

André Pragosa	Vasco Aguiar	João Mação
Smart grid management	**BESS**	**Smart grid management**
Website	Logistics	Interview / Partners
Blog	Blog	Design
BESS	Smart grid management	BESS
Research	Research	Research

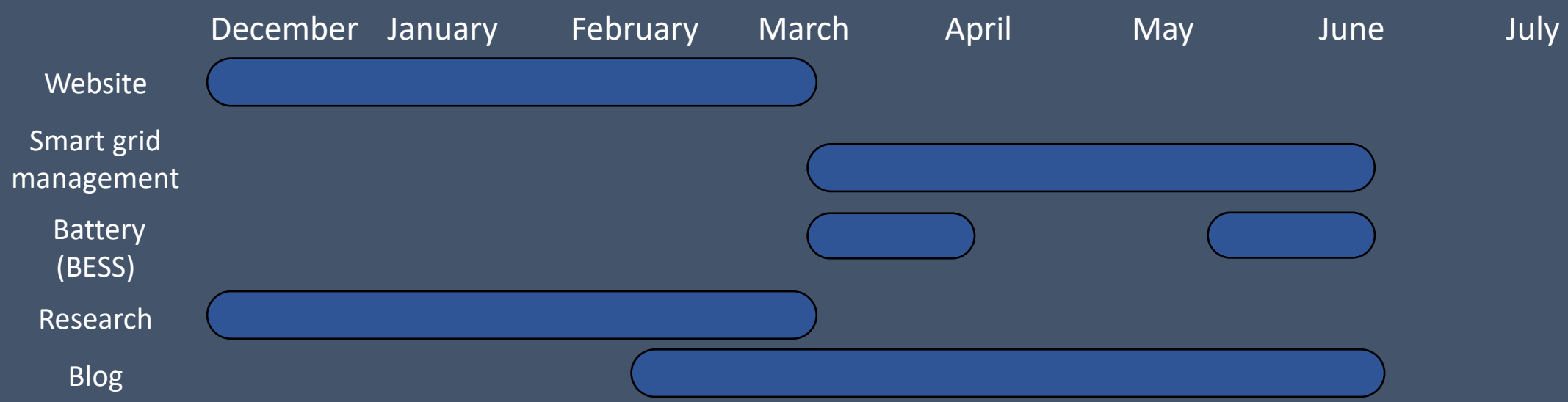
11. Division of labor (II)

TÉCNICO LISBOA

João Martinho	João Ferreira	Paulo Santos
Smart grid management	**BESS**	**BESS**
Logistics	Blog	Design
Design	Logistics	Website
BESS	Smart grid management	Smart grid management
Research	Research	Research

12. Schedule

TÉCNICO LISBOA



13. References

- Fig. 1, 2 - by Michael Fousert on Unsplash
- Fig. 3 - Image generated using ChatGPT-4 (by OpenAI) from the prompt: “Imagem de um edifício residencial com carregadores para EVs”.
- https://learnius.com