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BUSINESS MODEL INNOVATION IN RENEWABLE ENERGY COMMUNITIES

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Abstract

The reform of the electricity sector was promoted with the publication of the Directive (EU) 2018/1999 of 11 December, which Portugal subsequently adapted, publishing Decree-Law nr. 15/2022 of 14 January. This reform aims to achieve a carbon-neutral future for the 2030 horizon.

In an era of increasing energy demands worldwide, it is important to reduce greenhouse gas emissions, promoting the use of energy from renewable sources and energy efficiency and security (Decree-Law nr. 15/2022 of 14 January). In this sense, the European Union and Portugal have stipulated a series of incentives in the field of energy, contributing to the first steps through the creation of energy models, among them, renewable energy communities (REC) (Azevedo, 2023; Cabrita, 2021).

These RECs aim to encourage their members or shareholders, located nearby, to use renewable energy sources for the production, storage, consumption, and distribution of energy (Antunes, 2023). In this study, I sought to obtain a more in-depth and detailed view of the RECs in Portugal, namely, to identify the reasons that may have enhanced or limited the adherence to RECs.

For this purpose, a case study was conducted using interviews. In the approach to this work, the framework "The Triple Layer Business Model Canvas" was used, which integrates factors that affect sustainable business models, among them, environmental and social factors (Joyce & Paquin, 2016; Kluza *et al.*, 2021; Osterwalder & Pigneur, 2010).

The results show that the involvement of the different pillars and layers of the framework used contributed to a broad vision of the business model of the REC. The reduction of the cost of electricity bills, network resilience, and the existence of support companies, are positive aspects of adherence to RECs, however, it is verified that the number of actors for the creation of an REC, the associated legislation, the high initial costs, the lack of information and the lack of capable information systems, are detrimental to the community's membership.

Keywords: Energy efficiency, Renewable energy communities, The Triple Layer Business Model Canvas.

Resumo

A reforma do setor da energia elétrica foi promovida com a publicação da Diretiva (UE) 2018/1999 de 11 de dezembro, que posteriormente Portugal adaptou, publicando o Decreto-Lei n.º 15/2022 de 14 de janeiro. Esta reforma visa à obtenção de um futuro neutro em carbono para o horizonte de 2030.

Numa era de crescentes exigências energéticas a nível mundial, torna-se importante reduzir as emissões de gases com efeito de estufa, promovendo a utilização de energias de fontes renováveis e a eficiência e segurança energética (Decreto-Lei nº 15/2022 de 14 de janeiro). Neste sentido, a União Europeia e Portugal estipularam uma série de incentivos no domínio da energia, contribuindo para os primeiros passos através da criação de modelos energéticos, entre eles, as comunidades de energia renovável (CER) (Azevedo, 2023; Cabrita, 2021).

Estas CER, têm por objetivo o incentivo dos seus membros ou acionistas, localizados nas proximidades, a utilizar fontes de energia renovável com vista à produção, armazenamento, consumo e distribuição de energia (Antunes, 2023). Neste estudo, procurei obter uma visão mais aprofundada e detalhada sobre as CER em Portugal, nomeadamente identificar as razões que podem ter potenciado ou limitado a adesão às CER.

Para o efeito, foi realizado um estudo de caso recorrendo à realização de entrevistas. Na abordagem a este trabalho foi utilizado o framework "*The Triple Layer Business Model Canvas*" que integra fatores que afetam os modelos de negócios sustentáveis, entre eles, os fatores ambiental e social (Joyce & Paquin, 2016; Kluza *et al.*, 2021; Osterwalder & Pigneur, 2010).

Os resultados mostram que o envolvimento dos diferentes pilares e camadas do framework utilizado contribuíram para uma visão alargada de modelo de negócio das CER. A redução do custo da fatura da eletricidade, a resiliência de rede, e a existência de empresas de suporte, constituem aspetos positivos de adesão às CER, contudo, verifica-se que o número de intervenientes para a criação de uma CER, a legislação associada, os elevados custos iniciais, a falta de informação e a não existências de sistemas de informação capazes, constituem aspetos prejudiciais à adesão da comunidade.

Palavras-chave: Eficiência energética, Comunidades de energia renovável, The Triple Layer Business Model Canvas.

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List of Abbreviations

BMC	Business Model Canvas
CCE	Citizen Communities for Energy
DGEG	*Direção Geral da Energia e Geologia*
EPC	Energy Performance Contracting
ERSE	*Entidade Reguladora dos Serviços Energéticos*
ESC	Energy Supply Contracting
ESCO	Energy Services Company
ESPC	Energy Savings Performance Contract
EU/UE/CCE	European Union
ENSE	*Entidade Nacional para o Setor Energético*
MIBEL	*Mercado Ibérico Comum de Energia*
MWh	Megawatt hours
OMIP/OMIE	*Operador de Mercado Elétrico Portugal/Espanha*
PEB	Positive Energy Block
PEDs	Positive Energy Districts
PNEC	*Plano Nacional Energia e Clima*
RE	Renewable Energy
REC	Renewable Energy Community
REN	*Rede Elétrica Nacional*
SEN	*Sistema Elétrico Nacional*
TLBMC	Triple Layer Business Model Canvas

1. Introduction

In an era of enormous environmental difficulties and increasing energy demands worldwide, the importance of sustainable and renewable energy sources is becoming increasingly apparent. Just look at what has been done in the last few years. The definition and operationalization of various instruments such as the roadmap for carbon neutrality 2050, the *Plano Nacional Energia e Clima* 2030 (PNEC 2030), and more recently, the long-term strategy for the renovation of the building, are proof of its importance and show that efficiency is even a priority to achieve the objectives of carbon neutrality (Observatório de Energia *et al.*, 2021).

The energy market is not as simple as it seems. It requires a great deal of knowledge to understand it correctly. However, when it comes to improving energy efficiency in our own homes, many people are becoming increasingly interested in this topic. Today, more and more attention is being paid to the rising cost of energy, the environmental problems caused by greenhouse gas (CO_2) emissions, urban pollution and the related effects on the social and economic spheres (Aruta *et al.*, 2023).

According to Pätäri & Sinkkonen (2014), and Kelly (2011), the most significant energy consumption in dwellings is the combination of several factors such as household composition, type of housing, heating patterns, room temperature, floor area, among others.

Energy efficiency has been improving since the first oil crisis in 1973, but there is still enormous potential to evolve and develop new ways to reduce energy consumption.

It is expected that this study will constitute another modest contribution to the set of knowledge so far disseminated on renewable energy user communities, especially in Portugal. The findings will not only provide practical advice for community organizers and residents interested in launching their own sustainable energy programs but will also provide policymakers with information that will help them create more effective strategies and legislation. In addition, this research could be a starting point for comparative studies, as well as serve as inspiration for other projects in this area or in other countries struggling with the difficulties related to the energy transition.

1.1. Motivation

The researcher's professional activity is linked to the energy sector, to the commercialization of energy in Portugal. The interest in the subject of this research comes from familiarity with the problems of the sudden increase in energy prices and the constant search by customers for a sustainable alternative solution.

In addition, the search for modern innovation practices linked to technology and its implementation in the market are themes of the first order for the future professional activities of the researcher. Therefore, this work contributes to the development of crucial skills and knowledge for an innovation management professional.

1.2. Research Question

The aim of this study is to gain a more in-depth and detailed insight into the existing renewable energy communities in Portugal. The research question proposed is: What are the main factors that affect the adhesion to renewable energy communities?

1.3. Methodology

Regarding the methodology, and given the research question previously formulated, qualitative methodologies emerge as the most appropriate, since they confer the freedom to make detailed observations of the real world, avoiding the influence of models and theoretical conclusions already known (Yin, 2015).

After the review of the initial literature, the fieldwork was conducted, seeking to find data that allowed characterizing the community movement in Portugal for renewable energies.

According to Yin (2015), case studies contribute to the understanding of individual, organizational, social, and political phenomena. In the present work, a sole case study was conducted, although with several units of analysis and in an environment not previously studied (Yin, 2015). This type of method allows the use of various sources of evidence, including interviews (Yin, 2015). This source of evidence was used for the collection of primary data, such as data that is obtained directly and not yet manipulated (Lüdorf, 2004).

A framework will be used in the analysis and discussion of results, based on the Business Model Canvas (BMC), developed by Osterwalder & Pigneur (2010) with an integrative approach of environmental and social character (Joyce & Paquin, 2016).

2. Literature Review

Articles published between the years 1998 and 2023 were searched in the online academic databases of Scopus, Science Direct and the European and Portuguese legislation, based on the following keywords: energy efficiency, Energy Services Company (ESCO), renewable energy communities and business model. In addition, an open online search was conducted to also include sources from established websites and online books. The literature review is organized as follows:

1. Exploration of the evolution of the electric energy market;
2. Exploration of definitions of energy efficiency, its advantages, disadvantages and how it can be put into practice;
3. Addressing the different business models in energy efficiency, including those applied to renewable energy communities;

2.1. Evolution of the Electric Energy Market

The energy market is conditioned and influenced by the huge amount of associated legislation, covering regulations for all activities of generation, storage, transmission, distribution, aggregation, and commercialization of electricity (Decree-Law nr. 15/2022 of 14 January).

According to Gomes *et al.* (2014), Portugal has had a framework regime to produce electricity from renewable sources since 1988, the year in which Decree-Law nr. 189/88 of 27 May, came into force. This decree provides for the regulation of the status of small electricity producers. Self-production can now be exclusive (when in the legislative framework, since 1981, it was only ancillary to another activity conducted as a principal), establishing Decree-Law nr. 189/88 of 27 May, the right to commercialize the energy produced, either through the sale to the national grid, or by distribution in its own local network, with a subsidized tariff and for a period of 8 years (Decree-Law nr. 189/88 of 27 May).

In 1981, for the first time, the concept of self-production of energy from renewable energy sources emerged, being exclusively applied to electricity producers. Until then, large suppliers operated in the market that, from a group perspective, had a stake in the various

activities of the energy market, namely, production, transmission network, distribution, and commercialization network, dominating and controlling market prices (Ferreira *et al.*, 2007).

With a view to reforming the electricity sector and to improve energy efficiency and lead to lower prices, Portugal and Spain signed an agreement for the development of a common Iberian energy market, where electricity is now traded based on bilateral contracts or in an organized market. With the entry of independent agents to produce energy from renewable energy sources, and with the operability of the Iberian market, there was a decrease in the price of energy, although with medium-term effects (Ferreira *et al.*, 2007).

In 2004, the *Sistema Elétrico Nacional* (SEN) was composed of the public electric system and the independent electric system, both regulated by the *Entidade Reguladora dos Serviços Energéticos* (ERSE). The public electric system is obliged to ensure the supply of electricity throughout the national territory and comprises the productive activity, the national transport network, the national distribution network, the suppliers, and the final customers. However, it was not until 2006, after the implementation of the computer system necessary to manage the process of changing suppliers, that it was possible, on the part of consumers, to freely choose to buy electricity from any supplier (Ferreira *et al.*, 2007).

According to Gomes *et al.* (2014), Decree-Law nr. 189/88 of 27 May was expressly amended five times, becoming increasingly a specific framework of activities of electricity production from renewable sources, fixing rights and duties of producers (including the right to sell in its own network, which has since disappeared), prescribing the authorizing procedure of installation and operation of the generating plants, and establishing the tariffs applicable to each type of renewable source, and, consequently, an increasingly complex framework in its interpretation and legislation. According to Gomes *et al.* (2014), "multiplication of authorizing acts necessary for the entry into operation of the power plant – request for prior information: installation license, operating license – all issued within the same entity."

The average prices of the national market have not been constant. In the last year, 2022, energy prices more than doubled between January and July, compared to the previous year, as can be seen in the data available on the Electric Market Operator (OMIE) website and in Table 1.

Table 1: Average monthly prices of energy in Portugal in €/MWh. (Developed by the author)

Year / Month	2019	2020	2021	2022
January	67,77€	46,79€	69,89€	209,93€
April	56,40€	24,97€	71,38€	213,32€
July	56,58€	39,88€	96,45€	144€
October	52€	42,41€	209,35€	160,61€

The SEN in Portugal is primarily responsible for 25% of carbon dioxide emissions, as it is dependent on energy production from coal-fired power plants. These emissions of carbon dioxide, or greenhouse gases, cause, as it is known, situations of drought, floods, acidification of the oceans and the reduction of natural reserves, thus requiring a change in the mix of technologies, using energy sources with lower carbon emissions, such as wind energy and hydroelectric power (Hamwi *et al.*, 2021).

2.2. Renewable Energy

Renewables are characterized by energy sources that regenerate naturally over time, without ever running out. These constitute non-fossil energies that can materialize in the form of wind, solar, aerothermal, geothermal, hydrothermal, oceanic, hydro, biomass, and renewable gases (Decree-Law nr. 15/2022 of 14 January; World Energy Council, 2008).

Towards the goal of a carbon-neutral future and in compliance with Directive (EU) 2018/2001 of 11 December and Regulation (EU) 2018/1999 of 11 December, where "member states must prepare and submit to the European Commission an integrated national energy and climate plan for the 2021-2030 horizon", Portugal has developed the PNEC 2030, approved by the Resolution of the Council of Ministers nr. 53/2020 of 10 July, which appears as the main instrument of energy and climate policy at the national level. This plan aims to reduce greenhouse gas emissions by promoting the use of energy

from renewable sources and energy efficiency and security (Decree-Law nr. 15/2022 of 14 January, p.1).

As one of the objectives of the European Union's energy policy is the promotion of forms of renewable energy, in addition to the binding renewable energy target for 2030, the contributions of Member States to achieving this target have also been defined, including both reference quotas for national global targets and elements that are of vital importance for energy and environmental policy (Directive (EU) 2018/2001 of 11 December).

2.3. Energy Efficiency and Energy Transition

Energy efficiency consists of the optimization of energy consumption through the use of various energy-saving mechanisms, namely by the development of new sustainable technologies, which allows to maintain the level of comfort and avoid waste. This can be increased either through behavioral changes, that is by reducing the energy used for a particular purpose, such as heating and lighting, using the preferential use of new, more efficient equipment, or by the use of renewable energy sources from the introduction of new technologies (Decree-Law nr. 15/2022 of 14 January; World Energy Council, 2008).

The use of energy produced from renewable sources plays a key role "in promoting the security of energy supply, sustainable energy supply at affordable prices, technological development and innovation", as well as industrial and technological leadership, while creating environmental, social and health-sustaining advantages, as well as employment and regional development opportunities, "especially in rural, and isolated areas, in regions or territories with low population density or undergoing partial deindustrialization" (Directive (EU) 2018/2001 of 11 December p.328/82).

From an individual or collective consumer perspective or through energy communities, it is possible to move from mere passive consumers to active agents that produce electricity for self-consumption, the sale of surpluses, storage, the provision of flexibility services and aggregation of production, being established support for production from renewable energy sources, with the condition of carrying out competitive procedures. In this sense, it is a priority to evolve from a system based on centralized production, to a decentralized model, namely through local production and self-consumption (Decree-Law nr. 15/2022

of 14 January). To streamline the system, it is imposed by Decree-Law nr. 15/2022 of 14 January, the installation of meters and smart grids that ensure, through the creation of the figure of the aggregator, the elimination of barriers to participation in electricity markets.

Due to the increasing pressure on the environment derived from the high rate of greenhouse gas emissions, there is a need to implement renewable energy sources, adopt energy efficiency programs and energy conservation measures, which in turn face technical, environmental, economic, social, and cultural challenges (Cunha *et al.*, 2023).

The European Commission has established targets for the consumption of renewable energies which contribute to the development of technologies in this area. This involves incentives and financial support, which can be seen, in more detail, in annex IV.

3. Benchmarking of Energy Models

As we saw earlier, Portugal has stipulated a series of incentives in the field of energy, and is taking the first steps, through energy models, towards a sustainable energy system, thus contributing to the improvement of the climate environment and the reduction of electricity costs for consumers (Azevedo, 2023; Cabrita, 2021).

3.1. Energy Services Company

Engineering companies specializing in energy conservation services, also known as ESCO, already offer a variety of technical solutions, such as the implementation of policies to reduce energy consumption, the outsourcing of energy infrastructure, financing, technical assistance, installation, production, conservation and commercialization of energy, and risk management (Guimarães, 2009; Nurcahyanto *et al.*, 2020; World Energy Council, 2008).

ESCOs work using various models, including the Energy Performance Contracting (EPC) model and the Energy Savings Performance Contract (ESPC) model (Guimarães, 2009; Nurcahyanto *et al.*, 2020; World Energy Council, 2008).

3.1.1. Energy Performance Contracting Model

The EPC model is used in the European Union, where a contract is made between the customer and ESCO to share the power distribution and associated risks. This model provided by ESCO requires an initial investment by the customer and the installation of equipment, which can be purchased using immediate financial assets, bank loans, or tertiary loans contracted through the ESCO. This latter form of tertiary financing allows ESCO companies to guarantee energy savings, cover operating expenses, optimize shared energy savings and recoup the capital investment made in the equipment (Nurcahyanto *et al.*, 2020). After the implementation of the equipment, the ESCO conduct exhaustive examinations of the facilities, verify the need for modifications, create customized energy efficiency solutions, supervise the installation of the necessary parts and assume maintenance tasks during the period of the ESPC (Guimarães, 2009).

The main objective of this model is to reduce the overall consumption of energy, which implies sensitization to human behavior, as well as investment in technological and insulation equipment, where performance and credit risks are assumed by ESCO (Suhonen & Okkonen, 2013; World Energy Council, 2008).

3.1.2. Energy Savings Performance Contract Model

The ESPC model takes the form of a legal framework where a guaranteed energy saving solution is implemented by an ESCO and where the customer pays ESCO a percentage of the capital gains obtained. This model allows its customers to obtain capital gains without the need to make an initial investment, since ESCO retains ownership of the project and any related equipment for the duration of the contract, and without assuming significant financial and technical risks (Guimarães, 2009; World Energy Council, 2008).

The compensation received by ESCO is directly affected by the amount of energy saved, since the remuneration is based on the proper functioning of the projects, being predetermined for a certain period at a pre-defined rate in the contract concluded (World Energy Council, 2008).

3.1.3. Advantages and barriers to the adoption of the ESCO Business Model

ESCOs operate mainly in the industrial sector and are well prepared to implement energy-efficient solutions on a large scale (Niko Suhonen, 2013). In this sector, the need for initial investment as well as the lack of information and complexity in the perception of the ESCO business model, constitute the main barriers to its implementation (Pätäri & Sinkkonen, 2014; Suhonen & Okkonen, 2013; World Energy Council, 2008).

In the residential sector, the lack of interest of the owners in the use of this mechanism is highlighted, motivated by the lack of information, the complexity of the implementation of the project and the reduced potential for cost savings and energy limited by transaction expenses, as is the example of the costs of managing the systems, particularly when the ownership of the building is divided among the various owners (World Energy Council, 2008).

The verification of the improvement of energy efficiency for fixed load and consumption systems, such as a lighting system, is easy to carry out, however, when it comes to systems with changing loads and cycles dependent on production or other external elements of correlation, the verification of the savings made assumes a greater complexity (Guimarães, 2009).

However, it is noticeable by both the industrial and residential sectors that joining the ESCO enables small savings in addition to supporting the use of energy-efficient solutions (Guimarães, 2009; World Energy Council, 2008).

Table 2: Positive and negative aspects of the ESCO (Developed by the author)

Positives aspects	Negative aspects
Supports the use of energy-efficient solutions in industry. Possibility to share the distribution of energy savings and associated risks.	Lack of information. Lack of understanding of the business model. Requires a large amount of investment. The risk of ESCO projects is assumed by the client. High transaction costs.

As can be seen above, in table 2, the negative aspects outnumber the positive aspects regarding the ESCO, a fact that has led to the study and development of different business models. In this investigation, the term 'community projects' emerged, which will be studied in the next point.

3.2. Community Projects

Portugal has stipulated a varied set of community initiatives in the field of energy, through energy projects, where the community owns a property controlling and benefiting from the results, whether it is energy savings or income from energy production or transformation (Azevedo, 2023). The term community energy alludes to formal and informal citizen-led

efforts that come up with cooperative solutions to promote the advancement of sustainable energy technologies and methods (Bauwens, 2016).

REC, Citizen Communities for Energy (CCE) and Positive Energy Districts (PED) are three interconnected concepts aimed at promoting clean and sustainable energy practices. A REC stipulates the development and exploitation of renewable energy sources within local communities with the active participation of the community, a CCE requires collaborative efforts of citizens that can be carried out without imposing a geographical limitation, a PED is covered by metropolitan regions that are intended to generate more energy than they consume, fusing technology, energy efficiency tactics, and self-reliance (Bauwens, 2016; Derkenbaeva *et al.*, 2022; Vries *et al.*, 2016).

3.2.1. Positive Energy Districts

A PED consists of a metropolitan area, or a network of connected buildings, where the production of energy from renewable sources, with zero greenhouse gas emissions, exceeds electricity consumption, actively maintaining a local or regional surplus of renewable energy. This concept emerged to help in the energy transition and support climate neutrality, where a building, community, or district, in the use of affordable renewable energy sources, contributes to the constitution of livable and climate-friendly urban environments (Derkenbaeva *et al.*, 2022).

In possession of a structure of renewable source it is expected that this will serve several functions, among them, the production, consumption, and storage of energy, with incentives to the increasing use of electric heating (to the detriment of the use of gas) and electric means of transport. A group of at least three nearby buildings that have an average annual positive energy balance is called the Positive Energy Block (PEB) which, on a larger scale, passes to communities and later to PEDs (Derkenbaeva *et al.*, 2022).

3.2.2. Citizens' Community for Energy

CCE acts as a legal entity, whose primary purpose is to provide environmental, economic, or social benefits to their members. These communities are seen as a source of innovation

and sustainability, since they enhance the transition to a sustainable energy supply system, even if at a distance. These communities create an infrastructure for the production and consumption of decentralized electricity from renewable sources, without geographical limitation. The efforts to build these communities come from citizens, who increasingly play an active role in the generation and conservation of energy, incorporating social and technical solutions into the environment (Cleawatts, 2023; Vries *et al.*, 2016).

3.2.3. Renewable Energy Communities

Energy communities, under the Directive EU 2018/2001 of 11 December, are seen as legal entities that within the framework of the applicable national law, operate for the promotion of energy from renewable sources. These communities are typically based on a social basis, based on open and voluntary participations, and are autonomous and controlled by shareholders or members, which may be natural persons, small and medium enterprises, or local authorities, which are in the vicinity of the geographical area. Its main objective is to provide members or localities where they are inserted, environmental, economic, and social benefits (Directive (EU) 2018/2001 of 11 December; Hicks & Ison, 2017; Mariuzzo *et al.*, 2023).

The establishment of energy communities implies the promotion of adapted energy initiatives that allow individuals who do not necessarily have technical proficiency in the field of energy to be involved. This cultivation of energy initiatives occurs within the scope of energy production, storage, distribution, and consumption often serving as catalysts for economic, social, and political changes (Antunes, 2023).

With the operability of REC, citizens can cooperate and manage projects at the local level, as well as participate in the reward and decision-making processes, increasing the level of social acceptance of renewable energies and, consequently, reinforcing the territorial and social cohesion of the country (Antunes, 2023; Bauwens, 2016; Cabrita, 2021).

Table 3: Characteristics of community projects (Developed by the author)

PED	REC	CCE
Specific governance, but not limited membership	Limited membership and specific governance	Specific governance, but not limited membership
Metropolitan area	Proximity to renewable energy generation	No geographical limitation
All renewable energy sources	All renewable energy sources	It only considers electricity
Technologically neutral	100% Renewable energy	Technologically neutral

4. Business Models for Community Projects

In this chapter, the definition of the term innovation and, subsequently, the concepts of business model, Business Model Canvas (BMC) and Triple Layer Business Model Canvas (TLBMC) will be presented.

4.1. Innovation

When talking about innovation, it is logical to talk about a new product or process put to use, or an improvement thereof, that have significantly different characteristics from those contained or used previously, even if the product or business process has already been previously introduced to the market. Innovation is also considered the process of small improvements made during a defined period, if these constitute an improvement of the good or process previously held (Organização para a Cooperação e Desenvolvimento Económico [OCDE], 2018).

The innovation process includes activities of production of goods and services, support, distribution and logistics, marketing, sales and after-sales services, IT, administrative, engineering, and technical services, which through well-defined methods and budgets tend to lead to improvements for the organization or community. However, the process may take longer than expected to meet the targets or, in the worst-case scenario, eventually fail (OCDE, 2018).

The starting point for any innovation should be a mutual understanding of the goals and concept of the business model, in other words, how a company conducts business, which should be simple, relevant, and intuitively understandable (Hamwi *et al.*, 2021; Osterwalder & Pigneur, 2010).

The object of the implementation of an innovation is usually the development of processes, products, and services, which stimulate the transformation of the traditional business model to a sustainable business model. (Klusa *et al.*, 2021).

4.2. Business Model

Although there is no consensus on the definition of business model, there is a structure of pillars in the value chain that are interconnected and irrefutable. (Kajtazi *et al.*, 2023; Rezazadeh & Carvalho, 2021). This structure reflects the operation of the company, which can be seen as a means to create and distribute value (Kajtazi *et al.*, 2023).

The business model shows us how a company, or community, operates and uses resources to generate financial profits. We increasingly observe that companies are punished and responsible for negative impacts on the environment and society, so it is necessary to integrate sustainability into their operations and thus contribute to making society more sustainable (Klusa *et al.*, 2021).

According to Kajtazi *et al.* (2023), strategy and business model are different concepts, and the first concept can be understood as the set of elements present in the business model whose objective is to create value and competitive advantage in the market.

The advancement of technology and its incorporation into business models has led to the concept of business models being transformed into business model innovation. The latter can be seen as the advanced concept of business model for the simple fact that it is a business transformation and the process that this involves (Kajtazi *et al.*, 2023).

4.3. Business Model Canvas

The BMC is a business model used to develop new business models and document existing ones. The template presented in figure 1, provides a visual graph with elements that describe a company's value proposition, product, infrastructure, customers, costs, and profits. This model encourages the use of a common language allowing us to describe, evaluate and change business models, thus creating strategic alternatives. This business model describes the logic of how an organization creates, delivers, and captures value, from nine blocks, not oversimplifying the complexity of a company's operation and helping companies in making strategic decisions and managing innovative technologies (Osterwalder & Pigneur, 2010).

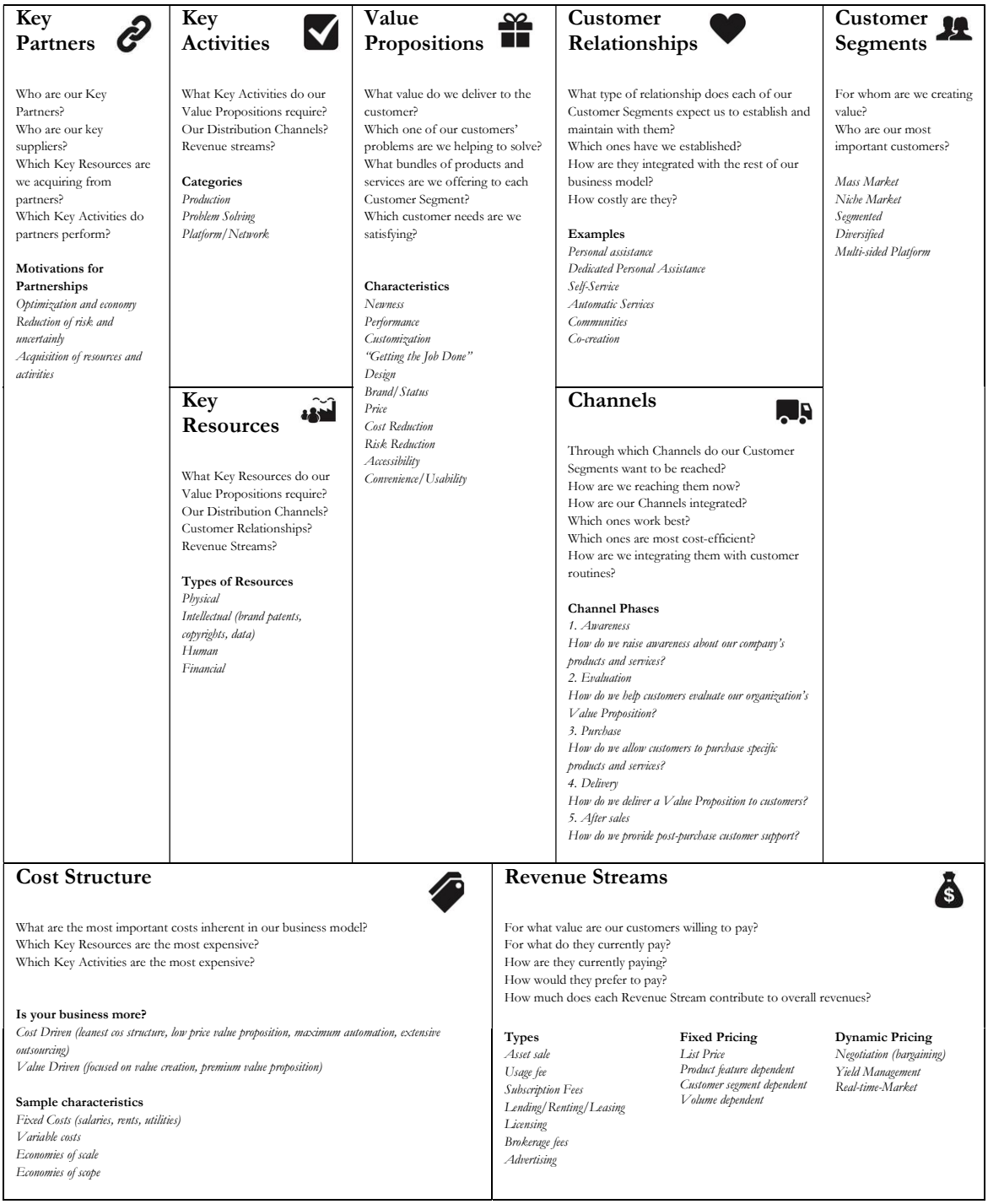

Figure 1: The Business Model Canvas (adapted from Osterwalder & Pigneur, 2010 and developed by Business Model Foundry AG)

Value Proposition

The value proposition consists of the package of products and/or services that the company offers to its customers, which will make the customer choose one company over

another. The value proposition can be quantitative (price, speed of service) or qualitative (design, customer experience), and should consider the needs, expectations and pain points of a product or service (Osterwalder & Pigneur, 2010).

Customer segments

Customers constitute the heart of the business since no business can survive without one or more customers. It is important for a company to group its customers into different specific segments, for example, according to their needs, size, or behaviors, to obtain a strong and complete understanding of the different customer segments and define a strategy accordingly (Osterwalder & Pigneur, 2010).

According to Osterwalder and Pigneur (2010), in this segment, the questions that usually arise are, namely, for whom we are creating value, which customers are most important, which customer segment we want to reach, among others.

Relationship with customers

A company must find mechanisms and strategies to build strong and lasting relationships with each customer segment, namely, to attract and retain customers, and boost sales. The better the relationship with customers, the better the customer experience, which naturally translates into more purchases. (Osterwalder & Pigneur, 2010).

Some of the questions that arise in this segment, according to Osterwalder and Pigneur (2010), are, namely, what kind of relationship each customer segment expects us to have with them, how it is integrated with the business model, among others.

Channels

Channels reflect how the company communicates and delivers the product and/or service to the customer. It is through the channels of communication, distribution, and sales that the company relates to the customer, playing a key role in the experience of each of these customers. Channels increase awareness among customers and a company's products/services, help customers gain knowledge of and evaluate a company's value proposition, enable customers to purchase specific products and/or services, and provide after-sales support (Osterwalder & Pigneur, 2010).

According to Osterwalder and Pigneur (2010), in these segments, the questions that usually arise are, namely, by which channels our customers want to be reached, which channels work best, which are the most profitable, among others.

Revenue stream

Revenue is the result of value propositions successfully offered to customers, that is, the money that a company generates from each customer segment, which can be obtained on a recurring (continuous service) or sporadic (single service) basis (Osterwalder & Pigneur, 2010).

This dimension of the model also includes, in addition to the amount to be charged to the customer, the means of payment available.

Some of the questions that arise in this segment, according to Osterwalder and Pigneur (2010), are, namely, what is the value that our customer segment is willing to pay, how are they paying it, how do they prefer to pay, among others.

Key Resources

Key resources are the necessary assets that make a company create and deliver a value proposition, reach target customers, maintain the proposed relationship with customers, and earn revenue. These key resources can be financial, human, physical, intellectual, acquired or rented (Osterwalder & Pigneur, 2010).

According to Osterwalder and Pigneur (2010), in this segment, the questions that usually arise are, namely, what key resources our value proposition, our channels, revenue streams require.

Key activities

The key activities are those considered essential to make the business model successful. These activities, as a rule, are related to the product and/or service and its delivery and are fundamental to the operation of the company and provide a value proposition and generate revenue for the customer (Osterwalder & Pigneur, 2010).

Like key resources, key activities answer questions such as, what key activities our value proposition, channels and revenue streams require.

Key Partners

Partners are the third parties to whom the company turns, external to the entity, who make the business model work. The basis of many business models is to create alliances to mitigate the risks that the company would incur if it did not opt for this model. In choosing the main partners for the business, the company must evaluate whether they can optimize their operations, maximize their revenue, and reduce risks and costs (Osterwalder & Pigneur, 2010).

Some of the questions that arise in this segment, according to Osterwalder and Pigneur (2010), are, namely, who are our key partners, who will be our main suppliers, what key activities our partners perform, among others.

Cost structure

In this block should be described all the costs incurred to create and deliver value, maintain the relationship with the customer and generate revenue. These costs cover operational, financial and all other costs aimed at putting into practice their strategy for revenue generation (Osterwalder & Pigneur, 2010).

According to Osterwalder and Pigneur (2010), in this segment, the questions that usually arise are, namely, what are the most important costs for the operation of the business, what is the cost of resources and activity, among others.

4.4. Triple Layer Business Model Canvas

The basis of this model comes from the business model "Business Model Canvas", studied previously, developed by Osterwalder and Pigneur (2010), in which it is amplified by creating two layers, the environmental and the social layer, as we can see in figure 2 (Joyce & Paquin, 2016).

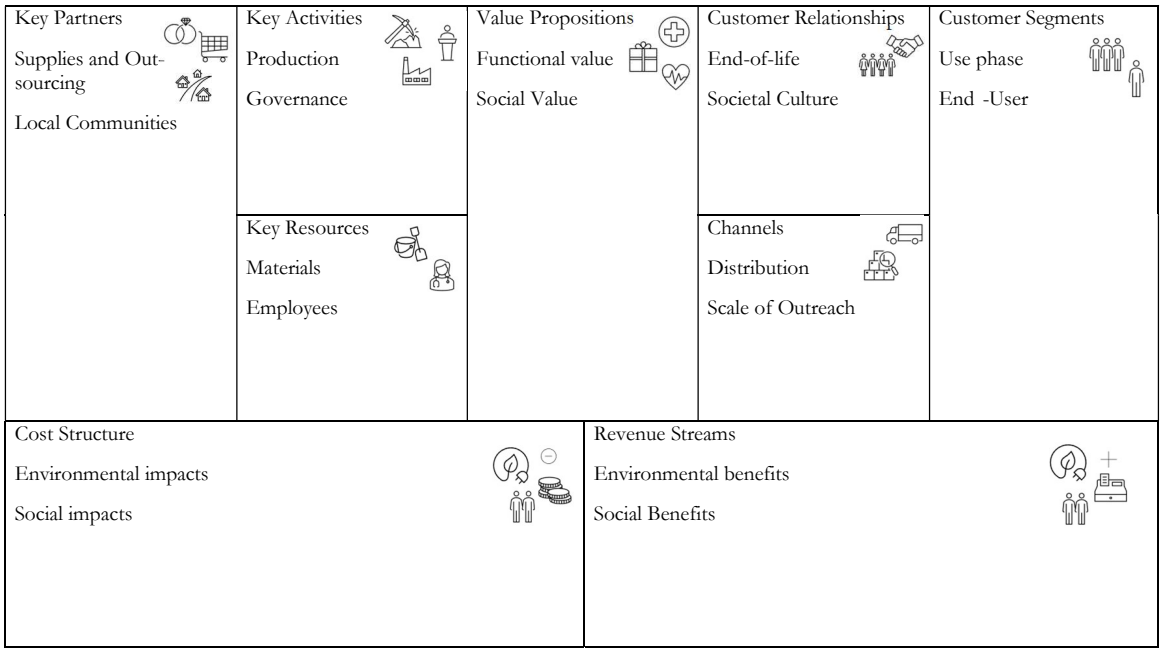

Figure 2: The Triple Layer Business Model Canvas (adapted from Joyce & Paquin, 2016) – annex I

The different layers have been recurrently studied in the literature in isolation, as demonstrated in the literature review above. A BMC tool, such as the one developed by Osterwalder and Pigneur (2010), can be quite effective in helping to understand the business model of a company or organization, since it visually represents the elements of a business model and the potential interconnections and impacts on value creation. However, the model defined by Joyce and Paquin (2016) brings together the three layers together and enables the study of the relationships that are established between them, in a horizontal and vertical perspective, as we can see in figure 3, thus adding greater capacity for analysis of the case study than any of those layers alone.

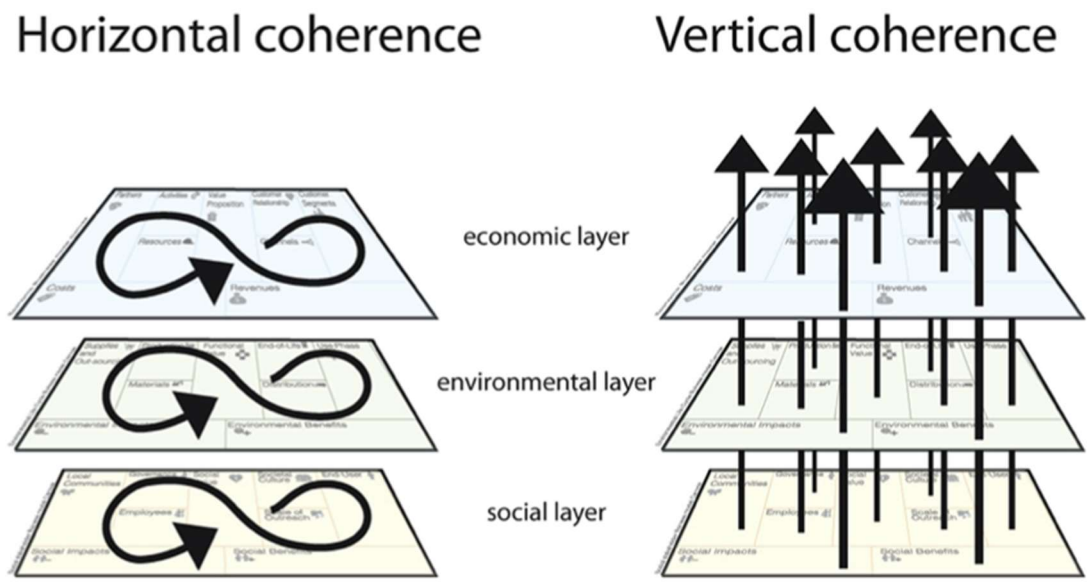

Figure 3: The Triple Layered Business Model Canvas creates two new dynamics: horizontal and vertical coherence (Joyce & Paquin, 2016, p. 1482)

4.4.1. Environmental Factor

The pressure for companies and citizens to respond to sustainability concerns is increasing, so they are expected to actively address environmental issues and technological development (Ferreira, 2023; Joyce & Paquin, 2016; Klusa *et al.*, 2021).

Sustainable business models have been gaining a new dimension, due to the positive perception of the relationship between sustainability and financial performance, and there is also pressure from investors and financial institutions to incorporate this non-economic factor into the decision-making process. Environmental benefits grant value creation, a new concept, which goes beyond the financial, encompassing the ecological value that the organization creates through the reduction of environmental impacts (Ferreira, 2023; Joyce & Paquin, 2016).

4.4.2. Social Factor

To explore the social impact of an organization, it is necessary to manage all the intervening parties of the process, where it is sought to balance the interests of the actors

with those of the organization, to the detriment of having a single focus, that is, the profits of the organization (Joyce & Paquin, 2016).

In renewable energy communities, citizens have a direct participation, being able to assume the role of self-consumers and co-owners, which means they are simultaneously consumers, producers and storers, and a decisive participation in the energy transition process (Ferreira, 2023).

In engineering firms, which help create and operationalize a REC, value creation is at the core of their mission, with financial gain positioned at a slightly lower degree of importance (Joyce & Paquin, 2016).

5. Implementation

After identifying the energy models that aim at an increasingly sustainable energy system and the easy-to-visualize business model designed by Osterwalder and Pigneur (2010), it is important to obtain a more in-depth and detailed view of RECs. This case study aims to take in depth the main factors of adhesion to REC.

In this sense, the following chapters will answer the research question: What are the main factors that affect the adhesion to renewable energy communities?

5.1. Research Strategy

To answer the research question and to contribute to the case study, interviews to different stakeholders in the energy sector, were conducted.

In conducting an interview, it is fundamental and essential to listen, which in turn implies observing and understanding, and being flexible, though, for example, changing the order and/or content of the script to explore and follow directions that were not initially foreseen (Yin, 2015).

The interviews are characterized by being directed and perceptible, since they highlight the object of study and provide logical reasoning. However, these are subject to biased views and responses, and the interview can give the interviewer what he wants to hear (Yin, 2015).

5.2. Research Plan

In a first phase, in June 2023, a support script and an informed consent form were carried out to formalize the participation of the interviewees in the research, to support and guide the future interviews. As these were made in Portugal, the documents are in Portuguese, as set out in Annexes II and III.

In a second phase, in July and August 2023, the interviews were conducted. The literature highlights the richness of the data obtained through interviews, since it is

often possible to perceive emotions, perceptions, and motivations behind the testimonies (Lüdorf, 2004; Yin, 2015). A semi-structured interview modality was opted, because it allows flexibility in the conduct of the interview to, for example, change the order of the questions whenever the interviewer introduced on his own initiative a theme already foreseen later in the plan (Lüdorf, 2004).

Interviews were selected based on their roles and ability to intervene in energy efficiency, as follows in table 4.

Table 4: Interviews (Developed by the author)

Participant	Functions	Description
1	Director/ Shareholder	Energy commercialization company operating in Portugal
2	Co-Founder	Specialized software development for energy companies
3	Lawyer	Freelance lawyer specialized in the energy sector
4	Environmental Engineer	Energy commercialization company/ First renewable energy cooperative in Portugal

The interviews were conducted online, in the impossibility of being conducted in person, and were recorded in audio to allow greater focus of the interviewer on the dialogue and information to be collected. In these interviews, the interviewees anticipated the approach to some questions and new questions were also introduced by the interviewer, also with a view to ensuring the reliability of the information. The transcript of the interview was double-checked so that there were no errors that could lead to false inductions (Lüdorf, 2004; Yin, 2015).

5.3. Framework

In the approach to this case study, a framework was used, which was based on three layers – economic, environmental, and social – which, in each of these, nine blocks are present, to assist in the recognition and application of a more sustainable business model.

The model used, represented in 4.4., the TLBMC, provides an integrative approach to support those seeking to understand existing business models and creatively explore innovative potential sustainability-oriented business models (Joyce & Paquin, 2016).

These layers provide a horizontal coherence, in that there is an integrated approach to explore the economic, environmental, or social impact of an organization, and a vertical coherence, through the connection of the components of each layer to their analogues in the other layers, further elucidating the main actions, connections and their impacts between them (Joyce & Paquin, 2016).

The environmental and social perspectives add a new explanatory potential to my object of study, since RECs aim to produce energy from renewable sources [environmental factor] in an area, the area of residence, where citizens pursue common goals [social factor].

For the above reasons, the Framework developed by Joyce and Paquin (2016) was chosen, to the detriment of the isolated model of Osterwalder and Pigneur (2010).

6. Analysis and Discussion of Results

The notion of a sustainable business model, as is the case with TLBMC, provides superior value to members and describes how they can create economic, social, and environmental value. This model with great visual perception, helps to reduce the negative environmental externalities of electricity consumption and production (Hamwi *et al.*, 2021).

Each component in its different layers, that is, economic, social, and environmental, is essential to the elaboration of the business model for REC.

In this chapter, the TLBMC will be applied, comparing the information collected through the interviews with the existing literature, thus reinforcing the analysis and the interconnection between them.

6.1. Value Propositions | Functional Value | Social Value

The REC allows to "*sensibilizar e mobilizar a atenção dos membros e possíveis membros para modelos de responsabilidade social*", where there is a complement of consumption needs (energy sharing) and the sale of surpluses (local surplus) (as mentioned by Interviewee 1; Sousa *et al.*, 2023). The cost of the energy consumed within the REC is lower than the hypothetical cost of that same energy if purchased from a trader, which leads to fighting the energy poverty of those who need it most. However, the surplus is sold at below-market prices. The REC also has the advantage of reducing the initial cost and increasing resilience to the variability of public grid energy prices (Interviews 1 and 4).

An energy community has as its main objective the democratization of access to energy, through the production of 100% renewable energies, to the detriment of fossil energy, and without the need to transport it, leading to greater efficiency in the management of networks, and where plans are drawn up to improve and create tools for the benefit of the community (Interviews 2, 3 and 4).

As concerns about climate change increase, citizens become more receptive and interested in the benefits that a REC can bring (Gjorgievski *et al.*, 2023).

It is also important to emphasize that, from a perspective of collective self-consumption, the ownership, "*da produção de energias renováveis é a comunidade, i.e., os cidadãos ficam donos do equipamento e da produção de energia*" (as mentioned by Interviewee 4).

Sousa *et al.* (2023) argue that hybrid solutions from renewable energy sources can offer additional benefits, such as the integration of solar photovoltaic, wind, and water systems, where wind energy can be stored, either in the form of hydrogen or through a silly hydro storage system.

6.2. Customer Segments | Use phase | End-user

The customer segment of an energy community is the citizens, individual members, or shareholders, who come together, in their area of residence, to form a local community (reported by all interviews; Sousa *et al.*, 2023).

It is equally important to look at potential customers, that is, current passive consumers who, informed, could evolve into active energy producers, thus becoming producer-consumers. The aggregation of several producers-consumers in the same geographical area enhances their involvement in energy communities, bringing benefits namely in the momentary management of energy excesses (Sousa *et al.*, 2023).

Energy communities provide an "*participação aberta e voluntária dos seus membros*" that will depend on gender, income, profitability, level of education and their environmental awareness (as mentioned by Interviewee 2, Sousa *et al.*, 2023).

Since we live in community, the population, with the participation of all, must modify its energy behavior to accelerate the achievement of tangible and concrete results in terms of environmental and climate matters (Interviews 2 and 3; Prados *et al.*, 2022).

6.3. Customer Relationships | End-of-life | Societal Culture

As members of an energy community, citizens have an active role, and "*ficam mais atentos aos seus consumos porque querem maximizar o investimento efetuado*" (cited by Interviewee 4), promoting a cultural change in energy consumption (Mariuzzo *et al.*, 2023).

There is in Portuguese society a "*cultura tecnológica de* "early adopters" *que potencia a aceitação de novas soluções",* as mentioned by interviewee 1, however, there are companies and investors destined to the implementation of infrastructures with a view to creating a REC, as mentioned by interviewee 3. In the latter case, community members elect a managing entity, an intermediary company, to build, represent and manage energy sharing, the production of available renewable electricity and the surplus electricity that can be sold to the grid, being more frequent in situations where the local community intends to reduce the initial investment by paying a fixed price to the company/investor (Interviews 1, 3 and 4; Prados *et al.*, 2022; Sousa *et al.*, 2023). However, there may be resistance on the part of citizens in adhering to the REC, "*não percebem o ínfimo ganho em comparação com o da empresa investidora*", leading to non-receptivity to change their consumption habits (as mentioned by Interviewee 2; Prados *et al.*, 2022).

In this sense, it is necessary to develop appropriate solutions and tools, such as energy performance packages at the lowest cost for a dwelling, to encourage citizens to embrace community projects (Sousa *et al.*, 2023).

Landscapes are deeply rooted in communities, including their associated habits, values and beliefs, so it is important to develop shared strategies among the various citizens to form local communities and thus face together the challenge of decarbonization and the risk of social rejection of large-scale projects (Prados *et al.*, 2022).

6.4. Channels | Distribution | Scale of Outreach

Decentralized community electricity generation systems have multiple benefits, including alignment with the surplus generation of other members, reducing transmission and distribution losses, and increasing energy security of supply, enhancing greater savings, and added value for other stakeholders, such as transmission and distribution system operators,

since it attenuates network overvoltage's and overloads (Gjorgievski *et al.*, 2023; Sousa *et al.*, 2023). On the other hand, if the community is located at a different point from renewable energy sources, these may be subject to the payment of a total or reduced distribution network fee (Gjorgievski *et al.*, 2023).

Dissemination continues to exist, mainly in rural and poor areas, due to the lack of knowledge and technical support to citizens, so the need to share information, free of charge, through local authorities and organizations (Interviews 2 and 3; Sousa *et al.*, 2023).

There is a great commitment and interest in obtaining the commitment of the local population, so it is important to raise awareness and inform citizens, inside and outside the community, about the production of renewable energy and the associated benefits (Interview 4; Prados *et al.*, 2022).

6.5. Revenue Streams | Environmental benefits | Social benefits

A community's investment decision results "from the relationship between the marginal ~~price~~ realized price and the levelized cost of electricity generated by each renewable technology." The fair "profits redistribution ~~of profits~~ among members is highly influenced by the different ownership, the adopted sharing mechanisms" adopted and the load diagram of each member (Sousa *et al.*, 2023, p.1-2).

The commitment to develop a REC tends to boost the mitigation of global warming and optimization at an economic and environmental level, allowing members to take an active role in the energy transition process, since "they enhance the implementation of renewable ~~energy~~ generation ~~at~~ to a level beyond ~~higher than~~ that of the individual self-consumption" (Sousa *et al.*, 2023, p.11).

The higher the consumption within the energy community, the greater the economic profits, since the sale to the public grid of point energy surpluses is carried out with a lower added value, since it is subject to additional costs, that is, network access tariffs (All interviews; Gjorgievski *et al.*, 2023; Sousa *et al.*, 2023).

The economic, environmental, and social benefits of sharing energy within a community are affected by factors that are under the control of the community, such as internal energy sharing rules, and by external factors, such as budgetary regulations and policies (Interview 1; Gjorgievski *et al.*, 2023).

6.6. Key Resources | Materials | Employees

Key resources are the supporting infrastructures, namely transport, local distribution, technological maturity (digitals and bidirectional meters), and network resilience, that is, decentralization of production points and redundancy vis-à-vis the public network (Interview 1). For the operationality it is necessary to build energy systems, namely solar, photovoltaic and wind resources, which are subject to licensing, and which in turn require some space (Interview 1; Sousa *et al.*, 2023). The construction of renewable energy parks leads to the use of local labor, the use of local companies and the leasing of properties (Delicado *et al.*, 2016).

As mentioned by interviewee 2, "*são necessários desenvolvimentos tecnológicos de inteligência artificial para se reagir aos excessos ou defeitos de produção num determinado momento, e para isso é necessária uma integração de sistemas, disponibilização e diferentes tratamentos de dados*". Energy storage and management tools promote virtually autonomous consumption patterns, creating energy and economic benefits for consumers (Prados *et al.*, 2022). In addition, to constitute a REC it is necessary to create a legal entity, with its own personality that, in the possibility of resorting to a cooperative to streamline the investment and management process, then it will be necessary a certified accountant and other resources associated with monthly expenses (Interviews 1, 2 and 4).

6.7. Key Activities | Production | Governance

The production, sharing and distribution of renewable energy is the main activity of a REC (Sousa *et al.*, 2023). As previously mentioned, and cited in interview 1, renewable energy sources can constitute the form of "*solar, eólica, biomassa, hídrica ou geotérmica*".

To design, build and install new sources of sustainable production requires an "*avaliação holística do modelo de operação*", as referred to by interviewee 1, and defended by Sousa *et al.* (2023). This assessment should include social, economic advantages and disadvantages, environmental and health risks, transformations in landscape and land use, impact on local development, as well as negotiations and commitments between local stakeholders (Delicado *et al.*, 2016). Without prejudice to the need for evaluation, "*as comunidades de energia têm o mérito de aumentar a flexibilidade da infraestrutura de rede elétrica, diminuindo a dependência da infraestrutura pública e de fontes de produção não renováveis*" (cited by interviewee 1).

In places where there are limitations, namely due to the "*dimensionamento da capacidade de produção e infraestruturas de distribuição*" (cited by interviewee 1), photovoltaic panels and wind turbines are the main solutions to meet energy needs in autonomous and remote areas (Sousa *et al.*, 2023). However, it is necessary to be aware that "*produzir a energia junto ao local onde se consome, permite que não exista sobrecarga da rede de transporte e distribuição*" (cited by interviewee 2). However, as mentioned by interviewee 1, for there to be no waste of unused energy, it is necessary to manage consumption needs and, ultimately, due to the associated costs, the construction of energy storage (Sousa *et al.*, 2023).

There is also the possibility of the sale of surpluses (when the energy produced is higher than that consumed) which, as a rule, is carried out at market prices lower than the electricity tariffs of the members of the RECs (Sousa *et al.*, 2023).

6.8. Key Partners | Supplies and Out-sourcing | Local Communities

As mentioned earlier, energy design is subject to large regulatory burdens, so as cited by interviewee 1, "*existem demasiados intervenientes na cadeia de valor, entre eles, a Direção Geral de Energia e Geologia* (DGEG), *Entidade Reguladora dos Serviços Energéticos* (ERSE), *Entidade Nacional para o Setor Energético* (ENSE), *Sistema Elétrico Nacional* (SEN), OMIP[1], OMIE[2], ADENE[3], Certiel[4], *Redes Energéticas Nacionais* (REN[5]) and E-Redes[6], *frequentemente com responsabilidades que se sobrepõem ou que, pelo contrário, são omissas*".

[1] Operator of a regulated market in Portugal
[2] Manages the usefulness of the markets for the entire Iberian Peninsula (Portugal and Spain)
[3] Energy Agency
[4] Entity responsible for inspections of electrical installations

In order to accelerate the transition process, it is essential to help through state support, either through the central administration or the local administration, in the form of actions developed in conjunction with other institutions, such as "*empresa que ajudasse nessa implementação*", as mentioned by interviewee 3 (Prados *et al.*, 2022; Sousa *et al.*, 2023).

In addition, it was mentioned by interviewee 2 that technology suppliers and suppliers of installation of renewable energy instruments are needed, and by interviewee 3, that "*para a implementação de uma comunidade de energia renovável, é necessária uma equipa multidisciplinar, ou seja, pessoas com conhecimentos técnicos na área de engenharia, financeiros, conhecimentos legais, que para o cidadão comum não é simples*".

6.9. Cost Structure | Environmental Impacts | Social Impacts

As previously mentioned, environmental concerns have increased due to global warming caused mainly by CO_2 emissions (Directive 2018/2001 of 11 December; Sousa *et al.*, 2023).

In the constitution of a REC, the members or shareholders incur several costs, among them, the registration/legalization of the community, administrative costs for the management of the REC, access to information platforms, hiring of a certified accountant, investment in renewable sources and the tariff for the use of public distribution networks (Gjorgievski *et al.*, 2023; Interviews 1, 3 and 4; Sousa *et al.*, 2023). The investment in renewable sources can be made from "*ótica de dependência dos fornecedores da tecnologia*", that is, they install the equipment(s) and have the right, "*por um determinado período de tempo, de revenda da produção à comunidade a um preço fixo, com um fee mensal adicional, fixo ou variável, e, após o número de anos fixado, a infraestrutura transita para a própria comunidade*" (as mentioned by Interviewee 1).

Europe, through its legislative packages defined by Directive 2018/2001 of 11 December, and Portugal, through Decree-Law nr. 15/2022 of 14 January, promote and aim to facilitate the development of REC, stimulating them to produce, consume, share, store and

[5] Responsible for energy transportation
[6] Entity responsible for the distribution of energy

sell renewable energy with free to all appropriate energy markets (Directive 2018/2001 of 11 December; Mariuzzo *et al.*, 2023; Prados *et al.*, 2022; Sousa *et al.*, 2023).

Fiscal policies, at the level of consumers, ensure the recovery of the cost of investment in infrastructure for the energy system, grant simple, transparent, and equitable electricity tariffs, and exempt energy losses from the grid and grid access tariffs, encouraging energy exchange between the community (Gjorgievski *et al.*, 2023).

However, with the construction and operationalization of wind farms and solar power plants, Delicado *et al.* (2016) found that mortality rates of birds and other wildlife have increased, thus leading to a duality, as renewable energy is also found to play a crucial role in preventing climate change.

Table 5: TLBMC with the results of the study (Developed by the author)

Factors	Description	Interviews	Literature
Value Proposition | Functional Value | Social Value	The value proposition of a REC goes through the democratization of access to energy, through the production of 100% renewable energy, without the need for transportation, where social responsibility models and plans to improve and create tools for the benefit of the community are outlined.	Interviews 1, 2, 3 and 4	Sousa *et al.*, 2023
	In situations where the production is conducted in the place where it is consumed, it is verified that the cost of energy produced within a REC is lower than the hypothetical cost of that same energy if purchased from a supplier, since there is no overload of the transmission and distribution network.	Interviews 1, 2 and 4	
	With decarbonization, RECs are contributing to the reduction of CO_2 emissions in the context of climate change		Gjorgievski *et al.*, 2023
Customer Segments | Use phase | End-user	The clients of a REC are citizens, individual members, or shareholders, who come together, in their area of residence, to form a local community. Current passive consumers who, informed, could evolve into active energy producers, becoming producer-consumers, are possible. clients.	Interviews 1, 2, 3 and 4	Sousa *et al.*, 2023
	RECs provide open and voluntary participation of their members, and the profile of the potential member will depend on gender, income, profitability, level of education and their environmental awareness.	Interview 2	Sousa *et al.*, 2023
Customer Relationships |End-of-life | Societal Culture	In Portugal, we are facing a technological culture of "early adopters" that enhances the acceptance of innovative solutions, where citizens play an active role and are more attentive to their consumption because they want to maximize the investment made, promoting the cultural change in energy consumption.	Interviews 1 and 4	Mariuzzo *et al.*, 2023
	In addition to citizens, there are companies and investors aimed at implementing renewable energy infrastructure, with a view to creating a REC through an intermediary company. In these cases, there may be resistance on the part of citizens in adhering to REC, since they do not perceive the tiny gain compared to that of the company/investor.	Interviews 1, 2, 3 and 4	Prados *et al.*, 2022 ;Sousa *et al.*, 2023
	The importance of developing appropriate solutions and tools, as well as shared strategies among the various citizens with a view to addressing together the challenge of decarbonization and the risk of social rejection of large-scale projects, is highlighted.		Prados *et al.*, 2022

Factors	Description	Interviews	Literature
Channels | Distribution | Scale of Outreach	RECs operate through decentralized electricity generation systems, with a reduction in transmission and distribution losses and an increase in the energy security of supply, enhancing savings and added value.		Gjorgievski *et al.*, 2023; Sousa *et al.*, 2023
	Dissemination continues to exist, in rural and deprived areas, due to the lack of knowledge and technical support to citizens, so there is a need to share information, free of charge, through local authorities and organizations.	Interviews 2, 3 and 4	Prados *et al.*, 2022 ; Sousa *et al.*, 2023
Revenue Streams | Environmental benefits | Social benefits	The higher the consumption within the energy community, the greater the economic profits, since the sale to the public grid of the surplus one-off energy is conducted with a lower added value, since it is subject to additional costs, for example, network access tariffs. The fair redistribution of profits among members is highly influenced by the different owners, the sharing mechanisms adopted and the load diagram of each member.	Interviews 1, 2, 3 and 4	Gjorgievski *et al.*, 2023; Sousa *et al.*, 2023
	The economic, environmental, and social benefits of energy sharing within a community are affected by factors that are under the control of the community, such as internal energy sharing rules, and by external factors, such as budgetary regulations and policies. It is verified that the operationalizations of the RECs boost the mitigation of global warming and the optimization at the economic and environmental level.	Interview 1	Gjorgievski *et al.*, 2023; Sousa *et al.*, 2023
Key Resources | Materials | Employees	The creation of a REC requires the formation of a legal entity with its own personality.	Interviews 1, 2 and 4	
	Key resources are supporting infrastructures, namely local transport and distribution, artificial intelligence technology, namely systems integration, digital and bidirectional meters, availability and different data processing, energy storage and management, and renewable energy sources, including solar, photovoltaic, wind, biomass, hydro and geothermal.	Interview 1	Delicado *et al.*, 2016; Prados *et al.*, 2022; Sousa *et al.*, 2023
	Renewable energy parks lead to the use of local labor, the use of local companies and the leasing of properties.	Interview 1	Delicado *et al.*, 2016; Sousa *et al.*, 2023
Key Activities | Production | Governance	The main activity of a REC is the production, sharing and distribution of renewable energy. Nevertheless, it is necessary to manage consumption needs, allowing the sale of surpluses and, ultimately, the storage of energy.	Interviews 1, 2, 3 and 4	Sousa *et al.*, 2023
	It is important to conduct a holistic assessment of the operating model, which should understand the social, economic, environmental and health advantages and disadvantages, transformations in the landscape and land use, the impact on local development, as well as negotiations and commitments between stakeholders.	Interview 1	Delicado *et al.*, 2016; Sousa *et al.*, 2023

Factors	Description	Interviews	Literature
Key Partners | Supplies and Out-sourcing | Local Communities	The creation of renewable energy communities is subject to major regulatory constraints and to many actors who, as noted, have overlapping responsibilities, or who were on the side of omission. Among these, DGEG, ERSE, ENSE, SEN, OMIP, OMIE, ADENE, Certiel, REN and E-Redes.	Interview 1	
	The State and the European Union provide support to speed up the process. In addition, there are energy service companies that support its legalization.	Interview 3	Directive (EU) 2018/2001 of 11 December; Mariuzzo *et al.*, 2023; Prados *et al.*, 2022; Sousa *et al.*, 2023
	The importance of the existence of a multidisciplinary team, with comprehensive technical knowledge, and the existence of technology suppliers (management systems and installation of renewable energy sources) is highlighted.	Interviews 2 and 3	
Cost Structure | Environmental impacts | Social impacts	The costs of an REC, its registration and legalization, the administrative costs for its management, access to information platforms, the hiring of a certified accountant, the investment in renewable energy sources and, in the case of communities being located at a point other than renewable energy sources, the tariff for access to and use of public distribution networks.	Interviews 1, 2, 3 and 4	Gjorgievski *et al.*, 2023; Sousa *et al.*, 2023
	These costs may be lower if the REC adheres to state and European Union support or, alternatively, to fiscal policies that ensure the recovery of the cost of infrastructure investment. In the case of communities located near renewable energy sources, they are exempt from the payment of grid energy losses and grid access tariffs.		Directive (EU) 2018/2001 of 11 December; Gjorgievski *et al.*, 2023; Mariuzzo *et al.*, 2023; Prados *et al.*, 2022; Sousa *et al.*, 2023
	There is an increased concern about climate change due to global warming caused by CO_2 emissions. With the construction and operation of wind farms and solar power plants, there has been an increase in the mortality rate of birds and other wildlife, thus finding us in a duality, since renewable energies play a crucial role in preventing climate change.		Delicado *et al.* 2016; Directive (EU) 2018/2001 of 11 December; Sousa *et al.*, 2023

7. Conclusions

The creation of a REC is subjected to major regulatory constraints and to many actors who, as noted, have overlapping responsibilities, or who were on the side of omission (Interview 1).

To speed up the process, there are ESCOs that support its legalization, however, members will incur much higher costs (All interviews, Prados *et al.*, 2022; Sousa *et al.*, 2023). Among the costs of setting up a REC, are the costs of investing in technologies, including management systems, and renewable energy sources (Interview 2).

One of the great advantages is the resilience of the network, that is, when the production is conducted in the place where it is consumed, since it does not imply overload in the transmission and distribution network (Interviews 1 and 2).

For there to be no waste of unused energy, it is necessary to manage the needs of consumption, storage, and sale of surpluses that, as mentioned by interviewee 2, currently do not yet exist information systems capable of integrating all the factors of obligation imposed, thus hindering the process.

In addition, the lack of information, namely on the websites of the competent entities responsible for the process, the lack of knowledge and technical support to the members were the main reasons not no adhere to RECs (Interview 2; Sousa *et al.*, 2023).

Reportedly, the cost of energy consumed within a REC is lower than when purchasing from a trader (Interviews 1 and 4), and the main objective of a REC is the democratization of fossil energy, contributing to minimize its carbon footprint and move towards a greener future in the short and long term (Interviews 2, 3 and 4).

Although the term renewable energy is still new, to enhance the increase in the consumption of renewable energies, it would be desirable that at the political level, through a true energy democracy, the design of actions to sensitize the public, for energy consumption to be promoted, accompanied by economic and financial incentives for the same purpose (Prados *et al.*, 2022).

A limitation of this study is related to the number of interviews conducted, which does not allow generalizing the conclusions of this study at the macro level. In addition, and, given that this theme is considered recent and is still in the early stages of implementation, the literature is also limited.

As a suggestion for future research, it would be opportune to use quantitative methodologies to assess the gain of the members and the shareholders in the RECs.

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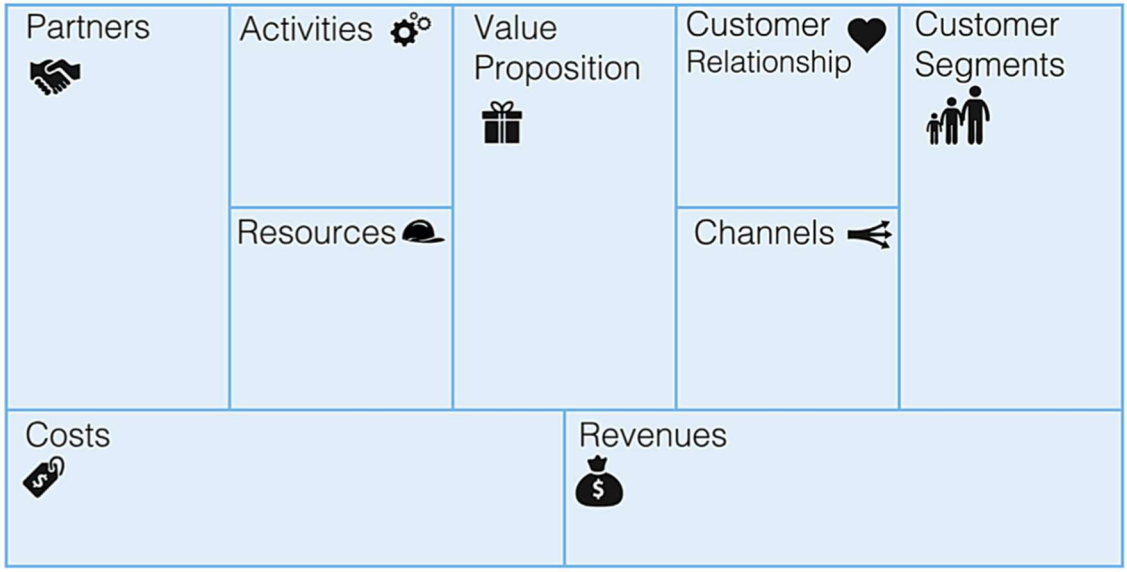
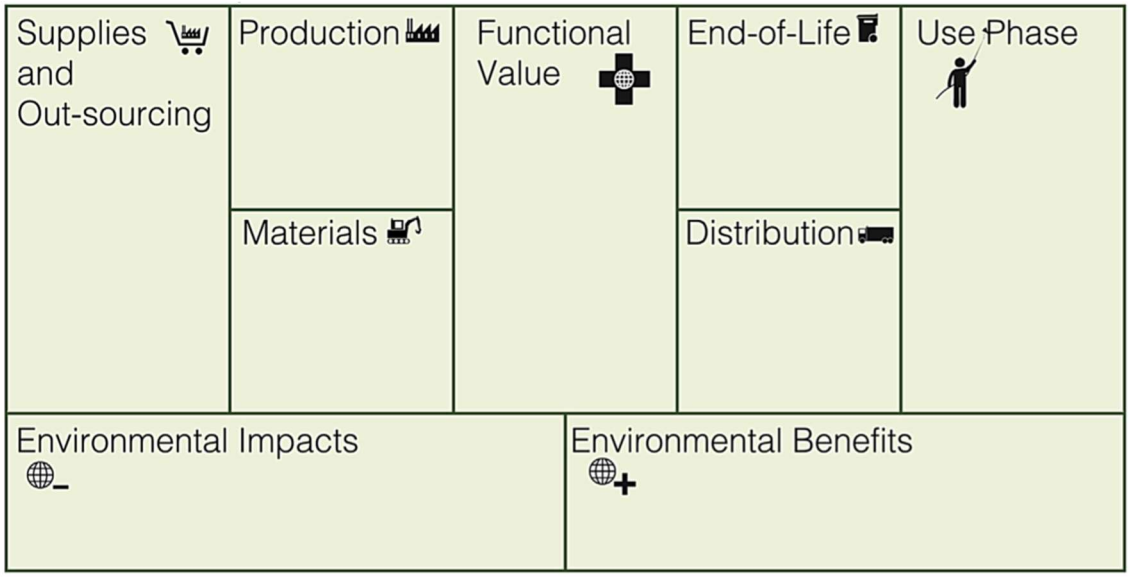
Annexes

Annex I - Triple Layer Business Model Canvas



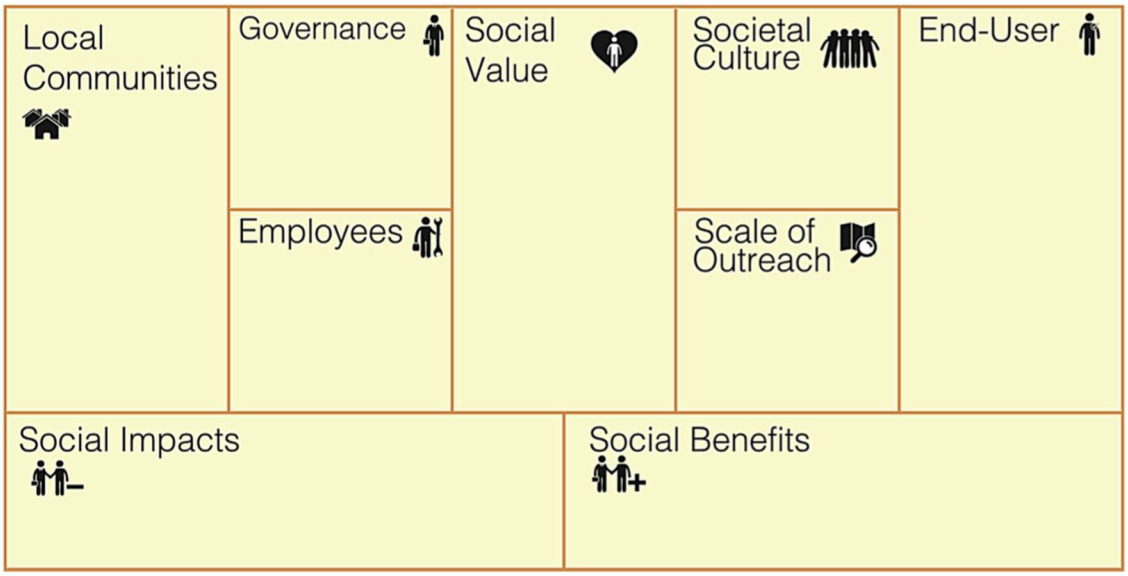
Source: Joyce & Paquin (2016, p. 1483).

The economic business layer model canvas of the triple layer business model canvas.



Source: Joyce & Paquin (2016, p. 1483).

The environmental life cycle layer of the triple layer business model canvas.



Source: Joyce & Paquin (2016, p. 1483).

The social stakeholder layer of the triple layer business model canvas.

Annex II - Interview

ENTREVISTA

[Apresentação] Bom dia/ Boa tarde, no seguimento do desenvolvimento da minha dissertação na Faculdade de Engenharia da Universidade do Porto, relacionada com as comunidades de energia renovável, irei efetuar um estudo de caso de modo a explorar este modelo de negócio.

Objetivo da entrevista: Percecionar de forma detalhada o modelo de negócio nas comunidades de energia renovável, e conhecer as principais barreiras.

Autorização do entrevistado: Para a realização desta entrevista irei necessitar do seu consentimento expresso [conforme anexo "autorização"]. Neste documento constam, para além dos objetivos desta entrevista, aspetos relativos à confidencialidade e anonimato sendo que os seus dados e os da instituição nunca irão ser revelados. Para facilitar o registo da informação recolhida, pedimos também autorização para que esta entrevista seja gravada, aspeto este que também consta desse documento.

1. O que entende por comunidade de energia renovável (CER)?
2. De que modo as CER são benéficas em relação ao modelo anterior (cada cliente por si)? Quais são as principais vantagens e desvantagens face ao anterior?
3. De que modo é que as CER são uma solução viável para quem pretende adotar um nível de vida mais sustentável?
4. Qual é a sua perceção relativamente aos principais pontos positivos e negativos das CER? Quais foram as barreiras que encontrou? O que faria para melhorar?
5. Considera que o mercado em Portugal está preparado para desenvolver este conceito? Quais os fatores que considera influenciarem este desenvolvimento?
6. Qual é a sua perceção do modelo de negócio das CER? O que alteraria neste modelo?

Annex III – Authorization

AUTORIZAÇÃO

A presente entrevista faz parte de um trabalho para a tese de mestrado no âmbito do Mestrado em Inovação e Empreendedorismo Tecnológico da Faculdade de Engenharia da Universidade do Porto e visa compreender as comunidades de energia renovável.

Com o objetivo de otimizar o registo da informação recolhida será gravado o áudio desta entrevista e os dados recolhidos serão somente utilizados em contexto de investigação. Os aspetos relativos à confidencialidade, anonimato e forma de tratamento dos dados estão, por isso, assegurados. A sua participação neste estudo é voluntária e pode retirar-se a qualquer momento, ou recusar participar, sem que tal facto tenha consequências para si. Após esta entrevista poderá ser necessário completar dados e, neste sentido, poderá vir a ser de novo contactado(a).

A investigação será desenvolvida pela mestranda Eduarda Barbosa Pereira Bastos, sob a orientação da Professora Maria Alexandra Lobo Xavier, da Faculdade de Engenharia da Universidade do Porto. Ambos agradecem a sua disponibilidade.

Eu …… [nome do(a) entrevistado(a)], consinto em participar voluntariamente no projeto de investigação acima descrito, consciente de que os meus dados serão confidenciais e que não serão citados nomes de pessoas ou instituições que eu não deseje. Acrescento que fui informado dos objetivos desta investigação.

....., …… de …… de 2023.

…….

[Assinatura do Entrevistado]

Annex IV – Energy Transition

This section is written with text extracted from the Directive (EU) 2018/2001 of 11 December, p. 328/82 to p.328/88.

An overview of the main barriers and challenges faced allows the design of more informed energy policies, contributing to a more sustainable and inclusive development, as well as to a more just energy transition (Cunha *et al.*, 2023).

The European Commission has proposed that the Union's binding overall target for 2030 for the share of renewable energy consumed in the Union should be at least 32%. That proposal, which was endorsed by the European Council in its conclusions of 23 and 24 October 2014, further specified that member states should be able to set their national targets more ambitiously to move closer to the contributions they have foreseen to meet the Union's 2030 target and, if possible, to overcome them. The establishment of this binding target will contribute to encouraging the development of technologies that produce renewable energy and, at the same time, provide certainty for investors in innovative technologies (Directive (EU) 2018/2001 of 11 December).

To support Member States' ambitious contributions to the achievement of the target set by the European Union, a financial framework should be designed to facilitate and promote investment in renewable energy projects in the Member States, including the use of financial instruments. The European Commission should also focus on the allocation of funds contributing to the reduction of the cost of capital for projects in the field of renewable energy, as that cost has a significant impact on the costs of projects in the field of renewable energy and their competitiveness, as well as on the development of infrastructure essential for a better technically feasible and affordable use of renewable energy, such as transmission and distribution system infrastructure, smart grids and interconnections (Directive (EU) 2018/2001 of 11 December).

The European Commission should encourage investment in new, flexible, and clean technologies, and establish an appropriate strategy to manage the abandonment of technologies that do not contribute to emission reductions and provide sufficient flexibility, based on transparent criteria and reliable market price signals (Directive (EU) 2018/2001 of 11 December).

Support schemes for electricity from renewable sources, also known as 'renewable electricity', have proven to be an effective way to promote the use of renewable electricity. If, and when, Member States decide to implement support schemes, support should be submitted in a manner that does not distort the functioning of electricity markets (Directive (EU) 2018/2001 of 11 December).

Together with measures to increase renewable energy shares, the support granted is an essential element to increase the integration of renewable electricity in the market (Directive (EU) 2018/2001 of 11 December).

Small installations can be extremely useful for increasing the level of acceptance and recognition by the public as well as for ensuring the deployment of renewable energy projects, in particular at local level (Directive (EU) 2018/2001 of 11 December).

To ensure the participation of small installations, it may be necessary to create specific conditions, including feed-in tariffs, to ensure a positive cost-benefit ratio in accordance with Union law applicable to the electricity market. The definition of small installations for the purpose of obtaining such support is important to ensure legal certainty for investors. State aid rules include definitions of small installations (Directive (EU) 2018/2001 of 11 December).

Electricity from renewable sources should be made available at the lowest possible cost to consumers and taxpayers. When designing support schemes and when allocating support, Member States should aim to minimize the overall cost of deploying the scheme by following the path of decarbonization towards achieving the objective of a low-carbon economy by 2050 (Directive (EU) 2018/2001 of 11 December).

As expressed in Directive (EU) 2018/2001 of 11 December, Member States are given the right to decide to what extent they support electricity from renewable sources produced in other Member States, and Member States may open participation in support schemes for electricity from renewable sources to producers located in other Member States.

The indicative shares may correspond in each year to at least 5% between 2023 and 2026 and to at least 10% between 2027 and 2030.

By 2023, the European Commission is expected to conduct an evaluation of the support schemes for electricity from renewable sources that have been implemented in the meantime. That assessment shall assess the need to introduce an obligation for Member States to partially open participation in their support schemes for electricity from renewable sources to producers located in other Member States to ensure an opening of 5% by 2025 and 10% by 2030 (Directive (EU) 2018/2001 of 11 December).

The financial support to be made available by the Member States shall be stable and a long-term timetable shall be published providing for the foreseeable allocation of the support, covering as a reference at least the following five years. That timetable shall be updated annually, where appropriate, to take account of recent market developments or the foreseeable allocation of support and, they shall assess, at least every five years, the effectiveness of support schemes for electricity from renewable sources (Directive (EU) 2018/2001 of 11 December).

One or more Member States may cooperate with one or more third countries on all types of joint projects concerning the production of electricity from renewable sources. Such cooperation may involve private operators and must fully respect international law. Electricity from renewable sources produced in third countries may be considered for the purpose of calculating Member States' renewable energy shares (Directive (EU) 2018/2001 of 11 December).