FINAL REPORT

Challenge@PoliTO – Electric Vehicles as flexibility sources for Renewable energy communities

RECHARGEV

Fill each section and subsection. Please, do not delete sections and/or sub-sections, in case of missing information it is possible to let the section uncompleted (please indicate N/A, non-applicable). It is possible to add sections and subsections only after the existing sections and subsections.

The final report cannot exceed 30 pages.

1. SECTION: PERSONAL DATA

1.1. TEAM NAME: RECHARGEV

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2. SECTION: DESCRIPTION OF THE PROBLEM

2.1. THE PROBLEM THAT THE CHALLENGE PROPOSES

In recent years, heavy dependence on fossil fuels and growing challenges related to climate change have underscored the urgency of a rapid and necessary climate transition. It is precisely in this direction that renewable sources are increasingly being used and spread among companies, the public sector and private citizens. On the other hand, it must be emphasized that their speed of deployment is still low due to various problems related to these technologies. Distributed generation combined with uncertainty related to renewable sources, such as solar and wind, go to strain on current generation systems. In the future, in addition to the generation side, the demand side will play an increasingly important role.

Among the various solutions, a key role is played by Renewable Energy Communities (RECs). A REC consists of a legal entity based on open and free participation by citizens, small and medium-sized enterprises, territorial and local authorities. Those who are members of a REC share with other members the renewable electricity produced by plants located within the community. Renewable electricity can thus be shared among the various producer and consumer entities located within the same primary substation, thanks to the use of the national electricity distribution grid, which makes it possible to virtually share that energy. The main objective of a REC is surely to provide environmental, economic and social benefits to its members or partners and the local areas in which it operates, through self-consumption of renewable energy. It should also be pointed out that in addition to the various savings on electricity purchased from the grid due to the use of renewable energy systems, such as solar panels installed on the roofs, there are also incentives on self-consumed energy within the REC.

In this perspective, the challenge concerns the integration of electric mobility and renewable energy communities (RECs), focusing on the potential of electric vehicles (EVs) with two-way charging technology to act as 'batteries on wheels'. This concept aims to improve the flexibility and self-consumption of locally generated renewable energy within these communities, enabling EVs to store and release energy as needed.

The company encourages the exploration and development of solutions that harness EVs for grid services, taking into account various factors such as potential battery wear due to frequent charging and discharging, the willingness of EV owners to contribute to RECs, the variability of EV availability, fluctuations in battery charge levels, and the specific mobility needs of EV owners who may require disconnecting their vehicles from charging stations. The objectives of the challenge include formulating technologically feasible and profitable market solutions, identifying current technological limitations, simulating scenarios for integrating electric vehicles into RECs and creating a roadmap for future technological advances.

In addition, business models will have to be defined that generate value for all stakeholders involved and create effective remuneration methods for electric vehicle owners participating in the REC. The ultimate goal is to find innovative ways to utilise electric vehicles within energy communities, balancing technical feasibility, profitability and user participation.

2.2. HOW THE PROBLEM PROPOSED IS SOLVED CURRENTLY

The integration of electric vehicles (EVs) with renewable energy communities (RECs) and the deployment of two-way charging technology, known as Vehicle-to-Grid (V2G), is an emerging research area. Currently, some EV models, such as the Nissan Leaf, are equipped with V2G capabilities, allowing them to discharge energy into the grid. Several pilot projects in different countries are testing the scalability and economic feasibility of this technology. The development of standards and protocols, such as ISO 15118, is facilitating communication between electric vehicles and the grid, ensuring compatibility and security.

The use of electric vehicles within V2G technology is not a new concept, as has just been mentioned already some vehicle models are able to discharge part of the energy stored within their battery to the grid. What is missing, however, is the system of integration with energy communities, which instead, especially in Italy, are not yet widespread but according to some forecasts will become increasingly prevalent.

Advanced energy management systems and smart grids play a crucial role in managing the flow of energy between vehicles, buildings and the grid. The technological advancement of these systems is currently growing, and the use of real-time data and predictive analytics is leading to an optimise energy use. In addition, some smart home systems allow vehicles to integrate seamlessly with home energy systems, maximising the use of solar energy and managing energy

consumption more efficiently. Several pilot projects and real-life implementations are exploring the integration of V2G and RECs. For example, the Parker project in Denmark and the Smart Solar Charging project in the Netherlands are investigating how vehicles can support grid stability and improve the use of renewable energy. Some communities have even created local energy markets, allowing residents to exchange energy generated by their solar panels and stored in their vehicles or home batteries.

Economic and policy incentives are critical in promoting the adoption of EVs and renewable energy solutions. Governments provide subsidies and incentives to encourage the development of V2G infrastructure, while utilities offer programs that reward EV owners for participating in grid services. The Italian legislation on V2G has still to address better this topic in order to take the best out of this innovative integration.

As for incentives provided by the Italian legislation for energy communities, among them we mainly find the "ritiro dedicato", which is remuneration for energy produced but not self-consumed and therefore sold to the grid, an incentive for shared energy, i.e., energy produced but not self-consumed, but at the same time still consumed within the energy community, and finally a small incentive for self-consumed energy.

Italian legislation currently provides no remuneration for energy fed into the grid from a storage system unless it is directly connected to the energy production system, which for energy communities is often a photovoltaic system. If the energy fed in from the storage system is counted as shared energy, that is, if it is fed into the grid during a period when the energy community is requiring energy from the grid to meet its demand, then that amount will be subject to the incentives provided for shared energy. Obviously, the initial limitation on the only configuration eligible for incentives through the use of V2G technology inevitably goes a long way toward limiting the use of this model, which is why it is desirable in the future, especially as this technology and the energy communities themselves become more widespread, to modify the current legislation.

3. SECTION: SOLUTION PROPOSED BY THE TEAM

3.1. SHORT DESCRIPTION OF THE SOLUTION (max 1000 characters)

The solution is a mobile application for members and non-members of the energy community, offering services for electric vehicle owners and users in general. Electric vehicle owners can control charging/discharging, set minimum battery levels and access energy data. Charging within the community is cheaper, with lower prices and more income for members. All users can access discounts and leasing for PV systems and charging stations through partnerships, promoting self-consumption. The app provides advice on sustainable energy and information on energy production/consumption and the location of charging stations. A points system rewards activities such as energy contribution and low vehicle usage with free transport, charging time, gift cards and discounts. A virtual money balance keeps track of electric vehicle charging transactions and can be used to pay bills. There is also remuneration for the discharge phase within an energy community based on the amount of energy fed into the REC, mainly to address the issues due to this process, such as increased battery deterioration, and to make the charging/discharging process convenient for the end user.

3.2. TYPE OF SOLUTION

A product/device ☑ A system ☐ A processing method ☐

An algorithm ☐ Other ☐ (explain)

Comment and short motivation: Although the application remains at the centre of the proposed solution, it is at the same time reductive to see it as only a mobile application. What is proposed mainly includes the development and in-depth analysis of a series of services designed specifically for a very specific target of users, i.e. anyone who is part of an energy community and owners of electric vehicles, whether they are members of a REC or not. As will be described in

more detail below, the application is merely a platform where the various users who have access to it can access multiple services. In particular, the possibility of controlling in detail the charging and discharging phases of your electric vehicle, and consequently the expenses and earnings relating to them, promotes the sustainable energy, it enhances energy community efficiency, encourages green energy adoption, and supports the transition to a self-sufficient energy system.

3.3. APPLICATION AREAS OF THE SOLUTION

The solution is particularly beneficial for several key application areas. Existing electric vehicle owners and REC members will find the app invaluable for managing their energy use, controlling the charging and discharging of their vehicles, and accessing financial incentives for energy contributions within their communities. Energy-intensive households can optimise their energy consumption, reduce costs and improve sustainability with the app's energy management functions and customised incentives. For sustainability-oriented people, the app provides tools and rewards for adopting and maintaining green energy habits, promoting a greener lifestyle. Large residential complexes, such as large apartment blocks, can use the app to facilitate collective energy management, achieving cost savings and greater efficiency through shared resources and community benefits. In addition, small and medium-sized private enterprises can use the app to improve energy efficiency, reduce operating costs and support corporate sustainability goals with customised energy solutions and incentives.

3.4. ACCURATE DESCRIPTION OF THE SOLUTION

The core of our solution is a mobile application available to every member of the energy community and not. This application should be seen as a platform where each user can access various services designed for him. These include some aimed at those who own an EV, others at those who are only members of an energy community but do not own an EV, and still others for those who belong to both categories. EV owners will have the ability to control the charging and discharging phases of their vehicle, while also having access to other information such as the amount of energy drawn from or fed into the REC.

To ensure full control of the vehicle by the user, the user will be able to set a minimum battery level beyond which the discharge process will not be able to go, to ensure that the user will always be able to use the EV according to his needs. The charging process will have more favourable prices, compared to normal market prices, if this is done within a REC, as this is encouraging self-consumption of energy within the energy community. It should also be specified that those who are part of the REC will be entitled to even lower prices than those who instead charge their vehicle within the REC but are not part of it. The same considerations also apply to the discharging process, whereby one will have access to some income based on the amount of energy fed into the REC. Again, those who are part of the energy community will be entitled to greater revenues than those who are not. All REC members will have the opportunity to access discounts, through partnerships with companies, and leasing for the installation of photovoltaic systems and charging stations, again with a view to increasing the amount of self-consumed and shared energy inside the REC.

Through the application one will also receive advice and suggestions regarding more sustainable energy habits, generally trying to shift the consumption of various members from the time slots characterized by lower RES production to those time slots characterized by higher production. In addition to this, one will be able to consult other information, such as the consumption and production of one's own REC and nearby RECs via a map, the location of other energy communities, and the availability of charging stations within them. It was also planned to introduce a points system through which various REC members can have access to various rewards, such as free public transportation tickets, free charging time, gift cards, and discounts and assistance on battery change, PV systems, and charging stations. Points can be earned according to the amount of energy charged and input by the EV into the REC, by staying under a certain daily or weekly threshold of km with one's EV, through low consumption during hours characterized by low RES production, and through invitations for REC enlargement. This will be coupled with a virtual money balance where each user will be able to look up payments and earnings inherent in charging electric vehicles and with which it will also be possible to pay the bills.

A sketch of a possible design of the planned application was also developed. Some screenshots of the application are shown in Fig.1, as can be seen each screen contains part of the services just listed.

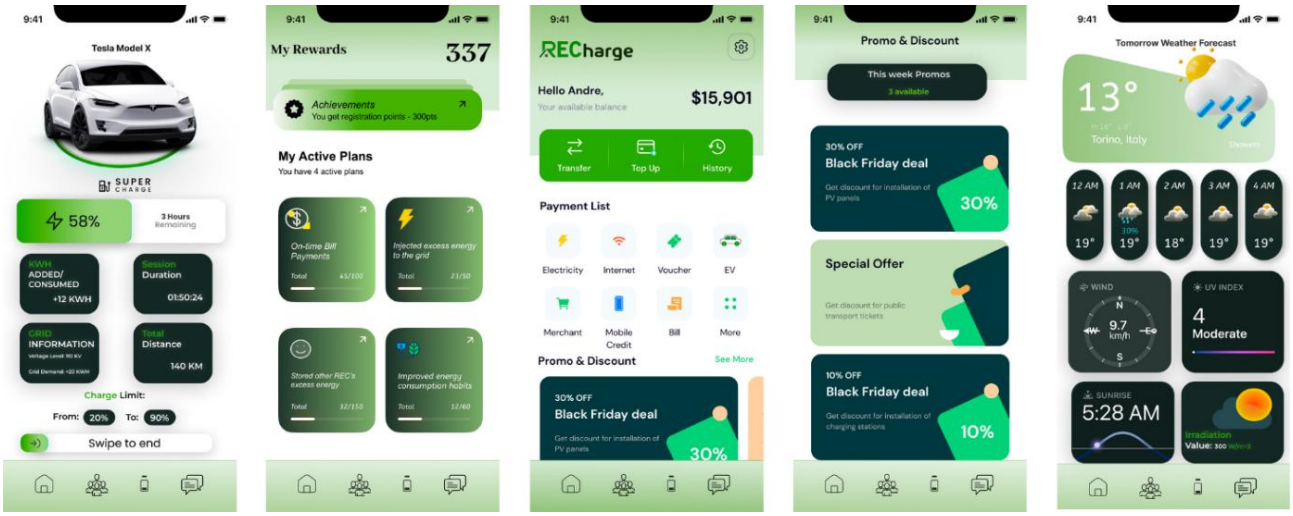


Figure 1: Application design sketch

In particular the first screen highlights the control of the charging and discharging phase of one's electric vehicle, as already anticipated it is possible to set a minimum level to the battery that, during the discharging phase, can never be exceeded, so that the user has full control of their vehicle. In addition to this, it is also possible to have access to additional information, such as the current remaining range, expressed in km, the duration of the current charge/discharge session, or the amount of energy stored or fed into the grid.

Then there is the balance of points obtained through the various functions available through the application, and various activities through which you can increase that amount, and the virtual money balance with which you can pay for various services, from simply recharging your vehicle, to recharging your cell phone, special discounts, and paying your bills.

Finally, there is a weather forecast service and the possible energy production from the photovoltaic system in the community. The latter, when coupled with data on the community's current consumption, can be used to provide suggestions to various users regarding their energy habits, seeking to shift consumption by the community at the most suitable times of day, thus enhancing the value of shared energy.

In parallel to all this, a deep economic analysis of the services just outlined was developed, particularly of the charging and discharging prices that the energy community can afford, again in line with current legislation, to make the REC model integrated with V2G technology profitable not only in comparison with the current REC model but also with the energy community model integrated with only the electric vehicle charging phase. What was then analysed is the total annual balance of the community, thus considering all the possible revenue streams and various costs, thus trying to maximize the total revenue as a function of the charging and discharging price.

To do this, an existing REC located in Magliano Alpi was analysed as a case study. The Magliano Alpi community, established on December 18, 2020, features a 20 kWp photovoltaic system installed on the roof of the town hall. Among the utilities connected to this community we have three municipal utilities, three household utilities, one small artisan business, and a number of charging stations for the recharge of electric vehicles that are available and completely free to the community. Starting from the data available for this small RECs, it was evaluated not only the economy related to the V2G system, but also the possibility of locating the charging points in the right places to get the highest incentives for the REC and the affordable charging and discharging prices that will make this project appealing for customers. This initial phase laid the groundwork for scaling up the system in alignment with ENEA's projections for future REC capacity. Quantitative analysis identified potential V2G participants and projected user interest in the mobile application through 2030. Calculations were made to determine the app's payback period and forecasted business revenues. Additionally, the study explored leveraging carbon credits from CO_2 emissions reductions in renewable energy production to finance the growth of EV-linked renewable energy communities.

What was obtained as the results of the economic analysis are thus trends in savings, compared to the standard case, obtained by the community as the price of charging and discharging EVs changes, which are commented on in more detail below.

As can be seen in the Fig.2, a linear trend can be seen between the gains and the recharge price. We have also identified two cut-off values for the latter, 0,127 €/kWh and 0,23 €/kWh, this is because outside these two cut-offs values this configuration is no longer cost-effective for the REC. If the charging price is less than 0,127 €/kWh, the price regarding the "ritiro dedicato", the REC's savings will be negative, so the total balance will be less than in the standard case, this is because with such a price it would be more convenient to directly feed this energy into the grid rather than to store it within EVs. On the other hand, the value of 0,23 €/kWh identifies the upper limit of the discharge price that the energy

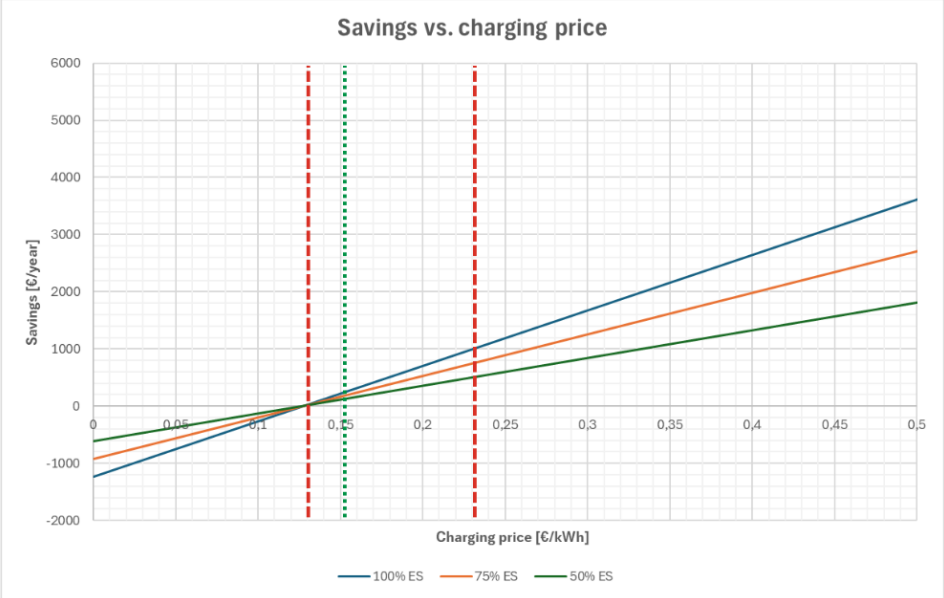


Figure 2: Savings as a function of charging price

community can afford to offer to the user, this is because the discharge price must be able to be covered directly by the incentives that the REC can obtain from this amount of energy, i.e., about 0,23 €/kWh. Moreover, as already anticipated, since the charge price is lower than the discharge price, the upper limit of the latter also coincides for the charging price. So as not to have too low earnings and a too high discharging price, a charging price of 0,15 €/kWh was chosen.

A linear trend between earnings and discharge price can also be seen for the discharge price, as can be seen in the Fig.3. In this case, when compared to the previous situation represented by the horizontal red dashed line, one can identify a

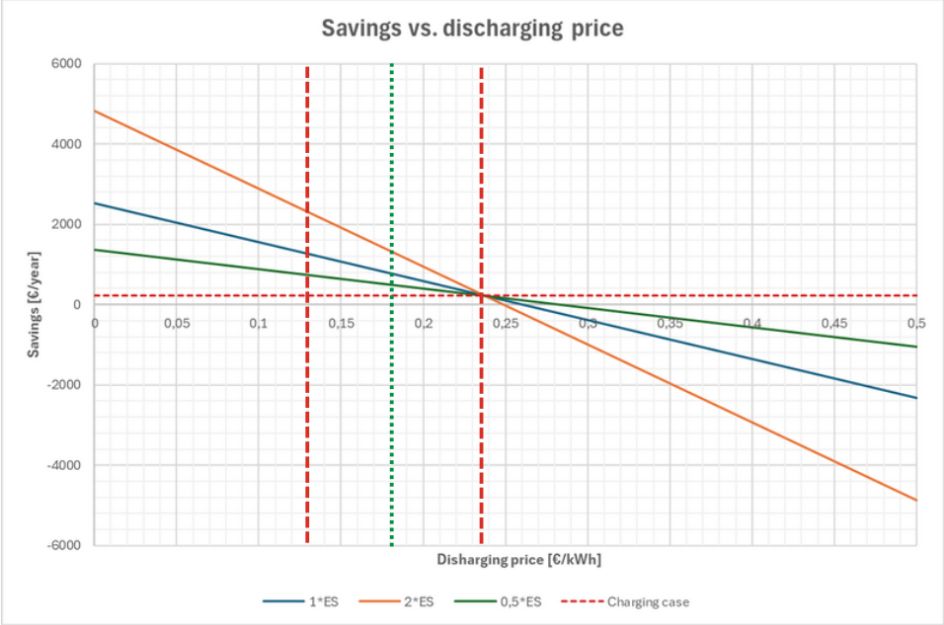


Figure 3: Savings as a function of discharging price

discharge price that is not worth exceeding, namely 0,23 €/kWh, which is equal to the sum of the "ritiro dedicato" and the incentives provided by the GSE for shared energy, amounting to about 0,11 €/kWh. Beyond this value, in fact, the discharge of energy within the REC would still be cost-effective compared to the standard case, but no more compared to the case with EVs charging only. In this case, a discharging price of 0,18 €/kWh is chosen, in order to have the entire system more profitable than the standard case but also to make the V2G more convenient compared to the only charging case.

With the previous charge and discharge prices, an annual balance in the three respective cases is conducted, so that they could be compared and the most profitable identified. Each energy flow is then identified as a cost or gain and then its contribution to the budget is calculated. Thus, among the costs we have imported energy and the discharge price, while among the gains we have self-consumed energy, exported energy, shared energy, and gains due to the charging phase. Once the contribution of each flow is calculated, the total REC budget is calculated on an annual basis, resulting for the standard case in -11.093 €/year, for the case with charging alone in -10.872 €/year, and for the case with V2G technology in -10.317 €/year. The latter thus turns out to be the most profitable configuration, with net savings of 776 €/year compared to the standard case, equal to the 7% of the initial balance, and 555 €/year compared to the case with recharging only.

The values relating to the annual budget, and therefore the possible gains for the community through the adoption of this service, obviously refer only to the case study analyzed, i.e. the REC of Magliano Alpi, the absolute values are obviously subject to the energy community considered, in particular they depend on the installed power of the photovoltaic system and the size of the community, i.e. the number of people who are part of it and the number and type of utilities.

3.5. Additional description of possible particularly Innovative aspects of the Solution

Among the most innovative aspects of the proposed project there is certainly the integration between the electric vehicle and the energy community, a connection made possible through the application already presented. Currently, there are already multiple applications for controlling the charging phase of your electric vehicle, an example of which is the Tesla application, through which it is possible to control the charging of your EV and identify the position of the various charging stations to connect to. However, none of these provide for the control of the discharge phase, as is possible through our application, for example by setting a minimum battery level that cannot be exceeded, nor do any of these provide integration with the current model of energy community.

The possibility for the final consumer to have full control of the charging and discharging phase of their EV and the possibility of accessing multiple services are the most innovative aspects among those proposed within the project.

3.6. Development status of the Solution

The proposed project is currently only in the development phase, no tests have yet been performed in the field, neither on a small scale nor on a large scale, as could be the validation phase within an existing energy community. What has been done so far consists in the formulation and development of the idea underlying the project, through a first elementary validation phase through, as already mentioned previously, the use of a case study, in this case of the REC of Magliano Alpi. Thanks to this it was possible to carry out some economic analyses, at least theoretical, on an already existing energy community. Despite this, the project has not yet been implemented within any REC, it has therefore not yet been possible to evaluate the actual impact that this may have within an energy community. This could almost certainly be the next step to take for a more complete evaluation of the project and the proposed services.

In light of these considerations, it is possible to identify a TLR 3 as the level of development and maturity of the proposed project.

4. SECTION: STATE OF THE ART AND COMPARABLE SOLUTIONS

4.1. DESCRIPTION OF THE KNOWN SOLUTIONS PRESENT IN LITERATURE/ PAPERS

Paper Title	Authors	Brief description of the Paper	Differences with the Proposed Solution
The Parker Project: Final Report	P. Andersen et al.	The Parker project, based in Denmark, focused on Vehicle-Grid Integration (VGI) to demonstrate the potential of modern electric vehicles in advanced smart grid services, including Vehicle-To-Grid (V2G). Building on previous projects like EDISON and Nikola, Parker used contemporary EVs and V2G DC chargers from industrial partners to conduct tests and demonstrations at PowerLabDK, a research platform for power systems. It collaborated with the Frederiksberg Forsyning V2G hub in Copenhagen, where EVs provided frequency containment reserve.	The project investigated grid applications, grid readiness, and scalability and replicability of VGI technologies. It focuses less on the end-user and how to incentivize the joining of this solution. It does not address directly RECs.
Smart Solar Charging: Bi-Directional AC Charging (V2G) in the Netherlands	Baerte de Brey et al.	In Lombok, Utrecht, the Netherlands, an innovative pilot project launched featuring smart solar charging stations, shared electric vehicles, and AC (alternating current) V2G technology. This initiative demonstrates that electric vehicles represent a grid opportunity rather than a challenge. A special collaboration with OEM Renault was established to develop a product line of AC V2G vehicles and to advance open standardized communication among the EVs, charging stations, and the grid.	It does not address directly RECs but the issue analysed is the same. It is mainly an analysis on the communication of EVs with the infrastructure. Again, it does not target directly the end-user that will interact with the system.
Business models for energy communities: A review of key issues and trends	Inés F.G. Reis et al.	The paper provides a detailed analysis of business models for renewable energy communities (RECs). The document identifies eight business model archetypes for energy communities within the current European regulatory framework. These archetypes are: Energy cooperatives, Community-owned renewable energy projects, Third-party financing models, Municipal energy companies, Virtual power plants, Peer-to-peer energy trading, Energy-as-a-service e Crowdfunding	Comparing the business models presented in the document with the one proposed for the application and functionality of energy communities and electric vehicle owners, some significant differences emerge. The business model proposed in the paper mainly focuses on different organizational structures and financing modes for RECs, such as energy cooperatives, community-owned renewable energy projects, and third-party financing. These models emphasize community involvement, local ownership, and democratic governance structures.

			The model proposed for the application, however, focuses on a more integrated and technological approach. The application not only facilitates energy management and charging of electric vehicles, but also offers a range of additional services, such as discounts, leasing for the installation of photovoltaic systems and charging stations, advice on sustainable energy habits, and a of points for rewards. Furthermore, the proposed model aims to incentivize energy self-consumption within RECs and create an ecosystem of integrated services that benefit members of the energy community and owners of electric vehicles.

4.2. PRIOR ART - EXISTING PATENTS

Despite an extensive search on web site on www.orbit.com, Google Patent and www.espacenet.com, it was not possible to find any existing patents representing a technology or product similar to the one currently under development. However, for a complete and definitive assessment, it may be necessary to conduct a more in-depth search to provide comprehensive confirmation of the absence of relevant patents.

4.3. KNOWN PRODUCT

Product Name	Manufacturing Company	Brief description and features of the Product	Differences with the Proposed Solution
Tesla	Tesla	The Tesla app is designed specifically for Tesla vehicle owners and provides complete vehicle control directly from your smartphone. It is primarily used to manage vehicle features and to find and use Tesla Supercharger charging stations. The app includes an interactive map of Supercharger and Destination Charger charging stations, with real-time availability information, and allows you to view the vehicle's charging status, including time remaining and battery level, and start or stop remote charging. The app is seamlessly integrated with all Tesla vehicle features, offering a seamless user experience and exclusive access to Tesla's Supercharger fast charging network, which offers very fast charging times.	The Tesla app is strictly aimed at owners of Tesla vehicles and customers of Tesla energy products, such as Powerwall. This is a specialized application that serves a specific audience, mainly made up of those who have already invested in Tesla brand products. On the other hand, the service we are proposing aims at a much broader target, including all members of energy communities, owners of any type of electric vehicle, and even users who do not own an EV but who participate in energy initiatives renewable. Tesla takes a proprietary approach, limiting the use of its app to only Tesla products, which creates a closed but very well integrated ecosystem.
Enel X JuicePass	Enel X	Enel X JuicePass is the official Enel X application for managing electric vehicle charging stations in Italy. It is widely used thanks to the vast network	Enel X JuicePass is aimed primarily at owners of electric vehicles who need charging solutions. The target includes

		of Enel X stations, national coverage and numerous advanced features. Also, in this case there is the possibility to view public and private charging stations on an interactive map, with details on real-time availability, and to book charging stations to guarantee availability upon arrival. Payment management for charging sessions is also implemented directly through the app, with different payment options. Distinctive features include access to one of the largest networks of charging stations in Italy, including the fast-charging network, and the ability to manage both public and domestic charging, offering a unified experience for all customers. types of charging.	both individual consumers who use electric vehicles for personal use and companies that manage fleets of electric vehicles. Our service is aimed at a much broader audience, including not only electric vehicle owners, but also all members of energy communities. This broader target includes people who participate in renewable energy initiatives without necessarily owning an EV, making the application proposed suitable for a wide range of users with different energy needs. The Enel X JuicePass app focuses primarily on managing the charging of electric vehicles. Its main features include charging station location, station booking, real-time charging monitoring, and payment management. The proposed service instead offers a wider and more diversified range of functions, in addition to managing the charging of electric vehicles, our app focuses on integration with energy communities. It includes tools to monitor and manage energy consumption and production within the community, encouraging self-consumption and energy efficiency.
PlugShare	EVgo Inc.	PlugShare is one of the most popular and widespread applications globally for finding electric vehicle charging stations. In Italy, it is widely used by electric vehicle owners for its comprehensive charging station map, detailed reviews and community features. Through this application, users can leave reviews and ratings on charging stations, providing useful feedback on their experience. One of PlugShare's strongest features is its active community of users who share reviews, photos and updates about charging stations, creating a reliable and up-to-date source of information. The app is free and offers most of its features at no additional cost, making it accessible to all electric vehicle owners.	PlugShare is aimed primarily at owners of electric vehicles of all brands looking for public charging stations. Its target audience includes both individual consumers who use electric vehicles for personal use and companies that operate fleets of electric vehicles. PlugShare is especially popular among those who travel frequently and need to find reliable charging stations along their routes. Our service, however, is aimed at a broader audience, including not only owners of electric vehicles, but also members of energy communities. This target includes people who

		PlugShare stands out for its extensive data base, active user participation and ease of use, making it a valuable resource for anyone who owns an electric vehicle and needs reliable information about available charging stations.	participate in renewable energy initiatives without necessarily owning an electric vehicle. The main differences between PlugShare and the app we offer lie in the scope and approach of the features offered. While PlugShare is focused solely on locating and evaluating charging stations, ours takes a broader, more integrated approach, addressing a more diverse audience and promoting sustainability and energy efficiency within energy communities. While PlugShare is a specialized solution for finding and evaluating charging stations, the project's app offers a more inclusive and community approach, integrating various features that support self-consumption and active user participation in sustainable energy management.
mySolarEdge	SolarEdge	SolarEdge is a widely used application for monitoring photovoltaic systems, designed for users using SolarEdge inverter systems. It provides a detailed, real-time overview of solar energy production, system efficiency and system health, helping users maximize energy yield and keep their system in optimal condition. Among the various features it provides updated data on the energy production of the photovoltaic system, allowing users to see how much energy is produced at any time, offers tools to analyze the performance of the system, identifying potential problems and optimization opportunities and supports integration with energy storage systems, allowing you to monitor and manage stored energy. Furthermore, for installers or users with multiple photovoltaic systems, SolarEdge allows you to monitor and manage multiple sites from a single platform, making management centralized and more efficient. In addition to the mobile app, it offers a web portal that allows access to data and management of the system from any device connected to the Internet, ensuring flexibility and convenience.	mySolarEdge takes a technical and oriented approach to solar energy management. The app is highly specialized for monitoring and optimizing the performance of photovoltaic systems, providing detailed data and analysis tools to help users maintain and improve the efficiency of their solar system. The service we propose instead adopts a more integrated and community approach. In addition to facilitating the management of photovoltaic systems, it promotes collaboration between members of the energy community and the sustainable use of energy resources. This open approach facilitates cooperation between different stakeholders and encourages wider and more sustainable use of renewable energy, promoting active user participation and incentivizing sustainable behavior. While mySolarEdge is focused exclusively on the management and optimization of photovoltaic systems, our

			service takes a broader and more integrated approach, addressing a more diverse audience and promoting sustainability and energy efficiency within energy communities.

5. SECTION: BUSINESS

5.1. DEFINITION OF VALUE PROPOSITION

Our value proposition focuses on innovation and inclusiveness, offering a wide range of services through a dedicated mobile platform that unites members of energy communities, electric vehicle (EV) owners, and users belonging to both categories. Here are the key points that outline the unique value that our business model brings to customers:

- **Control and flexibility of energy management**
  EV owners will have the ability to monitor and manage the charging and discharging phases of their vehicles directly from the app. They will be able to set a minimum battery level to ensure that their vehicle is always ready for use, guaranteeing maximum flexibility and peace of mind. Furthermore, subsidized charging prices within the Energy Community (REC), encouraging self-consumption and reducing energy costs compared to standard market prices will promote self-sufficiency, enabling users to maximise the use of renewable energy and reduce dependence on external sources. Improving the flexibility of energy management through application enable users to efficiently control their energy use.

- **Economic and energy saving incentives**
  REC members who power energy in the community will receive compensation incentivizing active participation and contribution to the community's energy self-sufficiency. Access to discounts and leasing for the installation of photovoltaic systems and charging stations, thanks to collaboration with partner companies, will promote the adoption of renewable energy. Economic benefits are unlocked through participation in REC programmes and leasing services, promoting cost-effectiveness and sustainability.

- **Advanced energy management and monitoring**
  The app provides advice on more sustainable energy habits, helping users to shift consumption towards time slots with greater production from renewable sources (RES). Viewing the consumption and production statistics of your REC and nearby RECs via an interactive map will facilitate information sharing and collaboration between communities.

- **Sustainability and innovation**
  The introduction of a points system that rewards virtuous energy behavior, such as charging and discharging the EV in the REC, meeting EV consumption and mileage thresholds, and inviting new members to the REC, and the various rewards that include free public transport tickets, free charging time, gift cards, and discounts on battery-related services, photovoltaic systems, and charging stations, all features designed to promote energy sustainability and reduce environmental impact, encouraging self-consumption and the use of renewable energy, supporting the transition towards a greener and more responsible energy future and an energy sustainable lifestyles. The app's innovative features, such as real-time monitoring and personalized recommendations, help users optimize their energy consumption and actively contribute to the success of energy communities.

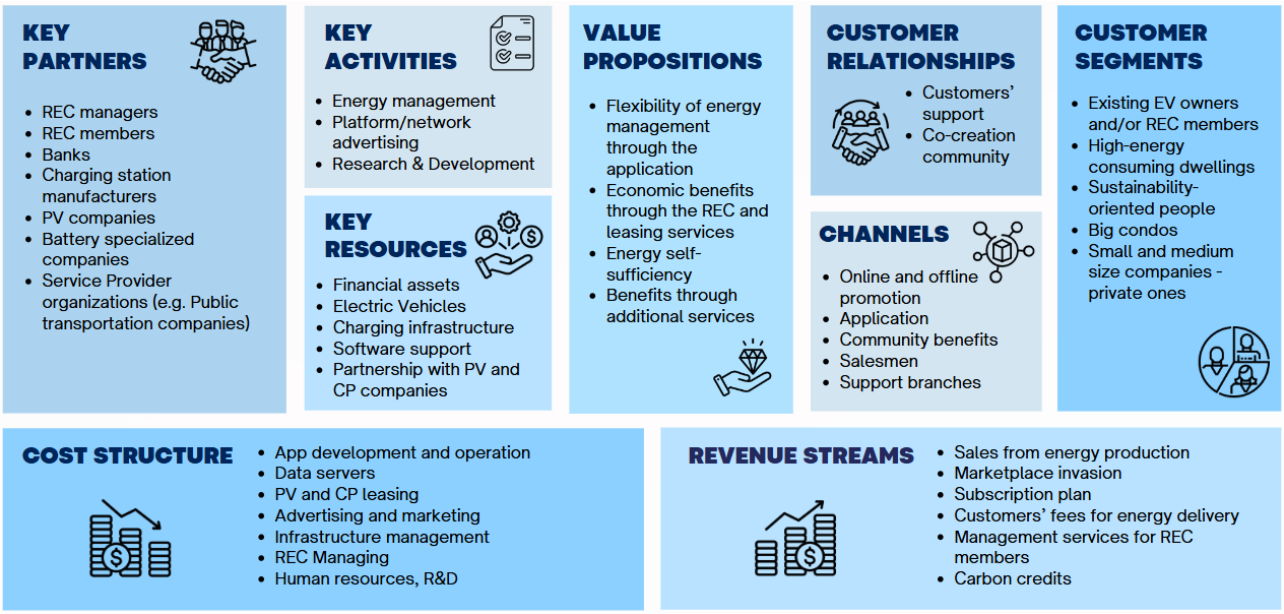
In summary, our value proposition is distinguished by the combination of control, cost-effectiveness, incentives, advanced management, integration, accessibility, sustainability and innovation, creating a dynamic and resilient energy ecosystem that benefits both individuals and the entire community.

5.2. DEFINITION OF ONE, OR MORE, "USE CASE" FOR THE USE OF THE SOLUTION

One use case for the solution could be a scenario involving an existing EV owner who is also a member of an energy community. Through the application, the user can monitor their EV's battery status and energy consumption patterns. They can set preferences for charging times to optimize cost savings by taking advantage of lower prices within the community's REC. The user also participates in V2G activities, earning rewards for contributing excess energy back to the grid during peak demand periods. Additionally, the application provides real-time updates on renewable energy production, allowing the user to align their energy usage with periods of high renewable generation, thus maximizing their contribution to sustainable energy practices.

Another use case can be an EV owner who is not currently a member of a renewable energy community but opts to charge and discharge their vehicle within the REC's infrastructure. By using the REC's facilities, the EV owner can benefit from lower charging prices compared to the open market rates and can also get paid for discharging a certain amount of its vehicle's charge within the REC in demand periods. The mobile app plays a crucial role by enabling real-time monitoring of battery status and energy usage, optimizing charging schedules based on REC pricing, and facilitating participation in Vehicle-To-Grid activities.

5.3. BUSINESS MODEL CANVAS



1- Key Partners

In the business model for the application, key partners play a fundamental role in ensuring the success and sustainability of the project. Energy community managers (RECs) are essential for organizing and coordinating activities within energy communities, ensuring that the application meets the specific needs of the community and facilitates the integration of new technologies. Members of energy communities are both end-users and key partners, actively contributing to the production and consumption of renewable energy and benefiting from the app's features, such as energy consumption monitoring and the points-based incentive system. Banks are strategic partners, facilitating access to financing for the installation of photovoltaic systems and charging stations, making the initial investments necessary for the transition to more sustainable energy more accessible. Charging station manufacturers provide the necessary infrastructure for charging electric vehicles, ensuring app compatibility and offering advanced features. Photovoltaic companies collaborate for the installation and maintenance of photovoltaic systems, contributing to the production of solar energy and supporting the community's sustainability objectives. Finally, service provider organizations, such as public transport companies, offer additional benefits to members of energy communities through incentives based on the application's points system, promoting the sustainable use of energy and public transport.

2- Key Activities

In the business model for the application proposed, the key activities are fundamental to guarantee the efficient operation and success of the project. Energy management is central, as it involves monitoring and optimizing energy consumption and production within energy communities. This includes managing the charging and discharging phases of electric vehicles, promoting self-consumption and encouraging the efficient use of renewable energy resources. Through careful energy management, the application aims to maximize energy efficiency and reduce dependence on the traditional electricity grid. Advertising activity on the platform and on the network is equally important. Through this activity, it's possible to attract new users and partners, promoting the benefits of the application and energy communities. Effective advertising helps expand the user network, raise awareness about renewable energy and promote sustainable behavior. Furthermore, it allows to create synergies with partner companies, offering them visibility and collaboration opportunities. Research and development (R&D) is a key activity for continuous innovation and application improvement. Investing in R&D allows to develop new functions, improve existing ones and adopt cutting-edge technologies for energy management and the integration of energy communities. This includes the development of energy storage solutions, the optimization of electric vehicle charging and the implementation of advanced algorithms for the intelligent management of energy resources. R&D is essential to keep the application competitive and respond to the evolving needs of users and the energy market.

3- Key Resources

In the business model, key resources play a crucial role in supporting the implementation and effective operation of the project. Financial assets are critical to funding initial investments and ongoing application development. Electric vehicles and charging infrastructure support sustainable mobility within energy communities by enabling the intelligent management of charging and discharging renewable energy. Software support optimizes application functionality, improving user experience and operational efficiency. Partnerships with photovoltaic and car sharing companies expand capabilities in providing integrated solutions, supporting the adoption of sustainable energy practices and promoting responsible behaviour within energy communities.

4- Value Proposition

In the business model of the application proposed, the main value propositions focus on four fundamental pillars. First, the app offers unprecedented flexibility in energy management, allowing users to optimize energy consumption and production through detailed and personalized control. This not only improves energy efficiency, but also offers significant savings opportunities. Secondly, the application allows users to access tangible economic benefits through Energy Efficiency Certificates (REC) and leasing services for the installation of photovoltaic systems and charging stations. This promotes self-consumption of renewable energy and reduces energy costs, thus improving the economic sustainability of energy communities. Third, promotes energy self-sufficiency, making it easier for users to manage and optimize the local energy produced. This approach not only reduces dependence on the traditional electricity grid, but also strengthens the resilience of energy communities against outages and increases overall energy independence. Finally, the application offers benefits through a range of additional services, including discounts on products and services from corporate partners, advice for more sustainable energy behaviors and support for plant maintenance. These services improve the quality of life of users, promoting responsible energy consumption practices and facilitating the adoption of sustainable solutions.

5- Customer Relationship

In our application business model, customer relationship management is centralized on building trust and satisfaction through two key approaches. First, it would be offered dedicated customer support, guaranteeing timely and competent responses to resolve any problems and provide assistance. Second, it actively promotes a co-creation community, where users can share feedback and ideas to continuously improve the services offered. This commitment to a proactive and collaborative relationship not only optimizes the user experience but also supports innovation and adaptation to the needs of the energy market and consumers.

6- Channels

In the business mode, the distribution of services takes place through different strategic channels to maximize the reach and effectiveness of the offers. A combination of online and offline promotion is used to raise awareness among a wide audience of the benefits of energy communities and the use of the application. The app itself serves as the main interface for users, offering direct access to all services, from energy management to

participation in self-consumption energy initiatives. Benefits for communities, such as preferential prices for electric vehicle charging and discounts on energy products, are promoted to improve the adoption and effectiveness of the initiatives. Sales agents and physical support branches provide personalized and local support, ensuring complete and immediate customer service. This multi-channel approach aims to optimize accessibility, user experience and the transition to a more sustainable and resilient energy system.

7- Customer Segments

In our business model, customer segments are carefully selected to maximize the impact and adoption of the energy solutions offered. Key customer segments include owners of existing electric vehicles and/or members of energy communities, who directly benefit from the energy management features and economic benefits of the application. Homes with high energy consumption represent another key segment, as they can benefit from consumption optimization and preferential tariffs offered within energy communities. Sustainability-oriented people are ideal targets, thanks to their intrinsic interest in renewable energy solutions and responsible consumption practices. Large condominiums can take advantage of the proposed services to improve collective energy efficiency and reduce costs through shared energy management. Finally, small and medium-sized private businesses represent a strategic segment, as they can use the various services to reduce operating costs and improve their sustainability. This segmented approach allows us to offer targeted and personalized solutions, promoting the adoption of sustainable energy practices in different contexts.

8- Cost Structure

The cost structure includes several key elements. The development and operation of the application represents a central component, including costs related to programming, maintenance and continuous updating of the software. Data servers are essential for storing and processing data, ensuring a reliable and secure service for users. Leasing photovoltaic systems and charging stations requires investments to encourage the adoption of renewable energy. Advertising and marketing expenditures are necessary to promote the application and increase awareness of its features and benefits. Infrastructure management, including the installation and maintenance of charging stations and photovoltaic systems, involves significant operational costs. Energy community management (REC) requires resources to coordinate and optimize community activities. Human resources are crucial to support all operations, from customer support to technical and administrative management. Finally, research and development (R&D) is essential to continuously innovate and improve the service offering, keeping the company competitive in the energy market.

9- Revenue

In the application business model, revenue sources are diversified and strategically structured. Sales from energy production represent a significant component, as the energy produced by energy communities is sold to members and the market. The marketplace invasion generates additional revenue through the promotion and sale of sustainable energy-related products and services. Subscription plans offer recurring revenue from users who pay to access application features. Fees paid by customers for energy delivery are another important source of revenue, as users pay for energy delivered within the community. Management services for members of energy communities (RECs) offer additional revenue by providing support and coordination of energy activities. Finally, carbon credits represent an additional source of revenue, as the reduction of CO2 emissions is valorised and sold on the carbon credit market. This diversified approach allows you to generate revenues from multiple sources, supporting the financial sustainability of the company and encouraging participation in energy communities.

5.4. S.W.O.T. ANALYSIS

Strengths

- **Complete Integration:** The application offers a wide range of services for electric vehicle owners and members of energy communities, enabling comprehensive optimization of energy management.
- **Economic Benefits**: Subsidized rates for charging electric vehicles and economic incentives for energy fed into the energy community.

- **Sustainability**: Promotes the use of renewable energy and reduction of carbon emissions, contributing to a cleaner environment.
- **Technological Innovation**: The app uses advanced technologies for energy monitoring and management, increasing energy efficiency.
- **Strategic Partnerships**: Collaborations with charging station manufacturers, solar companies and other service organizations, increasing the range of services offered.

Weaknesses

- **Dependence on Technology**: The technological complexity of the app requires ongoing maintenance and upgrades, leading to high costs.
- **High Initial Costs**: Initial investment in app development, charging infrastructure, and PV installations can be significant.
- **Barriers to Entry**: Potential difficulties in attracting users who are not technically savvy or less inclined to change their energy habits.
- **Regulation and Bureaucracy**: The need to comply with local and national regulations can complicate project implementation and expansion.

Opportunities

- **EV Market Growth**: Increased EV sales offer a significant opportunity to expand the user base.
- **Expansion of Energy Communities**: Growing focus on renewable energy and energy self-sufficiency may facilitate the creation of new energy communities.
- **Innovation and Differentiation**: Opportunity to develop new features and continuously improve the application to remain competitive.
- **Government Incentives**: Availability of subsidies and incentives for renewable energy and electric mobility that can reduce costs and increase adoption.
- **Education and Awareness**: Growing consumer awareness and interest in sustainable energy practices.

Threats

- **Intense Competition**: The presence of other competing energy companies and technologies can limit market share.
- **Energy Price Instability**: Fluctuations in energy prices can affect the profitability and economic attractiveness of the project.
- **Technological Risks**: Vulnerability to cyber-attacks and data security issues that can undermine user confidence.
- **Changing Regulations**: Changes in energy laws and regulations may impose new operational and financial challenges.
- **Market Acceptance**: Risk that consumers will not adopt the application or actively participate in energy communities, limiting the success of the project.

Our proposed solution consists of different aspects. As the main core of our idea for integration of electric vehicles into renewable energy communities, the application which we presented to be utilized as the communication between the customers and the company plays an important role. So, performing an analysis related to the performance of this application is crucial. In this case, we can realize the effectiveness of our solution. The analysis to be performed for the effectiveness of the application mainly depends on the customers feedback on their use of the application. The way they investigate the application, how they find their way through different sections of the application, how they connect to the company and other details are among the details which we can measure the quality of our application and see how user-friendly it is.

Updating the application regularly could help the customers to be better connected to the application and use it as easy as possible. Including new features to the app is another important issue that should be taken into account in order to cover the needs of the customers.

The application we proposed consists of some main parts which are critical for managing the usage of EV in REC. The state of charge of the EV, map of the RECs, weather forecast, battery condition, economic section and the main part of the communication with the company are among the sections we have considered for the application. These are the strengths of our application.

5.5. COMPETITORS

Below is a list of Iren's possible competitors in the field of energy communities, and who therefore could be interested in implementing a similar project within their business. Among the various competitors there are:

- **Enel X**
  Enel X is a division of the Enel group, one of the largest energy suppliers in the world. Enel X's mission is to lead the energy transition and promote the adoption of innovative technologies for sustainability. The company is focused on electric mobility, energy efficiency, energy storage solutions and smart grids. Enel X is present in over 20 countries and operates a vast network of charging infrastructure for electric vehicles, making it one of the main global players in the electric mobility sector.

  Enel X is a direct competitor of Iren for its vast network of electric vehicle charging stations and advanced solutions for energy communities. Enel X's ability to integrate smart grid solutions with electric mobility, combined with its global presence and capacity for innovation, represents strong competition for Iren. Furthermore, Enel X is very active in Italy with numerous energy community projects and sustainability initiatives, further strengthening competition.

- **Edison**
  Edison is one of the oldest Italian energy companies, founded in 1884, and is part of the EDF (Électricité de France) group. Edison is engaged in the production, distribution and sale of electricity and natural gas, with a growing focus on renewable energy and technological innovation. The company also operates in the renewables sector with wind, solar and hydroelectric projects and offers energy efficiency solutions for both individuals and companies.

  Edison is considered a competitor of Iren for its commitment to renewable energy and energy storage solutions. Its consolidated experience in the energy sector, combined with innovative projects and a strong presence on the national territory, makes it a strong competitor in the energy community market. Furthermore, Edison is investing heavily in electric mobility and smart grids, further increasing competition with Iren.

- **Hera Group**
  Hera Group is one of the main Italian multi-utilities, created from the merger of several municipal companies in 2002. Hera operates in the energy, environment and water sectors, providing services to millions of citizens mainly in the north-east of Italy. The company is known for its attention to sustainability, innovation and the quality of the services offered. Hera is particularly active in waste management, in the distribution of water and gas, and in the production of energy from renewable sources.

  Hera is a competitor of Iren thanks to its ability to offer integrated solutions for energy, water and waste management. Its electric vehicle charging infrastructure, along with community energy and smart grid projects, represents stiff competition. Hera also has a strong territorial presence and consolidated experience in the management of energy and environmental resources, elements that make it a significant rival for Iren.

- **Eni**
  Eni S.p.A., founded in 1953, is one of the largest global energy companies with a presence in over 70 countries. Originally focused on hydrocarbons, Eni has expanded its field of activity to include renewable energies, biofuels and innovative technologies for the energy transition. The company is actively involved in the production and distribution of oil, natural gas, electricity and chemicals, with a growing commitment to sustainability and the reduction of CO_2 emissions.

  Eni, with its vast experience in the energy sector, investments in renewable energy and electric mobility infrastructure, and commitment to energy efficiency and smart grids solutions, represents a strong competitor

for Iren. Both companies are working towards the energy transition and the creation of sustainable energy communities, making the competition between them particularly relevant in the context of the Italian and global energy markets.

- **A2A**
  A2A is an Italian group that operates in the energy, environment and heat sectors. Founded in 2008 from the merger of ASM Brescia and AEM Milano, A2A is one of the main energy operators in Italy. The company is active in the production, distribution and sale of electricity and natural gas, with a strong commitment to renewable energy and energy efficiency. A2A also manages environmental services, such as waste collection and disposal, and offers district heating solutions.

  A2A is a competitor of Iren for its wide range of energy services and energy efficiency solutions. A2A's charging infrastructure, together with its smart grid projects and energy storage solutions, represent strong competition. Furthermore, A2A has a consolidated presence in Lombardy and other Italian regions, with extensive experience in the management of energy and environmental resources.

- **Acea**
  Acea is one of the main Italian multi-utilities, based in Rome. Founded in 1909, Acea operates in the distribution of water, electricity and gas, and in the management of environmental services. The company serves more than 9 million customers and has a strong presence in the Lazio region and other parts of central Italy. Acea is committed to developing sustainable and innovative solutions for the management of energy resources, with particular attention to renewable energy and energy efficiency.

  Acea is considered a competitor of Iren due to its widespread presence in Lazio and its initiatives in the renewable energy and electric mobility sector. Acea's solutions for smart grids, together with its charging stations for electric vehicles, represent strong competition. Acea also has long experience in the integrated management of energy and environmental resources, making it a competitor in the energy community sector.

6. SECTION: FUTURE DEVELOPMENTS

6.1. POSSIBLE FUTURE DEVELOPMENTS

Among future developments there is certainly a need to test the proposed project in a real context, such as an existing energy community. We would therefore move from the analysis of a case study to the implementation of the project directly in a REC, to have the most complete analysis possible regarding the actual benefits and earnings for the consumers to whom this project is aimed. To do this it is therefore necessary to implement this project in different energy communities, even of different sizes, to be able to also evaluate the effect of the extension of the REC on the final results.

What is also necessary to do consists in the economic evaluation of some services that were included in the general idea of the project, but which, for reasons of time, it was not possible to evaluate from a purely economic point of view, in particular we refer to the point system on which the application is based. It was not possible to evaluate the effect of the various guaranteed rewards, such as free public transport tickets or discounts on the installation of photovoltaic systems and charging stations, on the economic balance sheet of the REC and the company promoting this service , in this case Iren.

Therefore, a more in-depth economic analysis of the project and a subsequent implementation directly within an already existing REC are the first two steps to be taken towards the definitive development of this project. Through validation within a real context, it will therefore be possible to collect other data and results, which can be used accordingly to validate the proposed project, or to make further modifications and present an improved and more effective version for the context for which it is thought.

6.2. INTERESTS OF THE TEAM IN CONTINUING DEVELOPMENT

After careful reflection and internal evaluation, we have made the decision not to continue with this project. While it has been a significant journey for us, we must consider several factors that influence this decision. Some of our members, part of a double degree program between chemical and energy engineering, have completed, or are about to conclude, their academic paths and are no longer available to continue the project as part of their studies or as a thesis. Additionally, other team members did not demonstrate sufficient ongoing interest to justify additional investments of time and resources. Given this situation, we do not believe that at the moment there are the conditions and interest to proceed with this project.

DATA PROCESSING

Data processing is authorized according to General Data Protection Regulation (EU) 2016/679 (GDPR) for the purposes contained in this application.

Date

26 June 2024

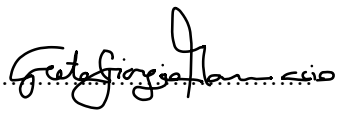
SIGNATURE OF EACH TEAM MEMBER

(Name, Surname and relative signature)

…… Angelica Fusiello ……

…… Mohammad Amin Ghorbani ……

……Khalil Ekradi……

Greta G. Maruccio. 

Giacomo Sandrone..