ElectroCap Project Proposal

Smart Grid Optimization through V2G System and Blockchain Transactions

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1. Advisors and Mentor

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- Mentor:

2. Problem definition

The current power grid faces challenges in maintaining a stable load profile. The transition to renewable energy sources poses a challenge due to their intermittent nature and the need for efficient mobile and decentralized energy storage solutions, where Electric Vehicles actively come into play as auxiliary service providers to the grid.

Furthermore, grids with mixed generation sources often lack robust optimization algorithms to manage assets and loads efficiently, limiting their ability to harness the full potential. The lack of integration of Renewable Energy Sources frequently leads to reduced and limited production.

With the increasing number of electric vehicles, the absence of a comprehensive charging management strategy presents significant challenges and consequences for the grid, including additional demand, power grid congestion, and energy import costs. Nevertheless, electric vehicles can emerge as an effective and crucial solution in balancing the grid and load management.

Additionally, traditional energy market transactions lack transparency and often result in high costs.

3. Solution beneficiaries

Citizens and businesses relying on the power grid, as well as those involved in the energy market, including general electricity consumers, electric vehicle owners, energy producers, and grid operators.

4. Technological solution

The project aims to use Machine Learning to create algorithms for optimizing grid flexibility and load distribution, using predictive models for production and energy consumption, market prices, and optimal transaction times. Furthermore, blockchain technology will be used to facilitate and ensure the safety of these transactions.

The integration of Machine Learning algorithms will enable real-time adaptation to changing energy demands and market dynamics, ensuring a more responsive and efficient energy distribution system. The predictive models will be continuously refined, to enhance their accuracy and effectiveness over time, which will allow the system to adapt to emerging trends, ultimately contributing to a more resilient and sustainable energy infrastructure.

The utilization of blockchain technology not only enhances transaction security but also establishes a transparent and decentralized ledger for recording energy-related transactions.

5. Competitors and previous work

- **Tesla:** energy storage solutions to store excess energy during periods of low demand and releasing it during periods of high demand (Powerwall and Powerpack).

- **EnerNoc (EnelX):** energy management services, allows businesses to adjust energy comsumption in responde to grid conditions.

- **AMS:** projects that integrate energy storage with renewable sources for better grid flexibility.

- **Siemens:** offers smart grid solutions (grid management and renewable resource integration) to improve stability and reliability of power grids.

6. Solution requirements

To ensure the successful implementation of the project, it is imperative to meet key solution requirements. These encompass optimizing grid flexibility through advanced Machine Learning, seamless integration of predictive models, and the assurance of high-speed performance for real-time adaptation. Robust security measures are vital to guard against cyber threats, unauthorized access, and data tampering.

In addition to these, the integration of blockchain transactions plays a pivotal role. Security measures must extend to protect blockchain transactions, ensuring the integrity and confidentiality of data within the distributed ledger. The transparency of blockchain transactions is crucial for fostering trust among stakeholders involved in energy exchange.

These combined requirements form the bedrock of an effective project implementation, addressing challenges and paving the way for the realization of desired outcomes in the realm of Smart Grid Optimization through Machine Learning and blockchain transactions.

7. Technical challenges

The project faces diverse technical challenges in Machine Learning, algorithm development, blockchain integration, and system optimization.

Key issues include managing data quality for predictive models, integrating algorithms into existing infrastructure, and addressing blockchain scalability. Ensuring transaction speed, balancing decentralization with security, and navigating regulatory frameworks pose significant concerns.

The project requires a comprehensive and adaptive approach, involving ongoing multidisciplinary collaboration, evaluation, and refinement for successful implementation.

8. Partners

In the pursuit of advancing our project, strategic collaborations with external entities play a pivotal role. In this context, we have identified four potential partners—REN, EDP, E-REDES and Mobi-E — that stand out for their significant impact on resources and operational capabilities.

These esteemed companies offer a unique set of resources that align with the objectives of our project:

1. Historical data repositories encompass crucial information regarding production, consumption, and prices, providing a robust foundation for well-informed decision-making;
2. Real-time data capabilities present an opportunity to optimize the system dynamically;
3. Direct involvement in the control of energy and monetary transactions affords the opportunity to test the solution in a real-world scenario.

The collaboration between our project and these key partners holds the promise of not only gaining a comprehensive understanding of energy dynamics but also testing the solution in real-world scenarios.

9. Testing and validation metrics

To evaluate the performance and validity of the project, will be considered the following:

- Impact on the Load Profile;
- EV battery utilization, and impact on its efficiency and lifespan;
- Total energy exchanged with the grid;
- Peak Load Reduction and Peak Load Shifting;
- Load Flattening;
- Total monetary value exchanged;
- EV owner's monetary gains;
- Scalability (how does the model respond to different numbers of connected EVs);
- Transaction security;
- Prediction accuracy.

10. Division of labor (I)

Diogo Faneco	Duarte Santos	Gonçalo Teixeira
Blockchain transactions / Interactive Mock-up Creation	**Machine Learning Development**	**Website and Marketing Development**
Smart Contracts Development	Data Set research and Statistical Analysis – energy market price	Website development
Legal Conditions Documentation	Development of ML model - energy market price	Project Presentation Video
Transaction Security Testing	Statistical Analysis Documentation	Scientific Poster Development
Modeling a Representative Model of the Project (Mockup - 3D modeling)	Technical Documentation (ML model)	Interactive Data Integration with Website

10. Division of labor (I)

Diogo Faneco	Duarte Santos	Gonçalo Teixeira
Blockchain transactions / Interactive Mock-up Creation	**Machine Learning Development**	**Website and Marketing Development**
Mockup Microcontroller Programming	Ideal Transaction Forecast – code implementation (KPIs, data output, and presentation)	Real Transaction Management – code implementation (KPIs, data output, and presentation)
Data Integration with Mockup Presentation (3)	Technical Documentation (code implementation)	Technical Documentation (code implementation)
Mockup Technical Documentation (4)	Data Integration with Mockup Presentation (3)	Integration of Predictive Data Into the Website (1)

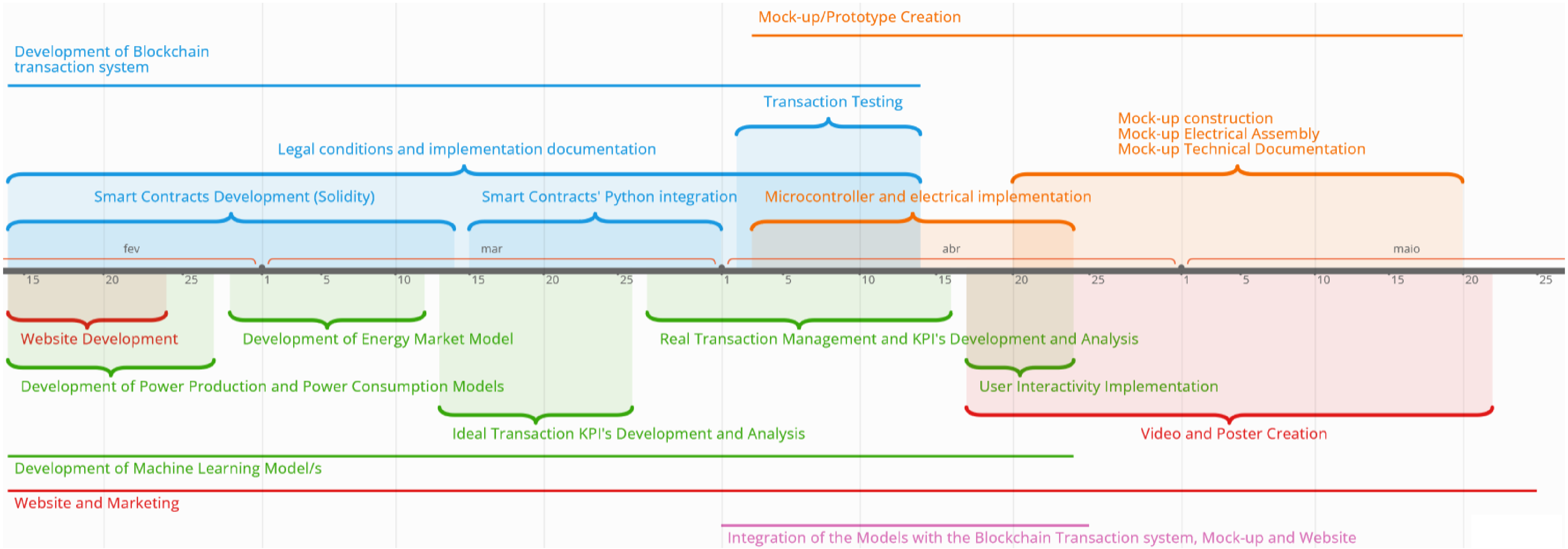
11. Division of labor (II)

José Correia	Rafael Rodrigues	Samuel Figueiredo
Blockchain transactions / Interactive Mock-up Creation	**Machine Learning Development**	**Machine Learning Development**
Smart Contract Interaction with Python Code	Data Set research and Statistical Analysis – energy consumption	Data Set research and Statistical Analysis – energy production
Technical Documentation	Development of ML model - energy consumption	Development of ML model - energy production
Analysis and Processing of Transaction Results	Statistical Analysis Documentation	Statistical Analysis Documentation
Mockup Electrical Assembly	Technical Documentation (ML model)	Technical Documentation (ML model)

11. Division of labor (II)

José Correia	Rafael Rodrigues	Samuel Figueiredo
Blockchain transactions / Interactive Mock-up Creation	**Machine Learning Development**	**Machine Learning Development**
Blockchain Transactions Integration (2)	Real Transaction Management – code implementation (real load and transaction)	Ideal Transaction Forecast – code implementation (identification of key transactions)
Mockup Technical Documentation (4)	Technical Documentation (code implementation)	Technical Documentation (code implementation)
	Integration of Predictive Data Into the Website (1)	Blockchain Transactions Integration (2)

12. Schedule



Mock-up/Prototype Creation
Development of Blockchain transaction system
Transaction Testing
Mock-up construction
Mock-up Electrical Assembly
Mock-up Technical Documentation
Legal conditions and implementation documentation
Smart Contracts Development (Solidity)
Smart Contracts' Python integration
Microcontroller and electrical implementation
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Website Development
Development of Energy Market Model
Real Transaction Management and KPI's Development and Analysis
Development of Power Production and Power Consumption Models
User Interactivity Implementation
Ideal Transaction KPI's Development and Analysis
Video and Poster Creation
Development of Machine Learning Model/s
Website and Marketing
Integration of the Models with the Blockchain Transaction system, Mock-up and Website