GRADO EN INGENIERÍA EN TECNOLOGÍAS INDUSTRIALES

TRABAJO FIN DE GRADO ÁNALISIS COMPARADO DEL MARCO Y LOS INCENTIVOS A LA CREACIÓN DE COMUNIDADES ENERGÉTICAS EN REINO UNIDO, CALIFORNIA (EE.UU.), QUEENSLAND (AUSTRALIA) Y ESPAÑA

Autor: Mónica Fernández-Vega Escandón

Director: José Pablo Chaves Ávila

Co-Director: Jesús José Fernández García

Madrid

Declaro, bajo mi responsabilidad, que el Proyecto presentado con el título Análisis del marco y los incentivos a la creación de comunidades energéticas en Reino Unido, California (EE.UU.), Queensland (Australia) y España en la ETS de Ingeniería - ICAI de la Universidad Pontificia Comillas en el curso académico 2022/2023 es de mi autoría, original e inédito y no ha sido presentado con anterioridad a otros efectos. El Proyecto no es plagio de otro, ni total ni parcialmente y la información que ha sido tomada de otros documentos está debidamente referenciada.

Fdo.: Mónica Fernández-Vega Escandón   Fecha: 27/06/2023

Autorizada la entrega del proyecto

Fdo.: José Pablo Chaves Ávila   Fecha: ……/……/ ……

José Pablo Chaves

Firmado digitalmente por José Pablo Chaves
Fecha: 2023.06.29 14:12:32 +02'00'

Fdo.: Jesús José Fernández García   Fecha: ……/ ……/ ……

45908046T JESÚS JOSÉ FERNÁNDEZ (C:Q1570003B)

Firmado digitalmente por 45908046T JESÚS JOSÉ FERNÁNDEZ (C:Q1570003B)
Fecha: 2023.06.30 21:30:48 +02'00'

GRADO EN INGENIERÍA EN TECNOLOGÍAS INDUSTRIALES

TRABAJO FIN DE GRADO

ÁNALISIS DEL MARCO Y LOS INCENTIVOS A LA CREACIÓN DE COMUNIDADES ENERGÉTICAS EN REINO UNIDO, CALIFORNIA (EE.UU.), QUEENSLAND (AUSTRALIA) Y ESPAÑA

Autor: Mónica Fernández-Vega Escandón

Director: José Pablo Chaves Ávila

Co-Director: Jesús José Fernández García

Madrid

Agradecimientos

Quiero expresar mi sincero agradecimiento a mis tutores, Jesús José Fernández García y José Pablo Chaves Ávila por su orientación, su implicación, sus aportaciones y su apoyo durante el Trabajo de Fin de Grado. Asimismo, quiero mostrar mis agradecimientos a ICAI por la formación recibida durante la carrera, que me ha permitido realizar este trabajo.

TÍTULO DEL TFG: Análisis comparative del marco y los incentivos a la creación de comunidades energéticas en Reino Unido, California (EE.UU.), Queensland (Australia) y España

Autor: Mónica Fernández-Vega Escandón
Director: José Pablo Chaves Ávila
Co-Director: Jesús José Fernández García
Entidad Colaboradora: ICAI – Universidad Pontificia Comillas)

RESUMEN DEL PROYECTO

Las comunidades energéticas han surgido como entidades novedosas e influyentes. Sin embargo, en la literatura existente, el análisis del marco regulatorio y los incentivos en el Reino Unido, California, Queensland y España para conocer los procedimientos óptimos a seguir, es algo que nunca se ha estudiado. Por esta razón, este proyecto sugiere analizar primero el sector energético en cada uno de estos lugares y seguidamente adentrarse en el tema de mayor interés, la energía comunitaria. El siguiente documento se divide en tres secciones principales, siendo el objetivo de la primera sección contextualizar la situación actual del sector energético en las cuatro regiones elegidas para el estudio. Las dos siguientes secciones se centran exclusivamente en el marco y los incentivos que conciernen a la energía comunitaria en los mismos lugares. En un mundo en el que la transición energética de los recursos tradicionales a los renovables es una realidad, la energía comunitaria se presenta como una solución viable que aún necesita consolidarse. Para elaborar este documento, se ha examinado exhaustivamente el estado del arte relacionado con el tema con el fin de analizar todos los aspectos relevantes de mayor interés para la cuestión. En base a todo lo anterior, se puede concluir que una regulación más estable es necesaria para hacer de las comunidades energéticas una realidad más atractiva para el inversor. Una comunidad energética ayuda en la transición energética y convierte al consumidor en partícipe.

Palabras clave: Comunidad energética, Energía renovable, PESTLE, Reino Unido, California, Queensland, España.

TITLE OF THE FINAL THESIS: Comparative analysis of the framework and the incentives for the creation of energy communities in the United Kingdom, California (USA), Queensland (Australia) and Spain.

Author: Mónica Fernández-Vega Escandón
Supervisor: José Pablo Chaves Ávila
Co-Supervisor: Jesús José Fernández García

Collaborating Entity: ICAI – Universidad Pontificia Comillas)

ABSTRACT

Community energy initiatives have emerged as novel and influential entities. Nevertheless, in the existing literature the analysis of the regulatory framework and the incentives in the United Kingdom, California, Queensland and Spain to understand the best procedures to follow, is something that has never been studied. This is why this project suggests analyzing firstly the energy sector in each of these places and then diving into the relevant matter, community energy. The following paper is divided in three main sections, the first section´s aim being to contextualize the actual situation of the energy sector in the 4 regions chosen to study. The next two solely focus on the framework and the incentives that regard community energy in the same places. In a world where the energy transition from the traditional resources to renewable ones, community energy is a viable solution that still need to be settled. In order to compose this document, the state of the art related to the subject has been thoroughly examined so as to gather every relevant aspect of interest to the matter. Drawing upon all the preceding, it can be concluded that to make energy communities an attractive initiative a more stable and reliable regulation is needed.

Keywords: Community energy, Renewable energy, PESTLE, United Kingdom, California, Queensland, Spain.

LIST OF ABBREVIATIONS

AB	Assembly Bill
ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
ACES	Advancing Clean Energy Schools
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ARENA	Australian Renewable Energy Agency
BEIS	Department for Business Energy and Industrial Strategy
BG	British Gas
BGGS	British Gas Green Street
BOE	Official State Gazette
BP	British Petroleum
CAISO	California Independent System Operator
CCC	Committee on Climate Change
CCS	Carbon Capture and Storage
CE	Community Energy
CEC	California Energy Commission
CER	Clean Energy Regulator
CIS	Centre for Sociological Research
CNMC	Comisión Nacional de los Mercados y la Competencia
COP	Conference of the Parties
COVID	Coronavirus Diseases
CPUC	California Public Utilities Commission
CSIRO	Commonwealth Scientific and Industrial Research Organization
CSP	Concentrated Solar Power
DOE	Department of Energy
EED	Energy Efficiency Directive
EIA	Energy Information Administration
EIS	Enterprise Investment Scheme
EPA	Energy Policy Act

ERF	Emissions Reduction Fund
ETS	Emission Trading Scheme
EU	European Union
FIT	Feed-in Tariff
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GW	Gigawatts
ICAI	Catholic Institute of Arts and Industry
IDAE	Institute for Diversification and Saving of Energy
IEA	International Energy Agency
IEM	Internal Energy Market
INE	National Statistics Institute
IPCC	Intergovernmental Panel on Climate Change
IRA	Inflation Reduction Act
IRENA	International Renewable Energy Agency
ISO	Independent System Operator
IRPF	Personal Income Tax
ITC	Investment Tax Credit
IWG	Interagency Working Group
LCCC	Low Carbon Contract Company
LRET	Large-scale Renewable Energy Target
MW	Megawatts
NBT	Net Billing Tariff
NDC	Nationally Determined Contribution
NEM	Net Energy Metering
NER	National Electricity Rules
NIC	National Infrastructure Commission
NREL	National Renewable Energy Laboratory
PERTE	Strategic Projects for Economic Recovery and Transformation
PESTLE	Political Economical Sociocultural Technological Legal Environmental
PNIEC	Integrated National Energy and Climate Plan
PRTR	Recovery, Transformation and Resilience Plan
PUC	Public Utilities Commission
PV	Photovoltaic

PVSC	Photovoltaic Specialists Conference
RD	Royal Decree
REE	Red Eléctrica Española
RED	Renewable Energy Directive
ReMAT	Renewable Market Adjusting Tariff
RET	Renewable Energy Target
RPS	Renewable Portfolio Standard
SB	Senate Bill
SITR	Social Investment Tax Relief
SPAR-4-SLR	Scientific Procedures and Rationales for Systematic Literature Reviews
STC	Small-scale Technology Certificate
TW	Terawatts
UK	United Kingdom
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USA	United States of America
VAT	Value Added Tax

TABLE OF CONTENTS

FIGURES INDEX

TABLES INDEX

CHAPTER 1: INTRODUCTION

The aim of this final thesis is to study, analyze and compare the situation of community energy in Spain, the United Kingdom, California (United States), and Queensland (Australia). These regions were chosen to study is that they have all been heavily promoting renewable energy, as the alternative to fossil fuels and they have good conditions for exploiting renewable resources. Another reason is that they belong to different continents, except for Spain and the United Kingdom, but the latter one is not a part of the European Union, meaning that the regulations and incentives may vary.

The project starts by analyzing the actual framework of the energy sector in each of the places stated above. For this a PESTLE analysis has been followed, with the objective of covering every relevant topic, with the political, economic, sociocultural, technological, legal and environmental aspects explored.

Issues such as the generation and consumption of renewable energy in each region are discussed in the proper segments of the project. With the objective of comparison, the number of inhabitants is also one of the matters that has been researched, as well as whether or not the country belongs to those that have signed the Paris Treaty. With this the objectives set in each place for 2050 are also presented. Moreover, the most exploited natural resources due to the characteristics of the climate and geographies, as well as the technologies to do so, are other topics taken into account and explained in this section.

Once the contextual framework has been established, the study digs deeper into the subject of community energy. To do this, firstly, the regulations governing this figure in each of the places previously mentioned are analyzed. Based on this analysis, the legal framework that regulates them are described. Finally, the evaluation of the functioning of the renewable energy communities in each country allow us to conclude which methods are best to apply in order to promote their development in our country. In this chapter the aim is to best describe the general meaning of community energy (CE) and get rid of the uncertainty of its regulations in the four different regions used as example.

Similarly, the incentives provided by each country regarding energy communities are described. These incentives include those implemented through the government or associations that promote the consumption of local renewable energy. These incentives are classified into different categories in order to get the main picture that defines them. Finally, a comparison is made between the legal framework and the existing incentives in the UK, California and Queensland and those in force in Spain.

1.1 PROJECT MOTIVATION

The development of energy communities is progressing worldwide, particularly in Europe. In Europe alone, with over 1 900 energy community projects, renewable energies seem to be the preferred solution for the majority of countries. Spain is not lag behind in such a crucial field like energy [1]. The main motivation for studying energy communities is that in Spain is less developed, compared to other countries in the EU, there is much to explore and contribute value to.

Furthermore, there are increasing legal restrictions on traditional forms of energy, encouraging traditional energy companies to adapt their business models by reducing the use of polluting energies [2]. This global paradigm shift, driven by growing environmental concerns, is driving the search for alternative solutions. This concern is reflected in the efforts made by the international body IPCC in terms of climate change mitigation, as seen in the AR6 report [3]. The current trend in energy consumption is slower than in previous history, and it is worth noting that energy intensity has decreased by around 2% in the United States and the European Union, this might be due to the Covid-19 pandemic when transport, one of the most consuming sectors, decreased. However, energy remains a fundamental and a vital necessity [4]. To meet this basic need, renewable energies are increasing its importance as an alternative that allows the abandonment of other, less clean forms of energy.

On the other hand, the profitability of an energy community can be significant. This profitability continues to increase in the current global context, where situations like the war in Ukraine or other unforeseeable and uncontrollable circumstances result in an increase in energy prices in global markets [2]. Therefore, it is particularly interesting to be able to self-supply without depending on third-party suppliers, obtaining energy in a cheap and clean manner, without worrying about fluctuations in international prices of the electricity.

Governments and other public entities, aware of the benefits generated by energy communities, have approved numerous incentives that will be studied in more detail in this work. These incentives aim to encourage the population to follow the path of renewable energy and self-consumption, guiding us towards a better and more sustainable world. As mentioned before, energy is a basic necessity, and renewables are the chosen path.

In conclusion, the establishment of energy communities, their regulation, and incentives are topics that still have many gaps, making it particularly necessary to understand their impacts in order to promote them in Spain.

1.2 OBJECTIVES

The project aims to explore and compare the legislative frameworks and incentives related to community energy initiatives in four different regions, Spain, the United Kingdom, Queensland and California. Additionally, it seeks to propose a theoretical framework to guide on the implementation of energy communities' projects.

To describe the legislative framework related to CE in the previous paragraph and compare them is the first objective of the document. The legal framework refers to the laws, regulations and policies governing the operation and implementation of energy communities. By examining this aspect, the aim is to gain insight into the legal aspects and requirements that shape these initiatives.

The second objective is to study and classify the incentives designed for community energy in the four regions mentioned. Incentives play a crucial role in encouraging the growth and success of energy communities. The target is to identify the carious mechanisms used to promote and support these types of projects by understanding and categorizing the incentives offered.

The third objective of this study is to compare and evaluate the methods used to regulate and incentivize energy communities. With this the aim is to find the similarities and differences in each place to understand which are the most important measures to take in order to promote the initiative. Identifying the best practices and potential areas for improvement in the regulation and ways to incentivize them.

CHAPTER 2: METHODOLOGY

This section presents the methodology that will be applied in the rest of the study.

2.1 ANALYSIS OF THE SITUATION

The PESTLE analysis enables to gain insight of the factors that could affect an industry, it provides a valuable framework for understanding the outside environment. A PESTLE analysis helps situate the context of the project and give a broader and structured approach to the topic. The PESTLE study is a descriptive tool used to learn more about a business environment. A PESTLE analysis can be used to evaluate a country's operations regarding a specific sector in order to determine its outlook, potential for growth, and strategic focus by breaking down the analysis by the most relevant aspects [5]. In the case of this project, the energy sector of Spain, the United Kingdom, California and Queensland were evaluated studying their political, economic, sociocultural, technological, legal and environmental aspects, one by one in the order written above. For this chapter the information was found in Official State Gazettes and the governments' pages, international organisms or in relevant and reliable newspaper, and then proven by academic articles.

The steps followed to compose this analysis are the following.

1. The first step was to develop a template of the most important concepts of each aspect (political, economic, sociocultural, technological, legal and environmental) that needed to be part of the study. This was a list of key words for each of the aspects mentioned that had to be covered.

2. The objective is to explain each of these concepts and find information about them for every region of relevance, so that in general each subsection of the PESTLE contained similar topics.
3. After the template was laid out, the process started by researching those specific concepts for every subsection and in a particular order. It started with Spain, followed by the United Kingdom, then California and lastly Queensland. This approach was adopted because the research process was more concise and clearer if every region was completely finished. This means the six subsections covered and all the concepts that were selected as important closed before moving on to a different region.
4. Now, the concepts found of higher relevance in each subsection will be mentioned.

The process followed in this document was in order of appearance, first the political section was covered, then the economical, followed by the sociocultural, the technological, the legal and the environmental section.

1. **Political**: presents the willingness of these four regions to achieve net zero carbon emissions by 2050 and to increase the share of renewable energy in the power mix. The most relevant initiatives promoted by the government are laid out in the political section as well. What is relevant for the political section is the following: government initiatives, government goals, government policies and relevant events (in our case, the Paris Agreement for example).
2. **Economic**: analyzes the importance of the reduction of prices for the renewable energy sources is discussed, together with how this is helping further advance the deployment of these sources. The employment is also relevant to this section; the progress of clean energy sources can generate jobs even though the fossil fuels sector is losing employees, so the energy sector would not reduce its workforce. In this

section it would be important to cover the following principal economic aspects: fluctuation in prices, liberalization of the energy market and employment.

3. **Sociocultural**: presents the population of the region and its forecast. Research on the inhabitants' awareness towards climate change has been done for this section, to compare the concern regarding this matter now and a few years back. This part of the paper should include: the population of the region, the projection of the population and the concern of the use of renewables and climate change.
4. **Technological**: discusses the new technological advancements developed that influence the energy sector. Data is collected about each place's energy generation and consumption, the sectors that consume most and which are the sources that are most consumed. A review of the renewable sources and the technologies that help their promotion is also mentioned in this part of the project. It would be interesting to address the following in the technological section: energy consumption by sector, type of electricity generation (nuclear, coal, renewables…), technological advances, for instance smart meters, microgrids or development of energy storage technology.
5. **Legal**: presents the most important legal entities regarding the energy sector, together with the laws that were considered the significant regulations and laws for this specific project. In the legal section what should be included is the following: structure of the regulation of the energy sector, important entities and organisms for the regulation and laws that concern the sector.
6. **Environmental**: shows the most essential renewable sources that can be exploited in each of the jurisdictions studied, their relevant geographical characteristics and the share of renewable energy consumed. In this last section it is relevant to include: percentage of energy that comes from fossil fuels, percentage of energy generated from renewable sources and which are the most abundant natural resources in the region.

After the research was completed and the context of the actual situation was presented, in order to get a more visual and compact understanding of the information gathered, a comparative section is presented. In this section the data was organized and summarized by the six sections explained above, political, economic, social, technological, legal and environmental, comparing the similarities and differences of each region. This way the reader can obtain a more synthesized analysis of the knowledge collected.

2.2 REGULATION AND INCENTIVES ANALYSIS OF THE COMMUNITY ENERGY

In order to gather the academic articles used during this research the method of Scientific Procedures and Rationales for Systematic Literature Reviews (SPAR-4-SLR) was implemented. This encompasses both a research methodology and an output of scholarly articles of interest [6]. As a methodology this process involves a systematic gathering, organizing and evaluating of existing literature within a specific domain [6]. The search was done the 5th of February, 2023 and the result of this rigorous method is a list of academic articles gathered from the Scopus database.

To apply this methodology, the next steps have been followed:

1. A search was done with the in the Scopus database using the following search query (part between guillemets) « *("energy community" OR "energy cooperative" OR "energy communities" OR "energy co-op" OR "energy cooperatives" OR "energy co-ops") AND ("California" OR "United Kingdom" OR "Queensland" OR "England" OR Scotland" OR "Wales" OR "Ireland") AND ("feed-in-tariff" OR "feed-in-tariffs" OR "state aid" OR "state aids" OR "grants" OR "grant" OR*

“incentive” OR “incentives” OR “loan OR “loans” OR “subsidy” OR “subsidies”) ».

2. The arranging stage, regarding the organizational aspect it depends on using the filters and categorization features provided by Scopus to sort and structure the documents [7]. The documents collected from the search were organized. From that search a number of articles was extracted.
3. The next stage is the purification stage, this study only collected specific documents [7]. Those that were academic articles were kept and those that were published before 2015 were eliminated. After a thorough and detailed examination some articles were eliminated for the progress of the project, some because they were irrelevant (after having read the abstract), others because they were too old or outdated. A total of 57 articles were left and considered to gather the most relevant data for the study and research.

With help from the articles that were kept the regulation of CE’s was explained and divided into different sections in order to compare the different places studied progressively. Similarly, the incentives are presented in this same chapter after the comprehensive review, clustering the initiatives that the different places have in common or those that are alike so to compare them after.

2.3 DISCUSSION

To finalize, the discussion section is where the results from the previous chapters are analyzed and interpreted. Highlighting significant patterns that the different regions of interest follow. The author reflects on the information gained throughout the process.

CHAPTER 3: ANALYSIS OF THE SITUATION

This section offers a thorough examination of the state of the energy sector in the four different places of interest: Spain, the UK, California and Queensland. These areas were chosen because of their distinctive qualities, varied energy environments and significant contributions to the global energy transition. This chapter will thoroughly examine each of these regions' policy and regulatory framework, existing energy mix, consumption trends, deployment of renewable energy and governments' major initiatives. For this the method implemented was the PESTLE analysis, dividing the energy sector into its political, economic, sociocultural, technological, legal and environmental aspects in order to touch every part considered relevant to the subject.

3.1 SPAIN

In this subsection the PESTLE analysis of the Spanish country regarding the energy sector is covered. The study of its most relevant aspects concerning the energy industry are presented.

3.1.1 POLITICAL

Spain is a member of the European Union (EU) and is subject to EU laws and regulations related to the energy sector. These laws include the Renewable Energy Directive (RED) being its current target to reach at least a 32% increase in renewable energy by 2030 [8]. Another law imposed by the EU is the Directive of Energy Efficiency (EED), this directive aims to improve energy efficiency in the EU by setting binding targets for energy savings and requiring member states to develop energy efficiency plans, as energy savings are the easiest way of reducing greenhouse emissions, which is one of the main targets of the EU in order to stop global warming [9]. Although there are many more regulations governing the energy industry in the EU, these are the ones that are most pertinent to the discussion of energy communities (EC). The "Clean Energy for Europeans" package was adopted in 2018 and included the RED and the EED [10] [9]. The policy framework of this package is intended to ease the switch from traditional energy sources to cleaner ones, with a special emphasis on meeting the EU's pledges to reduce greenhouse gas emissions under the Paris Agreement. Consumers, the environment, and the economy will all benefit significantly from the new legislation' adoption. By enacting these measures at the EU level, the legislation strengthens the EU's position as a global leader in combating climate change [11].

Regarding the Paris Agreement on climate change, the long-term goal is to reduce global greenhouse emissions, limiting the temperature rise to 2 degrees Celsius above pre-industrial levels while pursuing efforts to restrict the increase to 1.5 degrees [12]. In December 2015, the Paris Agreement was approved by the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). It is a legally binding international treaty that has been endorsed by 197 countries and came into effect in November 2016. It is considered to be the first international climate change agreement of its kind and strives to lead the world toward achieving a level of greenhouse gas emissions that would prevent dangerous climate change [13]. Under the Paris Agreement, each country sets its own nationally determined contributions (NDC), and the parties convene every five years to evaluate the progress towards meeting their targets [14].

Continuing with Europe’s thrive to be the first climate-neutral continent, the EU also developed the Green Deal plan, in order to achieve net zero emissions by 2050, in line with the Paris Agreement goals [15]. There is an substantial amount of money destined to execute the Green Deal plan, a third of the investments from the Next Generation EU Recovery Plan as well as the EU's seven-year budget, will be allocated towards funding this plan [16]. With respect to the European funds towards renewable energy and its encouragement, in September 2020, the European Commission established the EU renewable energy financing mechanism. Its aim is to enable greater collaboration among EU countries in promoting and adopting renewable energy sources, which will help them meet both individual and collective renewable energy goals. Furthermore, the mechanism will advance renewable projects aligned with the European Green Deal [17]. With this mechanism, the implementation of renewables throughout the EU can be carried out in a more cost-effective manner, particularly in regions that have greater access to natural resources or are more geographically suited for such projects [17]. The main idea is the collective approach, the mechanism establishes a connection between countries that voluntarily provide financial contributions (known as contributing countries) and those that agree to allow new renewable energy projects to be constructed on their territory (hosting countries). Nonetheless, unlike other EU cooperation mechanisms, there is no direct link or negotiation between the contributing and hosting countries [18].

The European climate law legally obligates the achievement of the EU's climate objective of reducing emissions by a minimum of 55% by 2030. In order to do so the EU developed the “Fit for 55” package which is a collection of proposals that seek to update and revise existing EU legislation and introduce new initiatives, with the intention of aligning EU policies with the climate targets established by the Council and the European Parliament. The package aims to establish a comprehensive and equitable framework that will facilitate the attainment of the EU's climate goals [19].

The Spanish government offers a number of subsidies for renewable energy systems, for the installation of renewable energy systems, such as solar panels or wind turbines, which can be used by energy communities to generate their own electricity [20]. At the same time the

National Integrated Energy and Climate Plan (PNIEC) for the years 2021-2030 aims to significantly raise the level of renewable energy adoption in Spain, such that by 2030, renewables will account for 74% of electricity generation and 42% of final energy consumption. The primary objective of this plan is to increase the proportion of renewable energy in the final energy consumption, while taking advantage of the social and economic benefits that come with the renewable energy expansion. Given Spain's available resources, the country is well-positioned to tackle the necessary decarbonisation of its energy system and take advantage of the opportunity for sustainable economic growth and employment, with significant social and economic gains for local and vulnerable consumers through the promotion of renewable energy [21]. This ambitious goals for the country's energy transition, go along with the EU's plans to reach carbon neutrality by 2050.

3.1.2 ECONOMICAL

A report by the International Renewable Energy Agency (IRENA) highlights the crucial role of cost-competitive renewable energy sources in tackling the current energy and climate crises by accelerating the transition towards the goals set in the Paris Agreement. Solar and wind energy, are essential in countries' efforts to quickly reduce and ultimately eliminate the use of fossil fuels on the road to achieving net-zero emissions [22]. According to IRENA, renewables are the most affordable source of energy today, and the economic viability of new renewable energy generation is evident [22]. Investing in renewables not only frees economies from the unpredictability of fossil fuel prices and imports, but also reduces energy costs and increases market resilience, particularly in the current energy crisis [22].

IRENA's recent report found that Spain has some of the lowest costs for solar and wind power in Europe [23]. It shows the trend in weighted-average total installed cost of onshore wind projects in Spain, which saw a decrease of 65% between 2010 and 2020. In regards to the levelized cost of electricity for utility-scale solar PV, it declined in Spain by 85% in the decade [23]. Renewable energy projects such as solar and wind are now becoming more cost-effective [23].

The COVID-19 pandemic in 2020 led to a decline in the demand for electricity, which, combined with the increased use of renewable energy and a decrease in gas prices, resulted in a significant drop in wholesale electricity prices [24]. Between 2017 and 2019, the increase in retail prices was primarily caused by a rise in the energy component. In recent years, the cost of renewable energy has decreased and carbon prices have risen, leading to increased investment in renewable capacities that can compete with other participants in wholesale markets [24]. This is necessary to meet the more ambitious 2030 climate target that requires expanding renewable capacities across sectors [24].

The decreasing cost of renewable energy facilities, particularly solar photovoltaic (PV) plants, are a noteworthy advancement [25]. These expenses have reduced to the point where renewable energy may compete with traditional energy sources without any financial assistance [25]. As a result, in certain areas of Spain, the levelized cost of electricity was considerably less than the wholesale market price, and this trend is anticipated to continue. Spain's policy regarding demand-side generation, specifically self-consumption of electricity, is a good example of the energy transition [25].

The country’s economy will be affected by the goal of net-zero emissions transition on the employment area [26]. Job creation is one of the top concerns of the IEA, the transition will bring a rise in employment opportunities in the energy sector. Although fossil fuel production would experience a decrease in jobs, the estimation is that the generation of jobs will result in a net gain [26]. Creating new positions in the clean energy, efficiency and low-emissions technology sectors or even new roles for existing workers in manufacturing emissions-reducing products [26].

At present, the majority of jobs in the energy sector across the EU are associated with traditional energy sources like coal, oil, gas, and nuclear power [26]. However, investments in clean energy technologies are creating new employment opportunities in various sectors, including construction and manufacturing [26]. While some regions and sectors may require time to transition to renewable energy sources, efforts are underway to support these transitions, such as the European Commission's initiatives to aid coal regions in their decarbonisation efforts [26]. In 2020, the renewable sector in the EU provided direct or indirect employment to approximately 1.3 million individuals, with heat pumps, biofuels, and wind power accounting for the largest share of jobs. From 2019 to 2020, there was a gross increase of 65 000 jobs (5.2%) in the renewable sector. With Spain being on the top 4 countries in the EU in terms of employment with 140 500 jobs created [26].

3.1.3 SOCIOCULTURAL

In Spain there is a total of 47.6 million people as of January 2022 [27]. Awareness of climate change has grown over the past few years, as shown in the surveys taken by the Centre for Sociological Research (CIS) in 2010 a total of 65.2% of those who participated in a survey regarding the environment were very or quite concerned about climate change [28]. However, in the last poll taken by the CIS in March 2023 a total of 72.6% of respondents were very or quite concerned about climate change. In this last survey, 86.6% of participants agreed that human action does influence in the energy transition [29]. There is a strong cultural awareness of the need for sustainability and it could lead to a greater demand for renewable energy and therefore, energy communities.

3.1.4 TECHNOLOGICAL

The technological advancements in Spain could have a significant impact on the development of energy communities, making it cheaper to generate renewable energy. Spain is a leading producer of renewable energy. According to the BP Statistical Review of World Energy 2022, Spain produced 95.8 TWh of renewable energy in 2021, which was the 8th highest in the world [30]. And that same year the renewable energy generation accounted for 46.7% of the total electricity generated according to Red Eléctrica Española [31]. Regarding solar energy generation, the country has invested in new technologies like Concentrated Solar Power (CSP) created to produce electricity from solar radiation. The solar field consists of mirrors or lenses that focus the sun's rays onto a receiver, where it is transformed into high temperature thermal energy. This energy is then converted into electricity. CSP plants are not as modular as PV, due to the thermal nature of the technology, and require large scales to achieve high efficiencies [32]. Despite a significant reduction in the cost of generating electricity from CSP, it remains more expensive than electricity generated from other technologies [33].

Another example of advances in renewable energy technologies in Spain that are specifically relevant to energy communities are microgrids. A microgrid is a smaller power system that can generate, store, and use energy, operating independently of the main grid while supplying safe and reliable energy. Spain has invested in various microgrid projects at different levels, as it believes that these projects can contribute positively to the Spanish economy. The country is considered a leading country in the research and development of microgrids [34]. The Royal Decree 244/2019 opens a clear way for the development of this technology by including the possibility of having shared self-consumption [35]. Microgrids can be particularly beneficial for energy communities that are located far from the main grid and may experience frequent power outages.

Additionally, the Spanish government has expressed its backing for the advancement of energy storage technology for renewable sources in order to enhance system flexibility and network stability. The plan quantifies storage requirements to contribute to the energy system's decarbonization [36]. These technologies are already present in fields like electric mobility, construction, or manufacturing, and encourage the development of renewable energy communities, that facilitate a more proactive consumer role [36]. To develop and deploy technologies and new business models related to energy storage and flexible energy management that maximize the integration of renewable generation in our country. This involves leveraging Spain's strong position in the power electronics value chain and R&D&i to develop its own sector for intelligent storage and management [37].

3.1.5 LEGAL

Red Eléctrica Española (REE) is the Spanish electric transmission system operator (TSO) that operates and manages the high-voltage electricity network in Spain, as well as the interconnections with the neighbor countries [38]. In order to maintain the reliability and safety of the nation's electricity system, REE is essential to the Spanish energy sector. As the system operator, REE transmits electricity from producers to consumers, maintains grid stability, and controls the production and consumption of electricity in real-time. To fulfil the nation's future energy needs, REE is also in charge of developing and building the Spanish electricity transmission network [38]. The integration of renewable energy sources into the Spanish power system has been a recent area of emphasis for REE [39]. As a major participant in the energy transition, REE is working to adapt the Spanish electricity grid to accommodate the increasing share of renewable energy output, including wind and solar power. To facilitate the integration of renewable energy, REE is investing in developing new technologies and solutions for grid management [39].

The National Commission of Markets and Competition (CNMC) is an independent regulatory body in Spain that oversees the regulation and supervision of several sectors, including energy [40]. The CNMC is responsible for ensuring fair competition, promoting market transparency, and protecting consumers' interests in the Spanish energy market. This commission plays a critical role in the energy sector by regulating and supervising the activities of electricity and gas companies, ensuring compliance with regulatory requirements, and promoting the development of a competitive and sustainable energy market in Spain [40].

The Spanish government agency in charge of regulating the nation's energy policies and encouraging sustainable development is known as the Ministry for the Ecological Transition and the Demographic Challenge (MITECO) and it is another one of the principal regulatory bodies in the energy sector in Spain [41]. The creation and execution of energy policies that support the transition to a low-carbon economy, the promotion of renewable energy, and the reduction of greenhouse gas emissions are among the responsibilities of MITECO in the energy sector [41]. The MITECO works closely with other EU member states to promote the development of a common energy policy and to ensure that Spain's energy policies are aligned with the EU's objectives [42]. The Electricity Sector Law 24/2013 is what regulates the main aspects of this sector in Spain [43].

Spain had one of the world's strictest regulations on self-consumption, as per RD 900/2015. This regulation made renewable energy installations, especially photovoltaic, economically unviable for residential prosumers by not providing any compensation for surplus electricity exported to the grid [35]. This changed in 2018 with the passing of a new law, the Royal Decree-Law 15/2018.

The RD-L 15/2018 was further developed in April 2019 in the RD 244/2019 where the details about the economic, technical and administrative conditions of the Photovoltaic Specialists Conference (PVSC) are specified [35]. It establishes that self-consumed energy from renewable sources, cogeneration or waste will be exempt from all types of charges and tolls [44]. Furthermore, the regulation stipulates that the excess electricity that is sent back to the grid must be handled under the same conditions as any other power generation installation [35]. Spain has established a legal framework that enables energy communities to generate and consume their own electricity, participate in the electricity market, and receive compensation for any excess electricity generated.

3.1.6 ENVIRONMENTAL

The environmental factors in Spain can benefit the development of energy communities. The diverse climate of the country is an advantage, as the country can exploit both wind and solar power generating energy by renewable sources. Spain is recognized to have a vast potential of solar resources, due to its large land area and high levels of solar radiation compared to other European countries [25]. As for wind energy, it has become the primary source of electricity generation in Spain for 2021, with a total of 28 139 MW accumulated power, covering more than 23% of the country's energy demand, establishing wind energy as the most significant electricity generation technology in Spain. Spain is now the fifth-largest country in the world for wind power with its installed capacity [45].

Energy communities can contribute to achieving the goal of reducing carbon emissions, especially as the demand for electricity continues to rise, particularly in the buildings sector. Over the last decade, Spain has made significant progress in decarbonizing its electricity generation, with the share of electricity generated from fossil fuels decreasing from 56% in 2009 to 41% in 2019, while renewable energy sources' share increased from 24% in 2009 to

38% in 2019. Spain aims to achieve a 42% share of renewables in total energy end use by 2030, dominated by wind and solar power, accounting for 74% of total electricity generation in that year. This move will set Spain on a path towards meeting its 2050 target of sourcing 100% of its power from renewable sources, in line with its goal of achieving carbon neutrality by 2050 [46].

The renewable energy consumption in 2021 in Spain was a 17.3% of the total consumption [47]. The most consumed source in Spain that year was petroleum with a 42.4% and the second was natural gas accounting for 24.8% of the total [47].

3.2 UNITED KINGDOM

The United Kingdom's energy sector is analyzed in this subsection following the steps of the PESTLE analysis.

3.2.1 POLITICAL

The United Kingdom (UK) is party to the Paris Agreement, which means that the government has set a goal to achieve net-zero carbon emissions by 2050 [48]. The "Net Zero Strategy: Build Back Greener" is a proposal from the country that has the objective to establish measures and recommendations to decrease carbon emissions in all sectors of the UK economy [48]. The plan for a green industrial revolution establishes the groundwork for a green economic recuperation from the effects of COVID-19. The approach will help maintain the progress towards UK carbon budgets, the 2030 Nationally Determined Contribution for the Paris Agreement, and its net zero objective by 2050 [48]. This goal is a key driver for the adoption of renewable energy and sustainable practices in the energy sector.

In June 2019, the commitment to reduce emissions to 'net-zero' by 2050, became the first major step to combat climate change. The Committee on Climate Change (CCC), an independent statutory body that provides advice to the UK government on climate change, published a report in May 2019 “Net Zero: The UK’s contribution to stopping global warming”, which outlined a pathway to achieve net-zero emissions in the UK [49]. The Net Zero Target (2050) Order 2019 was introduced following the advice from the CCC. The goal has been enshrined in law, which means that businesses in the energy sector will have to adapt and transition towards renewable energy sources in order to meet the target [49]. Therefore, plans for deploying emissions need to be initiated in the short-term to align with the timeframe proposed by the CCC [49] [50]. The order also requires the UK government to publish a series of carbon budgets, which establish the level of greenhouse gas emissions that the UK can produce over five-year periods [51]. These carbon budgets are legally binding and must be approved by Parliament [51].

Furthermore, the UK’s government established in 2017 the “Clean Growth Strategy” initiative. To achieve clean growth, the UK's industrial strategy focuses on increasing national income while reducing greenhouse gas emissions [52]. The goal is to achieve this while maintaining an affordable energy supply for businesses and consumers. This approach will lead to increased productivity, the creation of jobs, higher earning power for people across the country, and it will help protect the environment [52]. The strategy focuses on key areas that require significant progress in order to meet the targets, including clean growth, business and industry efficiency, innovation, and delivering clean and flexible power [52]. The government published a set of proposals, which include it’s plans to establish green finance capabilities, develop measures to support businesses to improve their energy productivity, and invest in research and innovation in energy efficiency [52]. The strategy also aims to improve the energy efficiency of homes and the route to market for renewable technologies like offshore wind [52].

The CCC published a report on the “Clean Growth Strategy” in 2018, which provides an independent assessment of the strategy's strengths and weaknesses [53]. The report also includes recommendations for improving the strategy. The strategy needs to be strengthened to ensure the carbon budgets are met, and the government needs to provide clarity on how it plans to deliver on the strategy's ambitions and intentions [53].

On December 2020 the UK formally completed its separation from the EU, making the Brexit official [54]. This implied a few changes on the energy sector. However, as the UK has had a significant influence on the EU’s energy policy with the liberalized "British" model being a source of inspiration for the liberalization of EU energy policy, the changes have not been many [54]. Nonetheless, the EU has also influenced UK sustainable energy policy, with the UK adopting more hierarchical, rules-based approaches to climate policy oversight and implementation [54]. Despite speculation that Brexit could lead to a more voluntarist approach, there has been little official change in policy ideas, with the UK's Net Zero Strategy reaffirming a market-oriented policy position [54]. Brexit had significant implications on the UK's membership in the EU Emission Trading Scheme (ETS) and the Internal Energy Market (IEM), both of which were important for the country's energy decarbonization efforts [54]. The individuals involved in the Department for Business Energy and Industrial Strategy (BEIS) Brexit consultations argued for the UK to remain part of the EU ETS or at least linked to it [54]. However, the country chose a standalone UK ETS, that is not linked to the EU scheme, which affects its liquidity and volatility [54]. It is considered crucial to restore effective interconnection rules, specifically by returning to an implicit trading arrangement, to facilitate the advancement of joint EU-UK offshore wind projects in the North Sea, which are a key component of their plans for achieving electricity decarbonization targets. However, efforts to improve trading rules are being hampered by broader UK-EU relations [54].

Another approach taken by the UK's government to incentivize the generation of renewable energy was the Contracts of Difference (CfD). The UK's CfD's are a policy tool aimed at encouraging investment in low-carbon technologies, introduced as part of the 2013 Electricity Market Reform. The CfD is a contract between low-carbon generators and the government-established Low Carbon Contract Company (LCCC). The contract provides a fixed price for electricity generated over a 15-year period by paying generators the difference between the CfD's fixed price and a market reference price. If the market price is higher than the CfD price, the generator pays the difference to the LCCC [55]. The CfD auction scheme in the UK is aimed at supporting renewable energy, with a particular focus on offshore wind as a less-established technology [56]. It is important to highlight that in the auction in 2017, unexpectedly low bid prices for offshore wind were observed, which raised questions about whether the planned capacity would actually be built and whether the UK would be able to meet its renewable energy targets [56]. One possible explanation for the low prices is the setup of the CfD auctions that gives participants more freedom and flexibility, which may lead to it being perceived as a real option rather than a commitment to construct a power plant due to the non-stringent penalty for failure to deliver the project and the long lead time [56].

3.2.2 ECONOMICAL

The oil and gas industries have traditionally been a major source of revenue for the UK economy [57]. According to Oil and Gas UK's analysis, the oil and gas sector has experienced a challenging downturn, resulting in a decrease of almost one-third in supply chain revenues and the loss of approximately 204 000 jobs in the UK between 2014-2017

[57]. Nevertheless, the industry remains vital to the UK economy, with around £11.3 billion spent on operating and capital expenditures in 2018 alone. In 2018, the sector contributed over 1.2% of UK GDP, with over 2 000 oil and gas companies continuing to be a major employer sector [57].

However, fluctuations in global oil and gas prices can have a significant impact on the energy sector, as the UK still relies heavily on fossil fuel imports [58]. Fuel imports from non-EU countries have significantly increased since mid-2021, reaching £64.7 billion in the months to April 2022, representing a 193% increase. This is mainly due to the increase in gas imports, which became the largest component of non-EU fuel imports in October 2021 [58]. In the same way, exports of fuels to EU countries have also increased, exceeding £3 billion in a month for the first time in March 2022, mainly driven by increases in oil and gas exports [58]. Since the latter half of 2021, the global gas demand has increased, resulting in consistently high trade in gas. This increase in demand is due to the conclusion of many strict COVID-19 restrictions, a shift towards cleaner energy sources in Asia, supply constraints, and lower than usual gas storage levels in Europe, which have all pushed gas prices up [58]. About 50% of the UK's gas is imported from the international market, and most homes in England and Wales are heated mainly by gas supply. Additionally, gas fuels around a third of the UK's electricity generation, leading to rising electricity prices when gas prices increase [58].

The volatility in the energy market produced by the fluctuations of oil and gas prices together with the decreasing cost of renewable energy technologies is making the latter energy sources increasingly competitive with traditional fuels [23]. The significant decrease in costs over the past decade is a key driver behind the swift shift towards renewables in the worldwide electricity mix [23]. The expense of producing electricity through onshore wind and solar PV is now often lower than that of building new fossil fuel power plants or running some existing ones. In many nations, renewables are the most economical option for satisfying the increasing need for electricity [59]. Small-scale battery storage systems combined with rooftop solar PV in residential and commercial buildings have too emerged as a thriving market. Small-scale residential battery storage system prices in the UK are slightly lower than those observed in Germany, according to IRENA [23].

3.2.3 SOCIOCULTURAL

According to the IEA, in the UK there is a total of 67.8 million people as of the year 2022 [60]. The future projections expect the population to grow a 3.02% every 10 years, meaning that by mid 2030s the population will reach a total of 69.2 million approximately [61].

According to the Office for National Statistics' Opinions and Lifestyle Survey, 75% of adults in Great Britain expressed worry about the impact of climate change just before the COP26 UN Climate conference in Glasgow in October 2021 [62]. Women were more likely to worry about climate change and the environment's future than men [63]. The survey stated that those who were worried about climate change were more likely to have made lifestyle changes in response to the issue [62]. The survey also found that people commonly expressed concern for future generations and helplessness about the environment's future, and the expense of eco-friendly changes [62]. One quarter of adults in Great Britain reported feeling relatively unworried or ambivalent about the impact of climate change. The most common reasons for this lack of awareness were not knowing much about the issue or thinking there are other more urgent priorities [62]. The most frequent reasons for not making lifestyle changes was the believe that large polluters should change before individuals and the opinion that a particular's actions would not make a difference [62]. However, research in the UK shows that the messages used to raise concern about climate change and the importance of the implementation of renewable energy have had a result of desire to take action and a need to adapt [64].

The Department of Energy and Climate Change completed a study of the Community Energy in the UK. The main aim of the review was to investigate whether community-led energy projects offer more benefits than projects led by a third-party [65]. The evidence suggest that the benefits provided by community energy projects include: raising awareness about energy issues, providing a sense of ownership and responsibility for the project, developing locally relevant energy projects, being more self-sustaining and producing local economic benefits such as job creation, skills development, reduced energy costs and financial gains from electricity generation [65]. The BG Green Street (BGGS) study demonstrated that community energy projects can lead to significant carbon savings through the installation of energy-efficient measures in homes and community buildings [65]. The community survey showed a significant increase in awareness of the project and a high proportion of respondents claimed to have been inspired to take action on energy efficiency and renewable energy as a result of the project [65]. However, it is important to note that the BGGS project was a unique and well-funded initiative [65]. In this review it is interesting to highlight that among the key factors that contribute to the initiation of community energy projects the most commonly reported was commitment of community group leaders and volunteers, who played a crucial role in delivering projects [65]. These leaders, who often had some energy-related expertise, were essential in raising awareness of the projects within the community and encouraging volunteer work [65]

3.2.4 TECHNOLOGICAL

In the United Kingdom Electricity consumption per capita dropped by more than 20%, from 5 800 kWh in 2000 to 4 300 kWh in 2020 [60]. However, energy usage increased by 5%

from 2020 to 2021. Previously, between 2003 and 2019, energy consumption decreased by almost 2% every year [60].

Regarding the sources of electricity in the UK and their consumption, in 2021, coal consumption increased by 4% due to a slight rebound in coal-fired generation [60]. However, between 2012 and 2020, coal consumption decreased by 21% per year as numerous coal-fired power plants were closed [60]. The power sector accounted for 39% of coal consumption in 2020, a significant decrease from 88% in 2012. The National Infrastructure Commission (NIC) updated its target for renewable energy deployment in 2020, setting a goal of 65% of the power mix by 2030, it was 42% in 2021 [60]. In 2022, the amount of renewable generated increased 10% from 2021 reaching 134.8 TWh, this being due to the less favorable weather conditions for wind and solar generation [63]. The consumption of renewables has increased significantly, primarily through wind power, with it accounting for only 7.66% of total energy consumption in 2010 [60]. As we can see in Figure 1, the main source in the United Kingdom’s power mix is oil, highlighting the county’s reliability on fossil fuels [66].

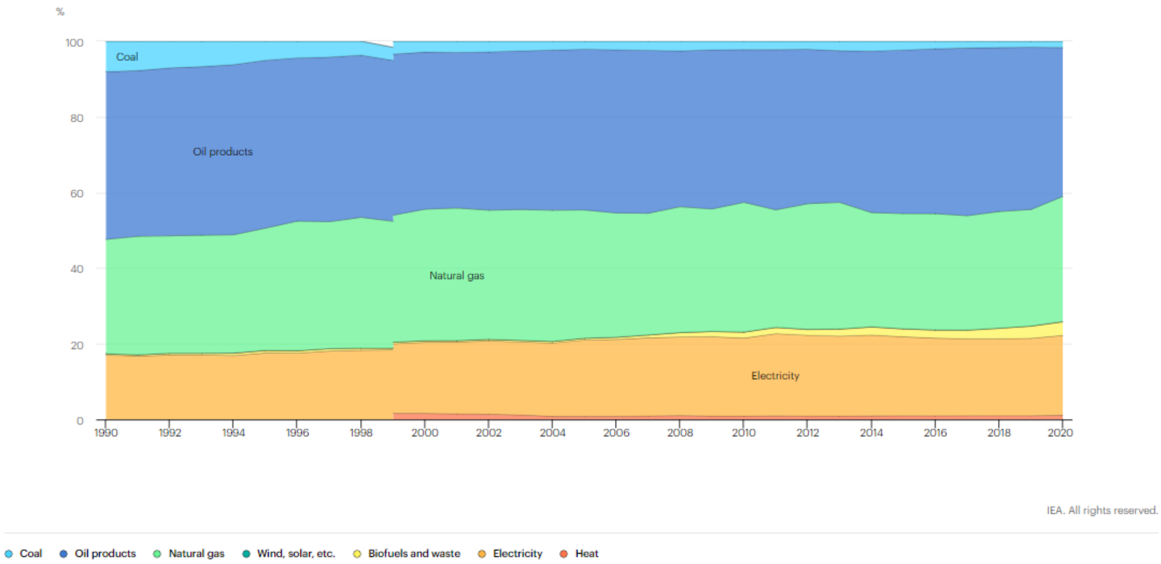

Figure 1: Total final consumption by source (%) from 1990-2020 [66].

With a particular emphasis on the sectors driving the changes in energy consumption between 2020 and 2021, a report developed by BEIS highlights the increased oil consumption in the transport sector, reflecting a relaxing of Covid-19 travel restrictions [67]. The increase in oil consumption in road transport is the largest contributor to changes in energy consumption, despite this, consumption remains lower than pre-pandemic levels, and the report acknowledges that Covid-19 restrictions have contributed to the decrease [67]. Energy consumption in the domestic sector increased by 5.8% during this period, final energy consumption reached 29.5% in the UK [67]. Nevertheless, transport remains the biggest sector of energy consumption in the UK [68].

Improving energy efficiency in energy-intensive sectors is crucial to achieving CO2 targets, as energy consumption is the primary source of CO2 [69]. Utilizing available technologies such as, Carbon Capture and Storage (CCS) and renewable energy technologies could contribute to reducing emissions by 19% and 17%, respectively [69]. These findings highlight the importance of adopting energy efficiency measures, which encompass the improved energy integration and management [69]. The technological advancements in the UK could have a significant impact on the development of community energy projects [67]. There is agreement that it is necessary to implement further public policies to decrease energy consumption in residential buildings in countries like the UK, enhancing energy efficiency in the building sector is considered one of the most cost-effective means to improve energy security and mitigate the environmental consequences [67].

Renewable energy technologies, including solar, wind, and hydroelectric power, have made significant advancements in recent years, leading to increased efficiency and affordability [23]. Specifically, Wind power is a significant contributor to the renewable energy mix in the United Kingdom. As of 2021, the UK has installed capacity of over 24 GW of onshore and offshore wind power, making it one of the largest wind energy markets in the world. The growth of wind power in the UK is driven by a combination of government support, technological advancements, and the reduction of its costs [70]. The UK experienced a significant increase in wind-generated electricity in 2019, with 64 TWh generated, making it the second largest source of electricity. This represents almost 20% of the total electricity generated in the country [70]. The increase was attributed to a record high in both onshore and offshore wind generation. The UK has been a pioneer in the development of offshore wind technology, which has allowed the country to harness the strong winds in the North Sea [71]. The country's largest offshore wind farm, Hornsea One, completed off the coast of Yorkshire, has an installed capacity of 1.2 GW, making it the largest in the world [71]. Overall, the UK has made significant progress in the development of wind power technology, which has allowed the country to increase its renewable energy capacity and reduce its carbon emissions. The continued growth of wind power in the UK is likely to be driven by further technological advancements, falling costs, and government support [70].

In addition to advancements in renewable energy technologies, the use of smart meters and grid technologies has enabled communities to monitor and manage their energy consumption more effectively [72]. Smart meters are advanced energy meters that can measure energy consumption in real-time and provide feedback to users on their energy use, allowing them to make informed decisions about how to reduce their energy consumption [72]. The adoption of smart energy technology has the potential to bring significant environmental benefits by improving energy production efficiency and flexibility, which in turn can reduce overall energy production and greenhouse gas emissions, as well as minimize the risk of blackouts and facilitate the integration of renewable energy sources into the energy system [72]. With the help of smart meters, consumers will have more options for energy plans and technology, allowing for better integration of electric vehicles and solar PV systems [72]. Furthermore, grid technologies such as demand response and energy storage can help communities manage their energy consumption more efficiently, reducing peak demand and allowing for more effective use of renewable energy sources [72].

Community groups engaged in energy projects have also shown interest in energy demand management [73]. As the grid becomes more advanced, consumers receive more information about their energy use and are encouraged to shift their energy consumption to help balance supply and reduce the requirement for expensive generation capacity to meet peak demand [73]. This also facilitates the adoption of renewable electricity generation, electric vehicles, and the electrification of heating systems such as heat pumps [73].

3.2.5 LEGAL

In the United Kingdom the energy sector is regulated by Ofgem. In 2017 Ofgem analyzed the different drivers of change in the energy system, being the rise of local or community-based energy solutions one [74]. It was recognized that the degree to which these local solutions gain popularity would be a significant factor in determining the level of decentralization in the energy sector. Additionally, the preferences of consumers will play a vital role in dictating the direction and speed of progress towards reducing carbon emissions [74].

The Energy Act of 2008 creates a legal framework designed to support the UK's transition to a low-carbon economy and to encourage the development and deployment of renewable energy and energy efficiency technologies [75].

Regarding the legal aspect of community energy, in the UK, there is no specific legislation that regulates community energy projects [76]. However, several policies and programs have been introduced to support and encourage their development, explained in the political section [76]. Research indicates that there are several obstacles for Community Energy (CE) in the UK, mainly rooted in political or institutional matters [76]. The complexity and inconsistency of the policy framework for CE creates a lack of planning security for initiatives. In addition, there is a gap between the needs of CE and energy policy in the UK [76].

3.2.6 ENVIRONMENTAL

Renewable energy sources have been recognized as an effective solution to combat climate change and reduce greenhouse gas emissions [77]. Compared to traditional energy sources like fossil fuels, renewable energy technologies have lower environmental impacts as they produce little or no greenhouse gas emissions during their operation [78]. Studies have shown that increasing the share of renewable energy in the energy mix can have significant environmental benefits [78]. In the year 2019, a total of 12.2% of the energy consumed in the country was renewable [79]. The source of energy most consumed was natural gas accounting for a 38.6% and oil was the second with a 34.8% of total final energy consumption [30].

The environmental factors in the United Kingdom can catalyze the development of CE projects through the exploitation of renewable resources such as wind, tidal and solar power [80]. The UK's offshore wind industry is thriving with significant investment and innovation driven by ambitious targets and the deployment of new technologies. The country is currently one of the largest markets for offshore wind globally [80]. The UK's offshore wind sector benefits from the country's extensive coastline and shallow seas, allowing for easier construction and maintenance of wind turbines. This has resulted in the UK generating more offshore wind power than any other country [81]. The Ten Point Plan for a Green Industrial Revolution, released in late 2020, highlights the government's commitment to supporting renewable energy sectors [81]. This plan includes a goal to quadruple offshore wind production to 40GW by 2030, which would be sufficient to power every UK home with offshore wind in 2030 [81]. The offshore wind sector in the UK has rapidly matured in recent years, with proven technology and a reliable supply, contributing about 13% to the UK's electricity mix [81]. The UK has the greatest wind energy potential in Europe, with offshore wind energy having the biggest potential due to higher wind speeds at sea. The sector is important for clean growth, tax revenue, and job creation in coastal communities [82].

3.3 CALIFORNIA

In the following subsection the energy sector of California, state of the West coast of the United States, will be presented dividing the relevant information by the PESTLE strategy.

3.3.1 POLITICAL

California as one of the states of the United States of America (U.S.A.) is affected by federal and state energy policies and regulations. In the U.S.A. in 2005 the Energy Policy Act (EPAct 2005) was passed, this mandates the creation of grant programs, demonstration and testing initiatives, and tax incentives to encourage the use of alternative fuels [83].

In 2016 the Paris Agreement came into effect with the United States (U.S.) being one of the signatories. The primary requirement of the agreement was reducing greenhouse gas emissions and the US accounted for 13% of the total emissions across the world [84]. The USA has established and upheld a powerful and well-organized structure for promoting low-carbon technology since the 1970s. By coordinating efforts across federal government agencies, significant scientific innovations have been achieved [84]. During negotiations on the Paris Agreement, the U.S.A. played an important role, driven by President Obama's desire for international climate leadership. However, President Trump's decision to withdraw from the agreement and his broader efforts to undo domestic climate policies had a negative impact on the effectiveness of the Paris Agreement [84]. In 2017, the Trump administration announced that the United States would withdraw from the Paris Agreement, citing concerns about the economic impact on the country. Trump's decision was primarily influenced by U.S. domestic politics rather than any obligations imposed by the agreement [85]. The termination process began in November 2019, and the United States officially withdrew from the agreement on November, 2020 [85]. In January 2021, the Biden administration announced that the United States would rejoin the Paris Agreement. President Biden signed an executive order on his first day in office, which initiated the process. The United States officially rejoined the agreement on February 2021 [84]. With a focus on raising domestic objectives and promoting more aggressive global climate action, President Biden wants to increase the U.S.'s participation in international climate cooperation [84]. However, the US's image as a stable long-term partner in the Paris Agreement has been damaged by its fluctuating positions as a result of the changes in political majorities [84]. The Biden administration wants to address this by enacting extremely ambitious domestic climate-policy measures, such as decarbonizing the energy sector by 2035 and reaching a net-zero-emissions economy by 2050 [84].

Particularly, the state of California is a notable subnational leader in terms of environmental and climate change legislation. The U.S. Constitution gives states a great deal of authority to create laws that advance the general good [86]. California may pursue ambitious environmental and energy policies thanks to the legal and political framework provided by the federal government of the United States. California has taken advantage of this opportunity by enacting several laws in this area, many of which are more ambitious than those in other states [86]. The state government of California has implemented several policies and initiatives to support the energy transition towards a cleaner and more sustainable energy system [86]. California took the initiative to regulate greenhouse gas (GHG) emissions through the California Global Solutions Act of 2006 (AB32) and a series of subsequent legislation [86]. AB32 was the first state-level mandate in the US for economy-wide reductions of GHG emissions and the transition to renewable energy. The six economic sectors of California's economy, industrial, electrical, agricultural, residential, commercial, and transportation, were all targeted by AB32 for GHG emission reductions [86]. This argued that reducing GHGs would encourage investment in low-emitting and renewable technologies, create employment opportunities, and develop innovative technologies. AB32 aimed to reduce GHG emissions to 1990 levels by 2020, a target that has been achieved, and subsequent legislation has set more ambitious goals [86].

In 2002 California became the first state in the USA to establish a Renewable Portfolio Standard (RPS), which requires utilities to procure a certain percentage of their electricity from renewable sources with the aim of achieving a 20% increase of renewable energy in the state's electricity mix by 2017 [87]. The program was accelerated in 2006 through Senate Bill 107. California's Renewables Portfolio Standard (RPS) is considered one of the most ambitious renewable energy standards in the United States [87]. In 2016, the objectives of AB32 were reinforced by Senate Bill 32 (SB32), which established a target for lowering GHG emissions to 40% below 1990 levels by 2030 [86]. Additionally, SB350 increased California's renewable portfolio standard to 50% by 2030, and SB100 increased it to 100% renewable electricity generation by 2045 [86] [88]. It has been estimated that the RPS program has reduced annual emissions as well as costs in energy procurement costs [89].

Another policy implemented by the state’s government is the Net Energy Metering (NEM) program. In 1995, Senate Bill (SB) 656 was imposed to develop standard contracts providing for NEM, which compensates customers for electricity generated by eligible renewable resources and fed back to the utility [90]. California's NEM policies have since gone through several changes, expanding the list of eligible technologies and increasing NEM caps for certain utilities [90]. NEM 2.0, which went into effect in 2016, provides customer-generators full retail rate credits for energy exported to the grid [90].

3.3.2 ECONOMICAL

The economic impact of the energy sector in the U.S.A. and California is substantial. The sector includes a wide range of industries, from oil and gas extraction to renewable energy development, and is a significant contributor to employment and economic growth [91]. In 2021, the U.S.’s energy sector employment grew 4% over 2020, outpacing overall U.S. employment [91]. The 2022 U.S. Energy and Employment Report (USEER) covers five major energy industries and shows that all industries, except fuels, experienced a positive job growth in 2021 [92]. In order to achieve net zero GHG emissions by 2050, employment in this area has grown, jobs related to achieving net-zero emissions include those in renewable energy, energy storage, energy efficiency, and clean transportation and those were the ones that most increased from 2020 to 2021 in the energy sector [92]. Specifically, the state of California was in the top three states of job growth in the clean energy sector [91].

To reach a future with minimal carbon emissions, California has committed to advance in clean energy solutions. The state's clean energy industry is defined as establishments involved with producing, manufacturing, distributing or implementing goods, or services related to renewable energy, energy efficiency or conservation, smart grid, energy storage, carbon management, and electric or hybrid vehicles [93]. In 2019, California's clean energy industry employed 406 751 workers. Solar generation had the most workers at 124 800 [93].

The employment of PV installers and wind technologies is projected to grow rapidly over the next decade, with PV installer employment expected to increase by 50.5% and wind technology employment expected to grow by 60.7% [94]. This is due to the declining costs of renewable energy technologies, making them more accessible to consumers [94]. For instance, the price of solar energy has decreased dramatically, leading to an increase in solar installations and an increase in the proportion of electricity generated by end users, as shown in Figure 2 [94]. Wind and solar power are more cost-effective than coal and nuclear power as the levelized cost of energy for renewables is currently lower than the marginal cost of traditional power production sources and is expected to continue to decline [95]. Solar and wind are commonly available resources in California, and they have become more competitive with fossil-fuel electricity due to the reduction of their costs [96].

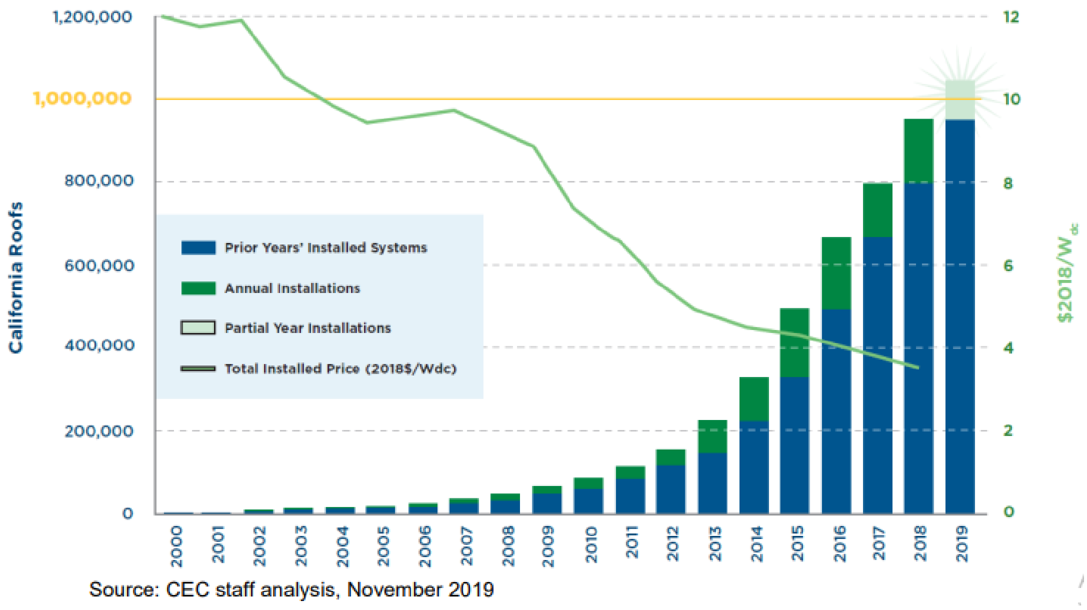

Figure 2: Decrease in price of solar energy and the increase in solar installation [94].

3.3.3 SOCIOCULTURAL

In accordance with the 2020 US Government Census Bureau, the population of the United States that year was 331.4 million [97], of whom 39 million lived in California in 2022 [98]. California's population increased a 6.1% since 2010 but slower than its 10% gain in the previous decade [99].

According to a survey conducted by the Berkeley Institute of Governmental Studies in August 2015, Californians supported stronger efforts to fight climate change by requiring more electricity to come from renewable resources and cutting gasoline use in half [100].

The report on the Climate Change in the American Mind: *Politics & Policy*, December 2022, published by the Yale Program on Climate Change Communication, shows that 52% of registered voters believe global warming should be a high or very high priority for the president and Congress [101]. Moreover, 65% of registered voters say developing sources of clean energy should be a high or very high priority for the president and Congress [5] [101].

In accordance with the Environmental Letter, change in US state-level public opinion about climate change from 2008 to 2020, exposure to wildfires and flooding have driven increased support for climate mitigation policies in states like California [102]. Moreover, those states with recent and substantial climate and energy policy efforts, such as California, have seen public support grow [102]. A similar result was reached by the survey on environmental issues conducted by the Public Policy Institute of California in July 2022, public awareness of the effects of climate change and state efforts to reduce greenhouse gas emissions has increased because of the severe drought and wildfire season California had experienced [103]. Discussions regarding increasing oil output and using renewable energy sources have arisen as a result of the rapid increase in the price of petroleum [103]. The survey specifically asked if, in order to help reduce climate change, the respondent would be willing to pay more for electricity if it were generated by renewable sources like solar or wind energy and 44% of the participants would be willing to do so, while 55% would not be willing [103].

Within this social climate, energy communities are well seen in California. Specially with the 100RE project which promotes renewable energy by enhancing cities to commit to the target of 100% generation of renewable energy [104]. In California those communities with less resources still consider joining larger community choice aggregators and switching to renewable energy as it will result in a decrease of energy prices, and it is a potential source of savings [104].

3.3.4 TECHNOLOGICAL

Technological advancements in the energy sector have made possible the installation of more ways to obtain energy from renewable sources. According to a report from the California Energy Commission (CEC) from 2011 to 2021 the electric generation capacity by solar photovoltaics has increased from 226 MW to 13800 MW [105]. Similarly, the generation and generation capacity from all the renewable sources has increased in the last decade, in contrast with the energy obtained from traditional sources which has decreased [105]. In 2021 California's renewable generation was a total of 67.4 TWh, being this 33.6% of the total energy mix in the state [106].

California accounts for two-thirds of the U.S. West coast, due to the vast distances transportation consumes the most energy in the state [107]. In California, the transportation industry uses approximately a third of the state's total energy consumed, whereas of the state's overall energy consumption, the industrial sector consumes one-fourth, the residential sector around one-fifth, and the commercial sector one-fifth [107]. Nevertheless, per capita energy consumption in both the residential and commercial sectors is lower than that of all other states except Hawaii [107]. Some California petroleum refineries have recently added capacity to produce renewable diesel from biomass [107]. In 2021, almost all of the renewable diesel consumed in the United States was used in California [107].

Renewable energy sources are prominent in California as it stands second in the United States, only after Texas, in generating electricity from different renewable sources. California is the largest producer of electricity from solar and geothermal resources in the country [107]. Solar power is the primary source of renewable electricity in California, with the majority of its resources located in the south-eastern deserts. In 2022, this energy accounted for 19% of the state's utility-scale electricity net generation [107]. California is the top producer of utility and small-scale solar PV electricity generation in the country, accounting for 31% of the nation's total [107]. As of the beginning of 2023, California had the largest utility-scale solar power capacity in the country, with over 17 500 MW, and almost 32 000 MW of total solar capacity when small-scale facilities are included [107].

Incorporating renewable energy technologies into the U.S. energy mix can lead to an improvement in environmental quality, decreasing its degradation [108]. The need to decarbonize the world's energy industry has become more pressing as a result of the adverse effects of global warming. Utilizing renewable energy sources is the most effective and affordable way to do this [109]. Innovation in energy sources is essential for the decarbonization process to be successful. Therefore, in order to cut carbon emissions and reach net zero carbon targets, nations all over the world are concentrating on energy innovation [109]. The development of smart energy grids for present and future demands is being supported by investors and manufacturers. These grids can improve the efficiency and reliability of energy distribution systems for energy communities [109].

The variable nature of renewable energy sources such as wind and solar means that they can produce excess energy at times, leading to system overload, or produce less energy than needed [110]. To address this issue, energy storage systems are considered the most effective solution. These can improve the reliability of renewable energy sources for energy communities [110].

Enhancing market access and norms requires the use of innovative technology. By rapidly developing smart micro-grids that use renewable energy sources like solar or wind, technological breakthroughs in the field of renewable energies can open up the possibility of electricity supply for undeserved communities and regions [110]. An increase in renewable energy innovation is anticipated to boost renewable energy production, as stated in the COP26 agreement [110]. Consequently, for energy communities, this can improve the effectiveness and dependability of energy distribution systems. [110].

3.3.5 LEGAL

California is a state with a thriving energy sector, which has become increasingly important in recent years due to concerns over climate change and the transition to a cleaner, more sustainable energy system [109]. In order to regulate and promote the energy sector, a number of legal organisms have been established. One of the most significant legal institutions in the state, the California Energy Commission (CEC), is in charge of setting the state's energy policy and planning [111]. Therefore, the CEC is essential to the state's efforts to make the transition to a cleaner energy future by promoting the use of renewable energy and energy efficiency [111].

The California Independent System Operator (CAISO), an independent, non-profit company that controls the flow of electricity through the high-voltage, long-distance power lines that make up 80% of California's grid, is another legal entity essential to the energy sector [112]. The CAISO is responsible for ensuring the reliability and stability of the grid, which is critical for the smooth operation of the energy sector in the state [112]. The scope of the CAISO model update cycle is expanding, mainly because of the fast pace of interconnection of renewable energy resources to the power grid [113]. This organization is in charge of ensuring that the network model accurately depicts these new interconnections in order to maintain the reliability of the system [113]. As previously mentioned the EPAct regulates the energy sector in the US and therefore in California [83].

The law that capsules the community renewable energy programs is the AB-2316, approved by California’s governor in September 2022 [114]. This law grants the California Public Utilities Commission (CPUC) regulatory jurisdiction over public utilities, including electrical companies [114]. The Californian government is attempting, through this legislation, to show all of its citizens the benefits that come from community energy programs when distributing renewable energy production at reasonable costs [114]. The Legislature also intends to promote low-income consumers' participation in any community renewable energy initiative that electrical companies may develop [114].

3.3.6 ENVIRONMENTAL

Climate change and the need to reduce greenhouse gas emissions are significant environmental concerns that affect the energy sector in the U.S.A. and California. Energy communities can contribute to reducing greenhouse gas emissions and address climate change [115]. Energy consumption in the United States comes from different sources, being the most consumed petroleum, in October 2022 the country's consumption of petroleum was a total of 897 090 GWh [115]. Consumption of renewable energy has remained steady from 2020 to 2022, being the third most consumed source of energy in October 2022, a total of 295 710 GWh, which is 12.9% of the energy consumed in the United States as Figure 3 shows [116]. From the renewable sources, solar and wind started to grow in relevance in 2010, and in 2021 energy generated by wind resource was the most consumed. Total energy consumed in the US has increased in the last years [115]. Specifically in California, 17.6% of the total energy consumed in the state was renewable energy in 2021 [107]. The most consumed source in the state is natural gas, a 28.7% of the total, and the second most consumed is petroleum which accounts for a total of 19.72% [117].

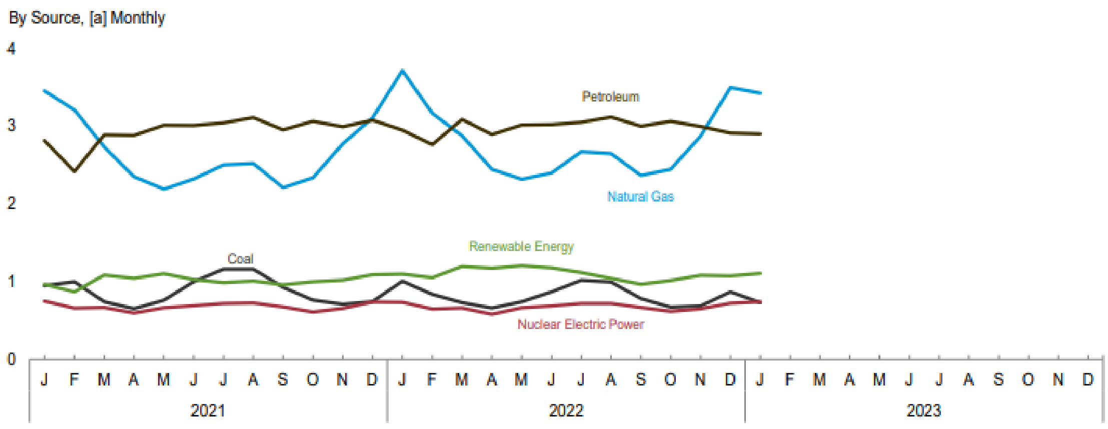

Figure 3: Primary energy consumption in the United States [116].

Specifically, California, as for data collected in 2020 the state was ranked second in total energy consumption among all states, but it had a lower per capita energy consumption than almost all other states that year [118]. In the same year, natural gas was the source most consumed in California [118]. Almost half of California's in-state electricity generation in 2022 came from renewable resources such as hydroelectric power and small-scale, customer-sited solar power, while natural gas accounted for 42% [107]. Nearly all of the remaining electricity generation was supplied by nuclear power. It is safe to say that renewables in the state of California have an increasing relevance for the supply of energy [107].

The geographical and environmental characteristics of California have played a role in accelerating the development of renewable energy sources in the state [119]. The abundance of natural resources, including wind, sun, and geothermal heat, has made it possible for the growth of renewable energy [119]. California is ideally situated for the production of solar energy because it is in an area with abundant sun irradiation [119]. In fact, California has the highest solar electricity production capacity in the country [106].

The state's extensive coastline, which offers substantial potential for offshore wind generation, is another crucial geographic element [107]. Offshore wind turbines can be installed in locations with consistently strong wind speeds, resulting in more reliable electricity production [120]. A report on the possibilities for offshore wind energy production was released by the CEC. This report discusses the opportunity for this source of energy to help California generate carbon-free energy and diversify its renewable energy portfolio, in line with the state's clean energy policy [120]. It states that California will need significant development of clean energy generation to achieve the goals set out in the 100 Percent Clean Energy Act of 2018 (SB 100) which raised the Renewables Portfolio Standard in California to guarantee that the state generates a minimum of 60 percent of its electricity from renewable resources by 2030, and offshore wind energy could play a significant role in meeting those goals [120]. Offshore winds off the California coast are strong, averaging up to 10 meters per second, there is a high potential for this source of energy and there are large resource areas that are suitable for development [120].

3.4 QUEENSLAND

Finally, Queensland, the Australian state situated in the Northeast will be described by the aspects that concern its energy sector in this subsection.

3.4.1 POLITICAL

Queensland is subject to the Australian Government regulations regarding the energy sector [121]. The government's policy is guided by many international climate change agreements. The most recent one is the Paris Agreement, which prompted Australia to adopt the objective of net zero emissions by 2050 and to commit, initially, to reduce greenhouse gas emissions by 26-28% below 2005 levels by 2030 [121]. However, compared to other nations, that was not a particularly ambitious goal. As a result, Australia modified its Nationally Determined Contribution commitment for the Paris Agreement in 2022, raising the 2030 goal. The country will undertake the task of reducing greenhouse gas emissions by 43% below 2005 levels, a 15% increase from its previous target [122].

To achieve the different objectives for renewable energy, the Clean Energy Regulator (CER) along with the government have implemented various policies [123]. The Renewable Energy Target (RET) which has two major parts, namely large-scale renewable energy target (LRET), which encourages investment in big renewable power stations and small-scale renewable energy scheme (SRES), that encourages the use of small-scale, such as household PV [122] [124]. The RET requires a proportion of electricity to be generated from renewable resources. This scheme had a target of 33 000 GWh produced from renewable resources by 2030 and was accomplished in January 2021 [123].

The country's government and the CER also implemented the Emissions Reduction Fund (ERF) in accordance with the goal of achieving net zero emissions [125]. A variety of economic sectors can benefit from the ERF's incentives for emission reduction actions, and it appears to have played a significant role in Australia's achievement of its 2020 goal [125].

Queensland in particular has a Labor Government which has also set ambitious goals regarding the reduction of greenhouse gas emissions, starting by the 30% emissions reduction below 2005 levels by 2030, as well as 50% of the energy mix being from renewable sources by that same year [126]. In order to lessen its dependency on fossil fuels and stimulate the growth of renewable energy, the state government has established a number of regulations and promoted initiatives [126]. The Advancing Clean Energy Schools (ACES) project is one of them. It aims to reduce energy expenditures in over 800 state schools by installing solar panels and other energy-saving techniques [127]. The program is anticipated to generate about 61.4 MW of solar energy to the Queensland Government's renewable energy target with a total investment of $168.1 million. This program will benefit the local economy by lowering emissions, preventing climate change, creating new jobs, and providing local businesses opportunities. [127].

3.4.2 ECONOMICAL

The energy sector is a significant contributor to the Australian economy, in particular, the coal industry has traditionally been one of the major sources of revenue of the country, as Australia is one of the largest exporters of this material [128]. Together with Russia and Indonesia, Australia is in the top three coal providers, as it is shown in Figure 4 [129], however, their exports decreased in 2020 [128]. Coal has such an importance that despite the increasing urgency to mitigate climate change, there was an approval in June 2019 of a mine project in Queensland, Adani's Carmichael coal mine [130]. This mine will increase Australia's per capita CO_2 emissions, and its approval lies on the traditional economic factors of the state of Queensland [130].

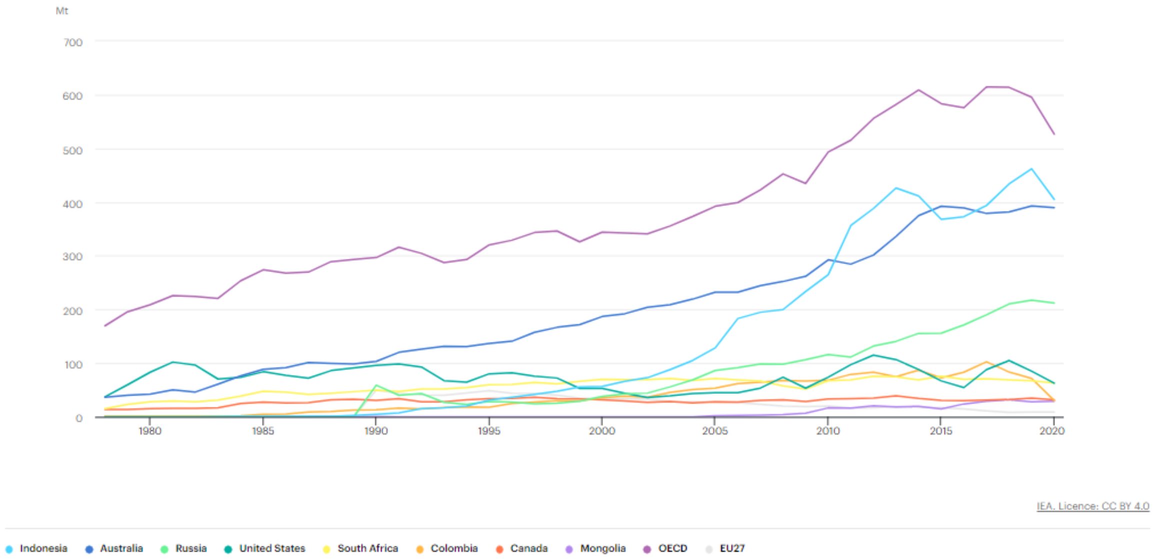

Figure 4: Major exporters of coal in the world, from 1980-2020 [129].

However, the global move toward renewable energy could have an influence on the demand for Australian coal exports, an industry that is vital to the nation's economy [131]. Two-thirds of Australia's fossil fuel exports are exported to nations like China, Japan, and South Korea, all of which have adopted commitments to achieve net zero carbon emissions by the middle of the century [131]. If these commitments are met, Australia's coal exports could decrease significantly by 2050. Nevertheless, it is anticipated that the impact on exports of liquefied natural gas will be less significant [131]. The overall impact on Australia's GDP is expected to be minimal and gradual as a result of the drop in fossil fuel exports, which may be partially offset by an increase in exports of renewable energy [131]. In some degree offset by opportunities in other sectors such as renewable energy, but the outlook is uncertain. A decrease in fossil fuel exports would have a severe impact on areas where mining employs a large share of the labor force [131].

According to Australian Bureau of Statistics (ABS) Census data, there has been a decline in employment in fossil fuel electricity generation in Australia between 2016 and 2021, while there has been an increase in employment in hydroelectricity and other forms of renewable energy [132]. Employment in renewable electricity generation now accounts for 34.3% of total employment in the electricity generation industry, compared to 19.2% in 2016 [132]. However, according to ABS Jobs in Australia data, in 2020 there was a 17% increase in jobs in coal mining compared to the previous year, in Queensland, jobs in coal mining increased by 10.5% [133]. The data gathered from the Queensland Government Department of Resources, Safety and Health indicates that there was a growth of 22.7%, since the last 5 years of the people working in operational coal mines in the state in June 2022 [133]. This means that even though employment in fossil fuel generation is slowly decreasing, the coal sector still hires employees, and it is still needed [133].

To create the energy infrastructure required for the transition to net-zero emissions, Australia needs significant investment. A qualified workforce must be available to develop and run the new technology as the energy industry shifts toward cleaner sources [134]. A pipeline of training and skill transfer is necessary for this [134]. The energy industry, which will generate jobs, economic growth, and energy security, must be identified by the government, and it must plan to assist it [134]. Roof-top solar PV system remains the highest employer among the renewable energy types, being the second largest contributor to employment solar PV large scale [133].

Another economic factor is the cost of renewable energy which is becoming increasingly competitive with traditional sources of energy. This has led to a higher investment in renewable energy projects in Australia, particularly in solar and wind energy [135]. This trend is expected to continue, as the cost of renewable energy technologies continues to decline and the demand for clean energy grows [23]. In summary, energy communities can provide economic benefits to local communities by offering a cheaper and cleaner alternative to traditional energy providers [135].

3.4.3 SOCIOCULTURAL

Australia's population was 26.1 million people on September 2022, with an annual growth of 418 500 people (1.6%). On the same date, Queensland had a population of 5.3million with an increase of 2,2% over previous year [136]. Australia's population is projected to reach between 37.4 and 49.2 million people by 2066 [137].

The majority of Australians favor action to prevent and adapt to climate change, even if they claim they don't believe it is occurring, according to the Commonwealth Scientific and Industrial Research Organization (CSIRO) climate attitudes poll of 2014 [138].

In September and October of 2021, the Griffith University Climate Action Beacon conducted a Climate Action Survey and found that while only a small portion of Australians may have been concerned about climate change last decade, in 2021 the majority of the participants in the survey, 72%, were concerned by the issue and demanded action [139]. Most respondents were in favor of different energy policies, such as, placing a price on carbon, promoting the use of electric vehicles, and supporting individuals whose livelihoods will be impacted by shifting away from fossil fuels [139].

3.4.4 TECHNOLOGICAL

Between 2010 and 2019, energy consumption in Australia increased by 9%. However, due to the Covid-19 pandemic, consumption decreased by 3% in 2020, primarily in the transport sector [140]. Industry is the largest energy consuming sector, followed closely by transport, and buildings. Coal consumption has decreased by 23% over the past decade, with coal-fired electricity generation being replaced by renewables and natural gas [140]. Oil is the main source of energy, covering 52% of total final consumption in 2021 as shown in Figure 5 [140].

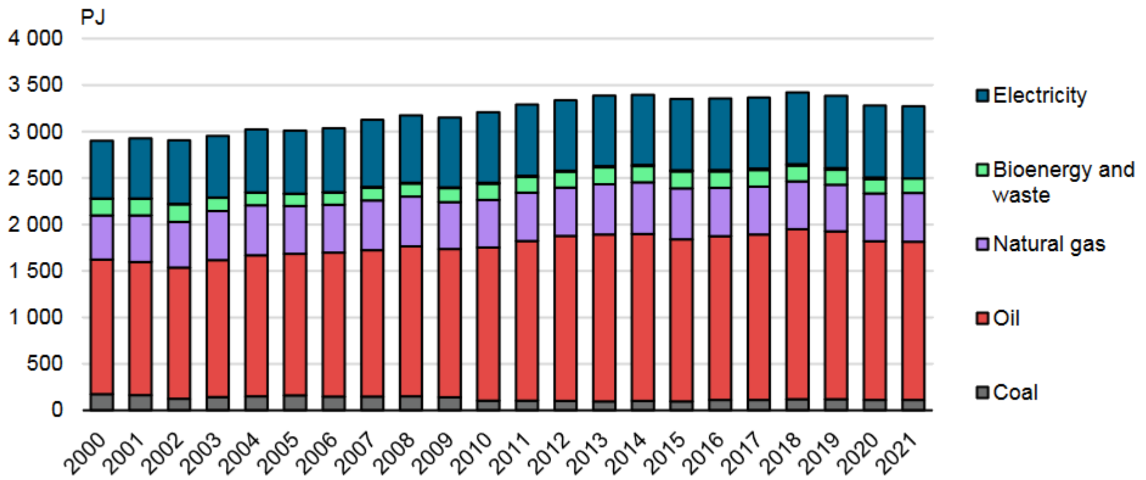

Figure 5: Total final consumption in Australia, from 2000-2021 [140].

The share of renewable energy in Australia's total final energy consumption has increased from 8% in 2000 to 11.5% in 2021 [140]. Since 2010, distributed solar PV and wind power have been the key growth drivers. The growing proportion of solar and wind energy in the nation's renewable energy supply, previously dominated by solid biomass, confirms the achievement of renewable energy targets [140]. With solar PV accounting for 27% of all renewable energy usage in 2021 and wind power for 19%, both sources have seen rapid expansion as displayed in Figure 6 [140]. The generation of renewable energy has also increased since the government established the target of renewable energy for 2030, Queensland produced 5 774 MWh of clean energy as of January 2022, which accounted for a total of 20.4% in the state's energy mix [141]. By sector, renewables covered 22.4% of energy consumption in buildings, 11.1% in industry, and less than 1% in transport in 2021

[140]. Investment in renewable energy has been growing due to declining technology costs [142]. Australia has the highest installed capacity per capita of solar PV in the world, and one in three households have rooftop solar. However, there has been no significant development of offshore wind, geothermal, biofuels, biogas, or biomass, and the renewable energy portfolio standard has low diversity of renewable investment [142].

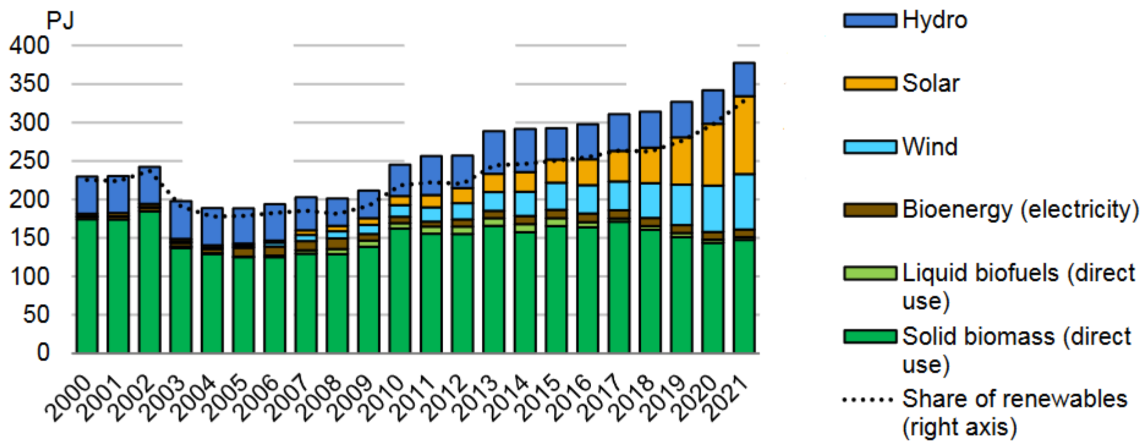

Figure 6: Renewable energy in total final energy consumption in Australia, from 2000-2021 [140].

The IEA analysis shows that Australia's energy consumption grew at a slower rate between 2000 and 2014 due to energy efficiency improvements, which were made possible by the country's investment in innovative technology and projects [140]. To support the development of renewable energy projects, including community energy projects, the Australian government established the Australian Renewable Energy Agency (ARENA) [140]. Despite being a significant exporter of coal, Australia has worked to advance important fields like hydrogen, which is crucial for the global energy transition and long-term energy security [140]. According to the Australian government, if the suggested changes are made, energy efficiency may increase by 53%. Meeting this target would enable Australia to reduce energy consumption while still experiencing GDP growth [140].

With the goal of combating climate change and establishing new renewable energy businesses, the Australian government is collaborating with other nations [140]. The country is concentrating on fostering technological collaboration, developing new clean energy trade opportunities, and expanding and diversifying clean energy supply chains [140]. Australia has established international clean energy partnerships with Germany, India, Japan, Korea, Singapore, the United Kingdom, and the United States. In addition, Australia is a leading technology partner in energy systems and renewables integration [140].

The Australian Government is investing in major energy infrastructure projects, including interconnectors, energy storage, as well as microgrids and clean energy generation at the local level [143]. However, timely permitting and environmental and social approvals are crucial for the country's energy transition. Energy efficiency in buildings and smart grids have not received enough funding [140]. Significant efforts are needed to adapt the power system to smaller-scale technologies and decentralized power generation, such as solar PV, as well as to strengthen the transmission and distribution grids against climate change and extreme weather events [140].

The Australian government is steadfast in its commitment to helping regional areas prosper economically and create jobs. The Regional and Remote Communities Reliability Fund will contribute up to $50.4 million toward this cause over the course of five years, from 2019 to 2023 [140]. In order to replace, improve, or reinforce off-grid communities' current electrical supply arrangements, the Fund aims to assist feasibility studies examining the implementation of microgrid technology in regional communities [140]. For remote and regional towns in Australia, microgrids may provide more reliable, secure, and affordable energy solutions [140].

3.4.5 LEGAL

Australia’s energy sector is highly regulated, with several legal organisms at both the national and state levels responsible for overseeing the industry. One of the most important legal organisms for the energy sector is the Australian Energy Regulator (AER) [144]. The AER is responsible for regulating the energy market in Australia. It works closely with other national entities such as the Australian Energy Market Commission (AEMC) and the Australian Energy Market Operator (AEMO) to ensure the effective regulation of the energy sector [144].

The regulations governing the national electricity and gas markets must be developed and recommended by the Australian Energy Market Commission (AEMC) [145]. The largest linked power system in the world, the National Electricity Market (NEM), that covers Australia's eastern and southern states, was established and is being implemented by the AEMC [145]. Ensuring adherence to regulations governing the National Electricity Market is the responsibility of the Australian Energy Regulator [145].

The Australian Energy Market Operator (AEMO) manages the day-to-day operation of the national electricity and gas markets, that includes the day-to-day operations regarding the NEM [146]. The AEMO is responsible for ensuring the security and reliability of the energy system, and for balancing supply and demand in real-time. On the growth of the energy system, including the incorporation of renewable energy sources, the AEMO also offers strategic planning guidance [146]. The Australian Competition and Consumer Commission (ACCC), another regulatory body, is in charge of upholding consumer and competition rules in Australia [147]. The ACCC is specifically tasked with monitoring and preserving competition in the energy sector, among other duties [147].

The energy sector in Queensland is governed by the Electricity Act 1994 which is supported by a more recent legislation, the Electricity Regulation 2006 [148]. These laws cover a wide range of topics, including the regulation of the electricity industry, its supervision, calculation of the electricity prices and management of restrictions and procedures [148].

3.4.6 ENVIRONMENTAL

In the path to achieve net zero emissions, the production and consumption of energy has changed in Australia [142]. Both production and consumption have declined in the last years specially due to COVID-19, renewable energy production has witnessed a surge while there has been a decrease in the production of almost all fossil fuels in the country [142]. Energy in Australia comes from different sources being oil the most consumed [140].

In the state of Queensland 24.9% of the energy consumed that came from renewable resources in April 2023, this is the lowest percentage of the country and Queensland has to work to improve this numbers [149]. In Queensland in 2021 oil was the most consumed source of energy with a 35.8% being coal the second with 35%, that year only 8.5% of the energy consumed came from renewable sources, so the state has increased its share of renewable energy consumption by 16.4% in the last two years [150]. In the country a total of 84 056 GWh was obtained from renewable resources which represented a 35.9% of the total energy consumption [149]. It is becoming increasingly apparent how traditional energy sources like coal and gas affect the environment [149]. These energy sources cause air pollution and greenhouse gas emissions, so renewable energy must become a larger component of the nation's energy mix if the government is to meet its goal of a 43% decrease in emissions from 2005 levels [149].

Australia's climate and geographic factors make it a distinguished place for exploiting renewable energy sources [149]. Solar, wind, hydro, and geothermal energy are all abundant sources of renewable energy in the nation. Hydrogen storage, has significant potential for an energy storage solution in Queensland [149]. Since hydrogen can be produced from solar and wind energy and used whenever there is a need for energy, it is considered as a consistent alternative for promoting energy security [149].

Regarding solar resources, Australia receives above the average solar irradiation, approximately 10 000 times higher than the country's annual energy consumption [123]. As solar energy usage is projected to grow swiftly, wind energy has emerged as the quickest expanding source in Australia [149]. Australia has one of the world's best locations for wind resources. It has been determined that among all renewable resources, solar and wind energy are the most cost-effective and easily accessible options [149].

One of the most important measures to reduce carbon emissions and lessen the effects of climate change is the transition to renewable energy. In order to prevent the worst effects of climate change and keep global warming to 1.5°C above pre-industrial levels, the Intergovernmental Panel on Climate Change (IPCC) has emphasized the necessity to rapidly reduce greenhouse gas emission [3]. According to the Australian Government's Department of Agriculture, Water and the Environment, the country has experienced an increase in the number of heatwaves, longer fire seasons, and more frequent and severe droughts, which have led to significant economic and social impacts [151] [152]. Additionally, the government notes that sea levels have risen since the late 19th century, which has increased the frequency and severity of coastal flooding and erosion [153]. Australia is considered one of the most vulnerable countries to the impacts of climate change, as it faces various environmental and economic risks due to its geographical location [3].

3.5 COMPARATIVE ANALYSIS

In this section of the chapter, a comparative of the data gathered previously has been done, in order to see the information in a more synthesized way. The information has been grouped by aspect of the energy sector (political, economic, sociocultural, technological, legal and environmental) instead of by country.

3.5.1 POLITICAL

All of Spain, the UK, the USA and Australia have signed the Paris Agreement on climate change, under which each country sets its own nationally determined contributions (NDC) to lower the level of greenhouse gas emissions. The USA withdrew the Paris Agreement under the mandate of Trump but signed it off again with Biden. In table 1, an overview of these jurisdictions can be observed. In order to achieve the NDC compromised, all of the countries, and more locally, California and Queensland, have established state and local regulations that are aimed at supporting renewable energy and reducing carbon emissions. Moreover, Spain, as a Member State of the European Union, is subject to the EU legislation on energy and climate change, which has established as an objective to achieve net zero emissions by 2050. In the case of the UK, the Brexit was effective as of December 2020 and since then, the UK is no longer a Member of the EU; however, its policy towards climate change has not significantly changed since then, and keeping its arrangements with the EU is one of the keys to achieve the decarbonization objectives set forth under its domestic regulations.

Regarding renewable energy generation, Spain has the objective of a 32% increase for 2030 which would be a 74% of clean energy generation. As for the United Kingdom, a goal of 65% of renewable energy in the power mix was set for 2030. In the state of California, a

50% of renewable energy generation was agreed on, same thing was settled for Queensland, where a 50% of the energy mix is expected to come from renewable sources by 2030. Table 2 shows a summary of the renewable energy generation target for 2030.

Table 1:Paris International treaty.

	Spain	**UK**	**California**	**Queensland**
Paris Agreement	Yes	Yes	Yes	Yes

Table 2: Renewable energy generation target for 2030.

	Spain	**UK**	**California**	**Queensland**
RE generation target 2030	74%	65%	50%	50%

3.5.2 ECONOMICAL

It is a worldwide trend that the cost of renewable energy sources and its technology is decreasing and becoming the most affordable source of energy. In the four places studied in this project, Spain, United Kingdom, California and Queensland, it has been highlighted that the clean energy sources that have become most cost-competitive are wind and solar, which has led to a higher investment in these technologies. Standalone in Spain wind installations' cost experienced a decrease of 65% in the last decade and an 85% decrease in cost was seen in solar PV projects.

Regarding employment created by the energy sector, jobs will experience a net increase, the fossil fuels workforce will be reduced but the clean energy sector will rise its number of employees contributing to the economic expansion. The job growth in the renewables sector in California accounted for a total of 406 751 new jobs in 2019, in the case of Queensland employment in renewable generation weighs a 34% of the total in the electricity generation sector.

Finally, it is important to underline the case of the UK with oil and gas and the case of Queensland with coal. Oil and gas are essential to the UK's economic equilibrium and being that they are both pollutant ways of generating energy, the transition towards a more sustainable energy sector can affect these pillars of the economy. So far, the oil and gas sector have not been extremely influenced as both imports and exports have increased. In Queensland similarly, the coal industry is vital to the state's and country's economy. Australia is one of the biggest exporters of this material and its demand could be conditioned by the same reasons as in the UK, as more and more countries have recently agreed on the target of net zero emissions by 2050. Nevertheless, employment in the coal sector in Queensland has kept growing which continues to give hope to those who dedicate themselves to this industry.

3.5.3 SOCIOCULTURAL

This project was set to be studied in areas of similar number of people so that the comparison would be easier to understand. However, Queensland has a smaller population than the other three places taken into account, being the number of inhabitants 5.3 million. 39 million people live in the state of California, then Spain has a total of 47.6 million people, whereas the United Kingdom has a population of 67.8 million. The latter one being the most populated approximately 9 times bigger than Australia's state of Queensland. These results can be seen in Table 3.

In accordance to the information gathered from different studies and reports, 72.6% of the individuals who participated in a survey in Spain were very or quite concerned about climate change, a total of 75% adults agreed on this same matter in the UK. In Queensland 72%, the majority of respondents were concerned about the climate change issue. In California 65% believe that technology for renewable energy sources should be expanded and invested. Clearly, people around the world are becoming more aware of the environment and how their actions can affect it, in California 44% of respondents in a certain survey would be willing to pay more for electricity if it came from clean sources. Also, it is interesting to point out that according to the Environmental Letter in the US, awareness of climate change and willingness to mitigate it has grown specifically in the state of California as wildfires, droughts and flooding have become more regular.

Table 3: Population in millions.

	Spain 2022	**UK 2022**	**California 2022**	**Queensland 2022**
Population	47.6	67.8	39	5.3

3.5.4 TECHNOLOGICAL

Renewable energy has advanced technologically in all four regions where significant advancements have been made, specially technologies such as smart meters, microgrids and energy storage. Specifically, energy storage and efficiency can help reduce carbon emissions and guide the way into a more sustainable world, that is why governments are investing big amounts of money, teams and time into the research of new and existing technologies for the exploitation of renewable sources.

Renewable energy generation in Spain was a total of 95.8 TWh in 2021, which accounted for 47.6% of the energy mix. That same year in the UK from the information gathered previously, renewable energy accounted for 42% of the total energy produced in 2021, which was 122.2 TWh. In California 67.4 TWh were generated from clean sources, this being a 33.6% of the generation in 2021. In Queensland 5.7 GWh of energy was generated from renewable sources, it was a total of 20.4% of the energy mix in 2021. This information can be observed in Table 4. In Table 5, the renewable energy generation is presented per capita. The percentages of the share of renewable generation in the energy mix can be observed in Table 6. As for the consumption in the UK and in California transportation is the sector that consumes the most, in Queensland in contrast, industry is the largest consuming sector. The levels of consumption differ among the regions.

Wind and solar renewable energy sources seem to be the most used and the ones where technology has advanced most in all four places. Spain and California have focused their efforts mainly in solar power, specifically California relies on this type of source, as in 2022 it accounted for 19% of the net electricity generation. Wind in the case of the United Kingdom has become a significant contributor to the country's power mix over the last years, turning into the second largest source of electricity in 2019. Finally, in Queensland both solar and wind have experienced advancements thank to technological developments, being solar PV the dominant between the renewable consumed sources.

Table 4: Renewable energy generation.

	Spain	**UK**	**California**	**Queensland**
Generation of renewable energy	95.8 TWh	134.8 TWh	67.4TWh	0.057 TWh

Table 5: Renewable energy generation per capita.

	Spain	**UK**	**California**	**Queensland**
Generation of renewable energy per capita	2 MWh	1.9 MWh	1.7 MWh	0.01 MWh

Table 6: Percentage of Renewable energy in the energy mix.

	Spain	**UK**	**California**	**Queensland**
% of Renewable energy generation	47.6%	42%	33.6%	20.4%

3.5.5 LEGAL

The energy sectors in all four regions have a specific regulatory body and a specific legal framework that oversees it. Spain's most important legal entities include Red Eléctrica Española, the CNMC and the MITECO. The United Kingdom's energy sector is regulated by Ofgem and in the case of California the most significant institutions are the CEC and the CAISO. Queensland as part of Australia, its energy sector is overseen by the Australian Energy Regulator. The promotion of renewable energy and the transition to a cleaner, more sustainable energy system is a shared objective in all these four places.

The concept of self-consumption or community energy projects is well addressed in Spain through the RD 944/2019 and in California by the AB-2316. The sector of interest in general is legislated in Spain by the Electricity Sector Law 24/2013, UK's transition to a low-carbon economy is supported by the Energy Act of 2008. In California the industry is regulated by the EPAct of 2005 and finally, Queensland's energy sector by the Electricity Act 1994 and the Electricity Regulation 2006. This data can be observed in Table 7.

Table 7: Main regulation of the energy sector

	Spain	UK	California	Queensland
Regulation of the energy sector	Electricity Sector Law 24/2013	Energy Act of 2008	EPAct of 2005	Electricity Act 1994 Electricity Regulation 2006

3.5.6 ENVIRONMENTAL

Climate in the four regions studied in this project is very beneficial for the exploitation of renewable sources. They all characterize for the abundance of natural resources, especially solar and wind power. The geographic factors in Spain, California and Queensland make these three places distinguished for the quantity of solar irradiation they receive, making it a reliable source of energy. Wind has also become the primary source of renewable energy in Spain and the United Kingdom, and in the case of California and Queensland this resource is quickly expanding and becoming essential for the states' energy mix. It is fair to consider that the geographic and environmental characteristics in these places favor the development of renewable energy resources.

Regarding energy generated from wind power, the UK's offshore wind industry has grown recently and become the biggest in the world. California similar to the UK, can highly benefit from this type of resource as in its extensive coastline there are very strong wind speeds.

The consumption of renewable energy has grown in all the four places, in California it accounted for 17.6% of the energy consumed in 2021 and in Spain the same year 17.3% of the final consumption was renewable. In the UK 12.2% of total final energy consumed was obtained from renewable resources in 2019. Queensland consumed 24.9% of this type of energy. This information can be seen gathered in Table 8. Due to its geographical location, Australia is one of the most susceptible countries to the effects of climate change. As a result, it confronts numerous environmental and economic concerns.

The most consumed sources in Spain was petroleum with a 42.4% and the second was natural gas accounting for 24.8% of the total in 2021. Similarly, in the UK it was natural gas 38.6% and petroleum was the second with a 34.8% the same year. Likewise, California natural gas, was a 28.7% of the total consumption, and the second most consumed was petroleum which accounts for a total of 19.7%. Finally, in Queensland in 2021 petroleum was the most consumed source of energy with a 35.8% being coal the second with 35%. This information is stated in Table 9.

Table 8: Renewable energy consumption of the total final energy consumption in %.

	Spain	**UK**	**California**	**Queensland**
Renewable energy consumption	17.3% (2021)	12.2% (2019)	17.6% (2021)	24.9% (2022)

Table 9: Most consumed sources in total energy consumption in percentage.

	Spain	**UK**	**California**	**Queensland**
Most consumed source	Petroleum (42.2%)	Natural gas (38.6%)	Natural gas (28.7%)	Petroleum (35.8%)

	Spain	**UK**	**California**	**Queensland**
Second most consumed source	Natural gas (24.8%)	Petroleum (34.8%)	Petroleum (19.7%)	Coal (35%)

CHAPTER 4: REGULATION AND INCENTIVES OF THE ENERGY COMMUNITIES

The fourth chapter of the document the research focuses on community energy. It is divided in two sections where specifically energy communities' regulation and incentives are exhaustively analyzed.

4.1 ENERGY COMMUNITIES' FRAMEWORK

In this section the regulation and policies that affect CEs will be described for each of the places studied throughout the project. The section is divided in 6 subsections that gather the information considered to be the most relevant to the subject.

4.1.1 REGULATION

The regulation for energy communities is different in each place, there is not a universal framework that captures the policies that need to be followed in order to establish a community energy, which makes it harder for consumers to understand the process and be ready to create and develop an energy community.

As part of the European Union, Spain takes an active role in the initiatives supported by the EU and also benefits from them. Specifically, the "Clean Energy for all Europeans" led to the implementation of the Royal Decree 244/2019 to regulate renewable self-consumption and a year later, the Royal Decree 23/2020 which introduced the concept of local energy communities in Spain [10]. At the European level, this concept was introduced in the 2018/2001 Directive, where the term renewable energy community was established [154]. The Royal Decree 244/2019 is one of the policies implemented by the Spanish government to support the development of energy communities, which simplifies the procedures for their creation and registration [35] [155].

Spain also follows the Directive 2019/944, which regulates the internal electricity market and recognizes the energy community's figure. This Directive presents a citizen-focused vision to create an Energy Union where citizens take advantage of new technologies and actively participate in the energy market and therefore, the energy transition [156]. With the help of this Directive, some types of citizen energy projects will be recognized as "energy communities" at the EU level, giving them access to a supportive environment, equal opportunities, and a clear set of rights and obligations [156]. In Spain, this directive has been transferred to the national legal system through the RD 224/2019 which authorizes the deployment of self-consumption installations, which are allowed to be shared by multiple individuals [157]. Also, from the European Union level, Spain is adhered to the 2018/2001 Directive, which regulates renewable energy communities, on the promotion of the use of energy from renewable sources. It highlights that enabling renewable energy self-consumers to work together also creates chances for renewable energy communities to improve household-level energy efficiency and combat energy poverty by reducing consumption [154].

As for the UK, as it is no longer part of the EU, self-consumption and specifically community or local energy act in accordance with the country’s own regulations. However, there is no specific legal framework that addresses energy communities in the UK. There is, nonetheless, a scheme implemented by Ofgem, the energy regulator, called the “Renewables Obligation” (RO) Closure, that applies to small-scale solar PV (total installed capacity of less than 5 MW), between other generation sources, and aims to encourage the production of renewable electricity [158]. Regulations in the UK make setting up a CE very challenging, as policy is complicated and frequently modifies [76]. The UK's energy system heavily depends on fossil fuels and is mostly centralized. The challenge of achieving energy security, equity, and environmental requires a transformation of the entire system [159].

Regarding California, community energy is regulated by a law that the state passed in 2022, AB-2316. This law places the power in the Public Utilities Commission of California to create initiatives to encourage residential consumers in disadvantaged communities to adopt renewable generation and establish renewable energy communities. The assembly bill also mandates that the CPUC generate an annual report to the Legislature detailing the facilities deployed and customers signed up as a result of the community renewable energy program within its establishment [114].

Finally, Queensland, similar to the UK, does not have a specific policy that endorses community energy. Community energy projects in Queensland may encounter ambiguity or obstacles due to the state's present legislative and regulatory framework. To promote the community energy sector, strong policy and regulatory frameworks are needed [160]. The community renewable energy sector faces many challenges but also opportunities. The main challenge in starting a project is a lack of awareness within political, financial, and community circles regarding the potential benefits of community renewable energy projects [161]. Nevertheless, the government of Queensland has supported the progress of energy communities in the state [126]. It has reinforced the development of community owned renewable energy projects like solar or wind farms in order to provide local communities with the access to this source of energy, promoting community engagement in the energy transition [160].

There is, however, the Electricity Regulation 2006 in Australia, which states that a person operating a 30MW or less particular generating plant has a special approval to connect it to a transmission grid or supply network [162]. As said before, energy communities are not specifically governed by any laws in Australia, although a number of laws and policies do apply to them and their activities. The Renewable Energy Target is one of the most significant regulations that affects energy communities in Australia [123]. A set percentage of electricity generation must come from renewable sources under the RET. By producing renewable energy and reselling it to the grid, energy communities may endorse the RET [123]. Another policy that applies to energy communities in Australia is the National Electricity Market, the wholesale electricity market that operates in Australia [163]. The NEM is governed by the National Electricity Rules (NER), which set out the rules and regulations for the operation of the market. Energy communities that generate and sell electricity into the NEM must comply with the NER [163].

Table 10 summarizes the information regarding the specific regulations regarding community energy in each place.

Table 10: Main regulation.

	Spain	UK	California	Queensland
Federal / European	D 2019/944 D 2018/2001	-	-	-1
State or country level	RD 224/2019	-1	AB 2316	-1

4.1.2 REGULATOR

The energy regulator is the institution that oversees the regulation of the energy industry in a specific area. It can be a government agency or an independent organization and it has the responsibility to ensure that energy is produced, transmitted, distributed, and used in a dependable, and efficient manner. Another duty is to look out for the interests of customers and support the growth of renewable energy sources.

In Spain the energy regulator is the National Commission of Markets and Competition (CNMC), it is an independent regulatory body that has the main responsibilities that an energy regulator holds. It manages the electricity and gas sectors of the country and is responsible for implementing EU directives and regulations in Spain [40].

The Office of Gas and Electricity Markets (Ofgem) is responsible for regulating energy in the UK. Ofgem is an independent agency that similar to the CNMC regulates the electricity and gas market of the country. Its primary role is to promote competition in energy markets, protect the interests of energy consumers in the UK, and ensure that the energy sector runs effectively, sustainably, and securely [164]. Ofgem suggests that local energy is becoming more popular due to several factors, such as the increasing involvement of local authorities in climate and energy governance, changes in consumer preferences and participation, and declining trust in traditional energy actors [165]. Local ownership and governance can help achieve broader societal goals such as environmental sustainability, learning, engagement, and participation. The growth of renewable energy technology has also played a significant role in enabling local actors in the energy sector [165].

In California, at the country level, energy is regulated by a combination of federal agencies depending on the energy sector, but the key energy regulators are the Federal Energy Regulatory Commission (FERC), independent agency of the US government that encourages the coordination of transmission planning at a regional level, between other things and the Department of Energy (DOE) which is a federal agency in charge of supporting energy efficiency and the creation of innovative energy technologies, as well as guaranteeing the dependability and security of the US energy infrastructure [166] [167]. At the state level California's energy sector is regulated by its Public Utilities Commission, responsible for a wide range of activities, including encouraging the development of renewable energy, addressing climate change and regulating utility operations [168].

Finally, Queensland in the same way as in California, there is an energy regulator at the national level, and that is the Australian Energy Regulator (AER), federal agency responsible for regulating the wholesale electricity and gas markets, as well as the revenue and pricing of electricity transmission and distribution businesses [144]. The AER also has responsibility for enforcing consumer protection provisions in energy legislation [144]. At the state level The energy regulator in Queensland is the Queensland Competition Authority (QCA). The QCA is an independent statutory body responsible for regulating the prices and quality of electricity, gas and every other business vital for the economy of the state [169]. The energy regulators for the different places can be found summarized in Table 11.

Table 11: Energy regulators.

		Spain	**UK**	**California**	**Queensland**
Energy regulator	Country level	CNMC	Ofgem	FERC	AER
	State level	-	-	CPUC	QCA

4.1.3 COOPERATIVES

Cooperatives are businesses whose members, are individuals or businesses who use the cooperative's services or goods, and democratically control them. The members of a cooperative pool their resources together to achieve a common goal or meet a common need. Cooperatives operate in various sectors and can take many forms, such as energy cooperatives. The form of community energy cooperatives is quite new but it still exists and it is becoming more and more common [170].

In Spain there are various energy community cooperatives. One of them is the Red de Comunidades Energéticas S. Coop which promotes the implementation of local energy communities, to effectively tackle the challenges posed by climate change while developing a business model that is socially responsible and cooperative in nature [171]. This cooperative also explains to consumers the meaning of a community energy and how to create one [171]. There are a few others, including Som Energia, Enerplus or Energética Coop.

As for the United Kingdom, cooperatives in this sector are also growing. One example is the Community Energy England cooperative which provides opportunities for community energy customers to connect, learn, share business models, and support one another in overcoming obstacles [172]. It is committed to assist community energy organizations in developing and implementing new projects, it also provides a guide on how to get started with a community energy [172]. Many other cooperatives are being born in the country in order to assess those who are interested on implementing this type of project, some are Energy4all and Co-operative Energy.

Following with California, cooperatives for energy communities also exist, one of the main cooperatives for these projects is Cooperative Community Energy (CCEneregy) [173]. It is recognized for being owned by its customers and having installed many solar energy projects in the residential and commercial sector, highlighting the lower energy costs these projects offer. The CCEnergy provides free consultation for residential customers who are intrigued by the outline [173]. Some other cooperatives include East Bay Community Energy or the Clean Power Alliance.

To finalize, in Queensland, a review done by Queensland Council of Social Services in 2018 stated that even though cooperatives are an ideal structure for community energy projects due to their emphasis on shared ownership, control, and participation, many cooperatives struggle to secure funding. Co-operative Capital Units (CCUs) was introduced as a financial instrument to address this issue and provide cooperatives with greater flexibility in raising capital. However, the use of CCUs is limited in Queensland due to restrictions in cooperative laws, which discourages community energy groups from using this structure [161]. Still, at the national level there are some cooperatives focused on the empowering of community energy projects, for example the Community Power Agency or Cooperative Power.

These cooperatives and others like them are crucial in encouraging the creation of community energy projects in these different places and in giving people and communities the tools they need to take charge of local energy production and consumption. Table 12 summarizes the data collected related to the different cooperatives.

Table 12: Examples of CE cooperatives.

	Spain	**UK**	**California**	**Queensland**
Examples of cooperatives	Comunidades Energéticas S Coop	Communit Energy England	Cooperative Community Energy	Community Power Agency (National level)

4.1.4 NUMBER OF CE

The number of energy communities has grown over the last years. In Spain thanks to the initiative CE IMPLEMENTA right now there is a total of 68 projects around the country. Almost half of the projects are being constructed in disadvantaged municipalities, which helps Spain's energy policy achieve its energy goals and the battle against depopulation [174]. Regarding the United Kingdom, the number of projects is even higher, overall, there were 495 energy community in 2021, that year the industry gained 18 new organizations, exceeding the 5-year average of 16, which means that the number of projects is steadily growing [175].

No actual information on the number of community energy projects has been found in the case of California or Queensland. In both these places there the energy communities vary from small-scale solar installations on individual homes to large-scale wind and solar farms owned by community-based organizations. The number of energy communities developed in each of these places can be found in a compact way in Table 13.

*In California and Queensland data regarding the actual number of energy communities is not available.

Table 13: Number of CE.

	Spain	**UK**	**California**	**Queensland**
Number of CE	68 [174]	495 [175]	- [1]	- [1]

4.1.5 GENERATION AND DISTRIBUTION

The amount of energy that a community energy project can generate and distribute will depend on a variety of factors, including the size and type of the project, the available resources in the area, and any regulatory or policy constraints.

In Spain, as established by the European Union in the Directive 2018/2001, communities that use renewable energy should be able to share the energy generated by the installations they own. Also, countries shall ensure that renewable energy communities have the legal

[1] Information on this was not available.

right to create, consume, store, and distribute renewable energy to the grid, including through renewables power purchase agreements. They must also have unrestricted access to all appropriate energy markets [154]. Specifically, in Spain, two types of self-consumption are recognized, those installations with surplus and those without it [34]. For the case of self-consumption installations without surplus, these although they are connected to the consumer's internal network that links to the distribution or transport network, they do not at any time transfer energy to the grid and they must be equipped with a mechanism that prevents the injection of the surplus to the grid. Secondly, the case of self-consumption with surplus, these facilities are connected to the distribution or transmission grid which can supply energy to the grid [34]. The community involved is considered an energy producer, although the actual production may be carried out by another entity. Installations can be connected in two ways, to the consumer's interior network or than external point to the internal network, using the public distribution network, called nearby installations through the network [176].

In the United Kingdom, self-consumption installations are also allowed to generate and distribute energy, they can be connected to the electricity grid and can export any excess energy back to the grid, subject to certain constraints, such as limits on the amount of energy that can be exported, technical requirements and safety standards [Solar photovoltaic self-consumption in the UK residential sector].

Following with California, the state permits customers to install renewable power generation facilities to meet their electricity requirements and link them with the electrical grid. The primary technologies used by customers include solar, wind, and fuel cell facilities. Several California laws have directed the CPUC to develop rules or tariffs to allow customer-generators to satisfy their energy needs onsite and earn a financial credit on their electric bills for any extra energy fed back to their utility [177]. The CAISO offers fair and transparent entry to the transmission grid, backed by a market that fosters competition for energy resources [178].

To finalize, Australian's state Queensland, same as the other three jurisdictions, community energy projects are permitted to generate and distribute energy [179].

In conclusion, in all the places studied in the project self-consumption installations and therefore community energy projects can both generate and distribute energy. The results from the data gathered in the investigation are summarized in Table 14.

Table 14: Generation and distribution of a CE.

	Spain	UK	California	Queensland
Generation	Yes	Yes	Yes	Yes
Distribution	Yes	Yes	Yes	Yes

4.1.6 MAXIMUM INSTALLED CAPACITY

The self-consumption installations in Spain do not have a limitation when it comes to maximum power installed capacity, therefore, the only restrictions are those of the facility itself and those derived from industrial quality and safety regulations [180].

In the UK, the energy regulator, Ofgem together with the Smart Export Guarantee (SEG) pursued a government-backed initiative to incentivize small-scale generators that met the requirement of and installed capacity of up to 5 MW for the different types of renewable energy sources, including solar PV, wind, hydro and others. This is the only power capacity limitation found in the research [181].

The Net Energy Metering (NEM), program that allows customers who generate their own electricity from renewable energy sources to receive credit on their utility bills for the excess energy they produce and feed back into the grid. There are three versions of this program, the first one the NEM 1.0 which had a limit in size capped at 1 MW, the NEM 2.0 which limit was the customer's annual electric load and finally the Net Billing Tariff (NBT) that imposes the same restriction as the previous program plus up to 50% if customer attests to need, this last version is the active one since April 2023 [177].

The Queensland government stablished in 2008 the program known as Solar Bonus Scheme, which compensates households and small customers for any excess electricity produced by their own rooftop solar photovoltaic systems. Qualified customers for this scheme are those whose consumption is less than 100 MWh of electricity per year [179].

In conclusion, the limitations are different on the maximum capacity permitted in each region, a summary with this information can be observed in Table 15.

Table 15: Maximum installed capacity of a CE.

	Spain	**UK**	**California**		**Queensland**
Maximum installed capacity	No limit	5 MW	NEM 1.0	1 MW	-1
			NEM 2.0	Annual load	
			NBT	Annual load + 50%	
Maximum electricity consumption annually	-	-	-	-	100 MWh

4.1.7 GUIDE ON SELF-CONSUMPTION

A guide on self-consumption can be seen as a useful tool for consumers interested on knowing more about the subject and it can also help increase the number of energy communities developed in a country as it may make it easier for customers to understand the steps and benefits these projects have. In Spain there is an updated guide on self-consumption released by IDAE in January 2023. It explains what to do before starting a project, the process that needs to be followed in order to successfully create a community energy and it gives recommendations as well as examples of existing projects [176]. The EU in the Directive 2018/2001 states that it has been demonstrated that the deployment of energy from renewable sources is hampered by the absence of transparent norms and coordination between the different authorization bodies. The EU has made it an obligation to provide guidance to consumers and such direction must be given at the proper level of governance, taking into account the unique characteristics of each Member State, assisting and directing the applicant throughout the full administrative procedure [154]. This could be a reason for the existence of the Self-Consumption Guide provided by the Spanish country.

In the case of the UK, there is a guide on community energy, it explains its meaning and support provided by the government and how to reduce the energy use, however it is quite old, the last update was in 2015 [73]. This agrees to what has been said before that there are barriers for the development of energy communities as the policies that surround the topic are complex [76].

In California the CPUC has released some helpful guides in order to provide direction for consumers in the innovative projects of community energy. A workshop was held on February 2023, where participants learned the different existing programs the government offers as well as the new tariff proposals. What is self-consumption and why it would benefit consumers are other insights he CPUC offers [182]. A Solar Consumer Protection Guide was also published by the CPUC in 2022 in order to give advice to customers on how the best way to establish a community energy project while being protected [183]. The Department of Energy in the U.S. provides a Guide to Community Energy Strategic Planning with useful tools and advices [184].

In Queensland, similar to what happens in the United Kingdom, there is a useful guide to start a community renewable energy project however this one provided by the Community Power Agency, is form 2014. However, it does offer useful information on what these types of projects are, how to get started with the process, the benefits and the challenges of the process [185]. On Table 16, there is a summary of the information found.

Table 16: Guide on self-consumption.

	Spain	**UK**	**California**	**Queensland**
Guide	Yes	Yes	Yes	Yes

4.2 ENERGY COMMUNITIES' INCENTIVES

As previously mentioned, community energy projects have emerged as a powerful model that promote renewable energy generation and therefore encourage the energy transition towards a more sustainable world. This chapter explores the incentives and advantages of starting a CE project, delving into the legal and financial benefits that make these initiatives an attractive proposition in each of the regions studied.

4.2.1 LEGAL ADVANTAGES

Legal advantages are those benefits and opportunities generated by the regulations and laws in a specific jurisdiction. These advantages offer favorable conditions, protections, or rights to the individuals interested in pursuing an activity in order to promote their endeavors. Legal advantages can include a regulatory support, which means a well-developed legal framework that offers stability, in the case of community energy, regulation and whether it facilitates compliance in each of the places has already been discussed in the previous section.

4.2.1.1 GOVERNMENT SCHEMES

Another type of legal advantage is the access to funding opportunities, in the case of CE there are different programs that are interested in investing so that individuals grow on interest towards the subject and contribute in the energy transition.

In Spain, the MITECO through IDAE and funded by the program NextGenerationEU offers different types of incentive programs with the objective to promote renewable energy and self-consumption, especially in the residential sector [186]. Renewable generation actions eligible for subsidies under these programs include photovoltaic and wind actions for self-consumption, as defined in Royal Decree 244/2019. These also consider new generation installations with associated storage installations as eligible actions for subsidies. The total grant to be awarded goes from 140 €/kW to a total of 2900 €/Kw for the installation of different self-consumption forms [186].

Another example is the program CE IMPLEMENTA, established by the Recovery, Transformation and Resilience Plan (PRTR) and funded by the EU Next GenerationEU the objective of this grants is to enhance the support available to individuals and organizations involved in establishing and growing energy communities. These grants primarily target citizens, small businesses, and local entities, with the aim of promoting a just and inclusive transition to a low-carbon economy. By encouraging investments in green infrastructure and involving actors who have not traditionally been part of the energy sector, the grants facilitate a more equitable and sustainable decarbonisation process [187]. This project funded by the EU Next GenerationEU recognizes energy communities as a significant contributor to the energy transition, enabling them with the required financial capability to undertake the construction and operational activities of infrastructures connected to communal engagement in the energy industry [188]. IDAE, the Institute for Energy Diversification and Saving, has released the first phase of the map of energy communities, the purpose of this map is to showcase the information and projects of energy communities in the CE IMPLEMENTA programs [174]. Through this map, Spain takes a step forward in promoting the deployment of this renewable, economical, democratic, and participatory solution, in which citizens become the protagonists of the energy transition [174]. IDAE aims to achieve a more democratic and participatory energy model while reactivating the economy, combating climate change, reducing external energy dependence, and creating wealth and employment by strengthening the business and industrial sector [174]. IDAE has already published four calls for the CE IMPLEMENTA program to support unique pilot projects of energy communities. In the first two calls, grants totaling €40 million were awarded to 73 energy communities, which mobilized more than €90 million in investment and had over 95 000 members [174]. Additionally, IDAE has also published a call for the CE OFICINAS program to execute start-up and operation projects of Community Transformation Offices that can carry out advice, and support activities for energy communities [174]. Regarding the map released by IDAE, it shows that the implementation of energy communities has started all around Spain. An interesting fact is that 85.39% of the participants are natural persons [188].

In the United Kingdom there are various schemes and programs that support renewable energy generation and specifically self-consumption. The UK government provides individuals with different funding opportunities, for instance the "Good Growth Strategy to Mitigate the Cost of Living" where funding is available to address the challenges posed by the high cost of living, a total of £5.5 million were destined to this program [189]. This funding aims to invest in renewable energy efficiency measures that reduce household expenses [189]. Another example is the "Domestic Renewable Heat Incentive" (DRHI) scheme administered by Ofgem, it is a government initiative designed to provide financial support for the adoption of renewable heating systems in households [190]. The DRHI is available to all households, regardless of whether they are connected to the gas grid or not, as long as they have installed a renewable heating system and meet the eligibility criteria [190]. Participants who adhere to the scheme rules receive quarterly payments over a period of seven years based on the estimated amount of clean and renewable heat their systems are expected to generate [190].

Regarding California, the CPUC offers grants and other financial incentives to encourage the development of Community Solar in the state. There are different community renewable energy programs that provide funds to individuals willing to install solar panels on their roofs [191]. The California Energy Commission incentivizes the development of sustainable homes through a project called California Electric Homes Program aims to offer incentives for the development of residential buildings that operate solely on electricity and the installation of energy storage systems, a total of $7.5 million will be destined to this initiative [192]. The program aims to promote the adoption of building technologies with near-zero emissions. Under the Electric Homes program, incentives will be provided to support the construction of these new residential buildings, ultimately leading to reduced construction costs [192].

Finally, Queensland, in order to support the target of 50% renewable energy by 2030, the government has launched different initiatives [193]. In the small-scale level, Decarbonising Remote Communities is one of these projects. A total of $3.6 million was allocated to install renewable energy systems in four Indigenous communities located in the far north of Queensland [194]. The primary objective of these installations was to decrease the reliance on diesel power. The project involved active participation and collaboration with the inhabitants [194]. By utilizing renewable energy sources such as solar power and battery storage, these remote communities experience several advantages which include job creation, cost savings in terms of energy consumption, and environmental benefits through reduced emissions [194].

Additionally, in the Australian state of Queensland the Small-scale Renewable Energy Scheme (SRES) offers a monetary incentive to encourage the installation of small-scale renewable energy systems [195]. This program targets households, small businesses, and community groups, providing support for eligible systems which include solar photovoltaic (PV) systems or small-scale wind systems [195]. This incentive is in the form of small-scale technology certificates (STCs). By creating and surrendering STCs, liable entities under the Renewable Energy Target legislation fulfil their legal obligation to support the scheme [196]. The renewable electricity generated by these systems replaces electricity sourced from non-renewable sources, contributing to the reduction of greenhouse gas emissions [196] [197].

These schemes cannot be comparable, mainly because the Spanish scheme of CE IMPLEMENTA covers a broader aspect of self-consumption, and the funding is greater also because of the EU's nudging. However, the other three government schemes chosen are more specific than the first one in terms of the types of installation they cover, nevertheless, those still promote self-consumption but with less funding. A summary of this subsection can be observed in Table 17.

Table 17: Type of government schemes and their funding.

	Spain	**UK**	**California**	**Queensland**
Government scheme	CE IMPLEMENTA	Good growth strategy to mitigate the cost of living	California electric homes program	Decarbonising remote communities
Funding available	€130 million	£5.5 million	$7.5 million	$3.6 million

4.2.1.2 ENERGY SURPLUS EXPORTED TO THE GRID

In Spain, the RD 244/2019, establishes the possibility of energy communities with or without surplus injected to the grid. In self-consumption without surplus, a mechanism must be installed to prevent any excess energy from being injected into the grid. Self-consumption with surplus allows for the injection of excess energy into the grid [34]. Those that have signed a contract for the compensation of surplus self-consumption can enroll in the compensation mechanism as long as they meet the specific requirements [176]. To be eligible, the renewable energy generation system must come from a renewable source and the power capacity of the system should not exceed 100 kW. No additional special payment scheme should be assigned to the installation [176]. A surplus self-consumption compensation agreement must be signed between the supplier and the consumer, even if they are the same entity [176]. The value of the energy produced but not used cannot exceed the value of the energy consumed from the grid during the billing period. The energy generated but not consumed is not counted as part of the electricity supply and is exempt from government charges [176]. With this decree-law the government promotes the development of energy communities and enables them to participate in the electricity market [34].

The United Kingdom, there is program called the Smart Export Guarantee (SEG), it was introduced after the withdrawal of the feed-in tariff to place value on electricity exported to the grid and ensure that larger suppliers offer consumers export tariffs [165]. SEG generators are paid by the designated SEG Licensee, which is an electricity supplier, for the electricity they export back to the National Grid [181]. The government aims to facilitate the transition to a smarter, cleaner energy system by compensating small-scale generators for the value of their exported electricity and enhancing their role in driving a smarter energy system [198]. The payment rate, duration of the contract, and other conditions are set by SEG Licensees. SEG tariff rates must constantly be higher than zero [181]. SEG payments are computed using readings from export meters. Individuals that can benefit from this are those with renewable energy installations with a capacity up to 5 MW [181]. This scheme ensures that small-scale low-carbon generators are compensated for the electricity they export to the grid [199].

In California, as mentioned previously in this same chapter, the program supported by the CPUC, the Net Energy Metering, which plays an important role in promoting renewable energy systems [177]. Participating customers under Net Energy Metering (NEM) tariffs receive a credit on their bill for any surplus electricity they generate and export to the grid when their energy consumption comes from renewable sources [200].

Finally, in the case of Queensland an individual's solar system can be connected to the grid [201]. Thanks to net metering the quantity of solar energy exported back to the grid can be recorded, when solar panels generate more energy than the community requires [202]. Net billing is the system through which members of the community are compensated for surplus energy generated by their solar panels and supplied to the grid [202]. However, the payment rate for this excess energy is typically lower than the rate charged for energy consumed by the household [202].

The four regions chosen for the study possess a compensation mechanism for any surplus of energy generated in their self-consumption systems. These type of incentive is not actual money that the individual receives but it is a discount for their energy bill. A summary of the information gathered in this section can be found in Table 18.

Table 18: Surplus generation compensation.

	Spain	**UK**	**California**	**Queensland**
Credit for surplus exported	Yes	Yes	Yes	Yes

4.2.2 TAX ADVANTAGES

Tax advantages refer to the various benefits and incentives provided by tax regulations and policies that specifically support community energy projects. These benefits can take the form of tax deductions, exemptions, or other mechanisms that lessen the tax burden on CE initiatives. Community energy projects are more financially viable and appealing to individuals, communities, and investors when the following tax benefits are available.

4.2.2.1 FEED-IN TARIFF

Feed-in tariffs (FiT) are designed to encourage the production of electricity specifically using renewable energy sources and to encourage the implementation of renewable energy systems among households and communities [203]. Feed-in tariffs for solar energy are the payments that electricity suppliers make to consumers who have solar PV systems and export excess energy to the grid [204]. In Spain, the new legal framework for self-consumption includes a provision for compensating exported energy through a net billing mechanism based on market prices is defined [157]. The remuneration takes the form of a discount on the electricity bill, ensuring that consumers pay for the difference between the economic value of the energy consumed and the economic value of the energy exported to the grid. This monthly difference cannot be negative [157].

The UK government has developed several policies and regulations to encourage the adoption of renewable energy. The Feed-in Tariff (FiT) subsidy, which started in April 2010, was reduced in value over time and was withdrawn completely at the end of March 2019 [165]. It was designed to provide financial incentives to households, businesses and communities that installed renewable energy technologies such as solar PV panels, wind turbines and hydroelectricity generators [165]. The FiT scheme was closed as it had achieved the objective of driving down the cost of renewable energy [165]. This resulted in a decrease in the attractiveness of investing in solar panel arrays [203]. The FiT provided subsidies for small-scale generation projects in the United Kingdom with installed capacity bellow 5 MW [165]. Now it has been replaced by the SEG scheme mentioned earlier [165].

The case of California in 2013, the AB 1969 Feed-in Tariff Program was substituted by the Renewable Market Adjusting Tariff (ReMAT) Program. The CPUC's Renewables Portfolio Standard targets are based on the electricity produced as part of the ReMAT initiative [205]. This program offers a feed-in tariff for small renewable generators with a capacity of less than 3 MW [205].

To finalize, in order to establish a national FiT program, promote, and give financial assistance for solar PV devices that connect to and feed energy back into the grid, the Renewable Energy Amendment Bill was launched in Australia in 2008 [203]. This scheme in the case of Queensland kept reducing the compensation of installing solar PV systems. Nevertheless, the introduction of FiTs in Queensland led to a significant rise in residential solar PV systems [203]. However, it is important to note that the adoption of residential PV systems is influenced by various factors and FiTs alone cannot account for the entire increase [203]. In 2021-22, there was a continued growth in the number of retailers providing retail plans with feed-in tariffs [204]. Specifically, for residential and small business customers in Southeast Queensland, the number of retailers offering feed-in tariffs increased. Additionally, the average residential feed-in tariffs saw a decline during the same period [204]. A summary of the information gathered in this subsection is presented in Table 19.

Table 19: Tariffs for a CE.

	Spain	**UK**	**California**	**Queensland**
Feed.in tariff in force	No	No	No	Yes
Other type of tariff	RD 244/2019	SEG	ReMAT	-1

4.2.2.2 OTHER TAX INCENTIVES OR TAX RELIEFS

In the case of Spain, the income tax deduction for installing solar panels entails that if your home or community of property owners has photovoltaic solar panels, there is a possibility of a deduction between 20% and 60% from the total amount of the investment made in improving the energy efficiency of the house or building on your Personal Income Tax, or in Spanish *"Impuesto sobre la renta de las personas físicas"* (IRPF) return [206]. The reduction applied to the IRPF depends on the energy efficiency of the community after the solar panels have been installed, this has to be at least of a 7% in order to be eligible [206].

In the United Kingdom there were two support systems of tax deduction, the Enterprise Investment Scheme (EIS) tax relief and the Social Investment Tax Relief (SITR) that community energy projects could access, however in 2015 investors in these projects were excluded from the opportunity to enter this scheme [207]. Nevertheless, there is a reduction in the value added tax (VAT) on energy-saving products, which include solar panels or wind turbines. Energy efficiency and renewable energy installations will be rewarded by a 0% VAT [208].

To continue with California, there is a program called "Active solar energy systems new construction exclusion", it is a tax law that exempts the added value of active solar energy systems from property tax assessments, which means that the property tax assessment does not consider the added value contributed by the solar energy system [209]. It is interesting to highlight that there used to be a program called the California Solar Initiative (CSI) General Market Program that concluded in December 2016 [210]. Although California remains dedicated to promoting clean and renewable energy, the substantial decrease in equipment prices and market transformation suggest according to the CPUC, that direct incentives are no longer required [210].

Regarding energy communities, it is important to highlight the policy implemented by the federal government of the Investment Tax Credit (ITC) which was introduced in 2006, and allowed a tax deduction of up to 30% of the solar photovoltaic system cost [89]. The ITC is an income tax, it has been modified and extended several times. The federal government's tax credits for wind and solar energy may be responsible for the rise in renewable energy in the U.S. [89]. The Inflation Reduction Act (IRA), signed by President Biden in August 2022, expanded the Federal Tax Credit for Solar Photovoltaics, which deduction had been previously reduced. The act increased the ITC amount and extended its timeline from 2022 to 2034 [211].

A synthesized version of this subsection can be observed in the Table 20 where the tax reliefs are presented.

Table 20: Tax deductions for the implementation of CE projects.

	Spain	UK	California	Queensland*
Tax deduction	Income tax	Value added tax	Income tax	-[1]

To finalize this chapter, a summary of the tax advantages provided by the installation of energy communities in the four administrations of interest can be found in Table 21.

Table 21: Summary of tax advantages

	Spain	United Kingdom	California	Queensland
Income Tax				
Feed-in Tariff				X
Other Tariff	X	X	X	
Property Tax	X		X	
Consumption Tax		x		

4.2.3 SOCIO-ECONOMIC ADVANTAGES

Thanks to the reduction of the prices of renewable energy, the implementation of energy communities can be benefited [212].

Regarding the community energy, UK's policies and incentives aim to reduce carbon emissions and replace fossil fuels, while also promoting the potential of renewable energy technologies to strengthen communities [213]. By promoting ownership of renewables, it is believed that local communities can increase their capacity and financial autonomy to address their own needs [213]. The first national Community Energy Policy Statement envisions a central role for community and local energy in the future energy system, with the potential to create socio-economic benefits and maximize the value of energy generated through community-based organizations [213].

In the case of the United States, according to the Energy Communities Interagency Working Group (IWG), energy communities generate new employment possibilities in the clean energy sector across the US while easing the transition to clean energy by lowering energy costs while improving energy security [214]. The growth of energy communities can create local jobs and stimulate economic development [214].

In summary, energy communities can provide economic benefits to local communities by offering a cheaper and cleaner alternative to traditional energy providers [135]. An empirical analysis published by the scientific magazine Energy demonstrates the effect that the usage of renewable energy, which Australia has already shifted toward, has a favorable and significant impact on economic growth [135].

CHAPTER 5: DISCUSSION

The community energy concept is one that has not been defined in the same way in every part of the world and far less is regulated by the same laws.

5.1 LACK OF DEFINITION OF THE TERM "COMMUNITY ENERGY"

In the literature review it has been observed that community energy projects in Spain, the UK, the US and Australia receive different terms, such as community renewable energy, energy communities, citizen energy, local energy communities and others, making the process of unifying the knowledge about this concept even harder. However, what has been extracted as the main idea that encapsulates the overall term of community energy is a group of people or an individual who takes advantage of the energy generated in their property by renewable sources that can include for instance solar, wind or hydro power, but not limited to those.

The uncertainty in the definition of the term "community energy" does not help with making it a well-known mechanism. In this regard the different regions that have been treated in this project treat CE differently. This implies lack of clarity regarding its specific meaning leading to ambiguity in its application. A solution to this problem would be to give community energy a strict definition and delimit the concept to reduce the differing interpretation of what constitutes community energy.

5.2 CE LEGAL FRAMEWORK

Governments are trying to promote CE initiatives, especially in Spain, encouraged by the measures adopted by the European Union, that recognized the figure of EC in 2019 and established a specific framework that addresses the concept of energy communities. California similar to Spain counts with a legal framework that admits CE. In the UK as mentioned in the project there is no specific legislation that regulates these initiatives, Queensland likewise. The governments in the UK or Queensland are pushing the development of CEs but still do not have a concise regulation to do so.

In order to advance, community energy must face several obstacles mainly related to the policymaking process. It is challenging to achieve regulatory measures that satisfy energy communities' requirements. Countries inside the European Union are progressing faster than others, as it occurs in the case of Spain where there is specific legislation to regulate self-consumption and particularly community energy projects. Regions like Queensland or the UK should come into a political agreement and establish a solid legal framework for the development of energy communities in order to reach the level of those jurisdictions that are more advanced in this relevant and beneficial instrument.

5.3 GUIDE ON SELF-CONSUMPTION

Another issue deserving attention is that the guides on self-consumption provided by the government or cooperatives in the cases of Queensland and the United Kingdom are outdated, whereas in California or Spain these consumers' guides provide useful and reliable information on the subject. To promote the development of CE it seems critical that governments or private entities provide the potential consumers with useful and accessible information on their implementation.

5.4 NUMBER OF CE PROJECTS

It is also interesting that even though there is not an actual solid regulation for CE projects in the UK, it has more than seven times the number of energy communities than Spain and only its population is only 1.4 times bigger than the Spanish one. This could be because the CE IMPLEMENTA first two announcements are quite recent (2022) and the funding was capped at € 130 million. The next two calls took place on February 2023; therefore, after the development of the existing CEs, and counting with the legal framework established, consumers in Spain could consider investing in implementing their own community energy.

5.5 GOVERNMENT FUNDING

Regarding the different incentives in each place, governments as stated before are interested in making renewables more attractive to consumers so other than creating a stable legal framework, this can be done through funding. Spain seems to have benefited from the help of the European Union who has invested in promoting the community energy initiatives, together with other projects that encourage the use of renewable sources. The governments in the UK, California and Queensland offer those who are interested different schemes to fund projects that reduce emissions in the residential sector by for example installing energy efficiency or storage systems in California. In the UK, Ofgem supports the adoption of renewable heating in households. These last examples are not specific funds for CE projects but still benefit those interested in investing in renewable energy. However, it is noteworthy to highlight that the EU has a positive impact in Spain.

5.6 SURPLUS OF ENERGY EXPORTED TO THE GRID

Another point of interest is that nowadays the energy generated in an individual's property can be injected back to the grid. In Spain, until 2018, this was not an option. However, to the present in the four regions studied it is a given. Not only that, but there is compensation when there is a surplus of generation. This seems to be a very attractive incentive, as customers can lower the price of their energy bill and when not all the electricity generated is needed, they can receive a profit in the form of a discount. Net metering has helped the system to regulate when there are surpluses, and it is the method of compensation used in California and Spain. This compensation is in some jurisdictions known as a feed-in tariff, however it does not seem to work everywhere, in the United Kingdom it was withdrawn in 2019 and in California it was also substituted, claiming that it had fulfilled its objective to lower the cost of renewables. Queensland is the only of the four regions that still holds an active feed-in tariff for excess of energy generated and it does seem to be working as residential PV systems are becoming more popular.

5.7 RENEWABLE RESOURCES

To continue with this discussion, it is interesting to note that solar energy is the most common of the renewable resources, not in electricity generation, as that is wind in the case of the four regions studied but in the way that it is the most incentivized source. It seems that many government schemes are exclusive for solar PV systems. This is an advantage for Spain, California and Queensland, as they receive a very high solar irradiation but the United Kingdom is not as benefited from this which is why not as many schemes and initiatives in the UK's government concern solar photovoltaic installations compared to the other three places mentioned.

As a result of EU's support Spain seems to be more advanced than the three other administration when it comes to CE initiatives. It is second to the UK of these regions regarding renewable energy generation, Queensland is last but not comparable as the number of people is considerably smaller. Leaving the generation of renewable energy aside, Spain has shown a more reliable and stable path for the development of CE. This encourages consumers to investigate about the subject and that is already a step closer to becoming familiar with this initiative that is so little exploited and has so many benefits. An example is that it can bring a country closer to the net zero objective and the renewable generation targets for the energy transition.

The world paradigm is shifting towards a sustainable version, where the traditional ways of energy are seen as a step back from the place the world wants to become. All around the globe the proportion of renewable energy generation has grown significantly and targets like the Net Zero strategy for 2050 are encouraging those countries that have been kept behind in the energy transition. Similarly, the consumption of renewable sources in the final energy consumption has increased in the last decade leaving outside the power mix some of the sources linked to the aggravation of climate change.

The regulation of energy communities is something that still needs to be improved. The idea of it exists in Spain, the UK, California and Queensland, however, in order to properly exploit its benefits a coherent and specific regulation is necessary, especially in the UK and in Queensland where there are no laws that encapsulate specifically the term. Something that has been found of extreme aid is a self-consumption guide, that consumers or individuals interested can consult when required.

The cost of renewables is decreasing and consumers should take advantage of this. Community energy is characterized by the individuals' participation and its democratic control, so a good way to benefit from these reductions of price is by developing an energy community. Favoring by the less expensive cost of installing a renewable system in their property together with the already existing incentives should encourage consumers. Governments should seize the opportunity and promote now the concept of community energy, pursuing therefore their efforts to mitigate climate change, but now with the help of the citizens.

When the study was started the UK, California and Queensland would be more advanced in the subject of community energy, that Spain would be the region that needed to speed up in the transition and modernization, however it seems that this turned out to be wrong. After this semester studying the matter, analyzing the data and existing literature we may conclude that Spain is currently the most structured in the subject of community energy, it counts with a well-regulated framework as well as, incentives to fund projects or deduct taxes. But the main difference is clearly the regulation, a firm and clear law where the most relevant issues are covered, in my opinion that is what the other regions are missing, especially the United Kingdom and Queensland. This does not mean that CE has not been developed in the other three places, only that the concept is too broad and clarifications in the regulation would help its promotion.

In conclusion a well-established legal framework and attractive incentives, together with the reduction of the cost of renewable sources technology is the perfect recipe for a successful nudge towards a world where community energy projects are normalized.

CHAPTER 6: CONCLUSION

In this study we have explored and analyzed the regulatory framework and the incentives that concern energy communities. To do so, four regions have been chosen to focus the study, these are Spain, the United Kingdom, California and Queensland. By examining the legislative framework, incentive programs and policy approaches in these jurisdictions, a comprehensive understanding of the current state of community energy initiatives has been achieved.

In the third chapter of the document the aim has been to contextualize the actual situation of the energy sector in each of the administrations mentioned. A PESTLE analysis of this matter has been done in order to obtain a deeper understanding of the factors that influence it. In this type of investigation, a thorough study of the political, economic, sociocultural, technological, legal and environmental aspects of the energy sector is carried out so as to situate the reader and elaborate a more accurate and informed comparison. At the end of this chapter we contrast the information gathered from the analysis.

From the political subsection we extract that the governments of Spain, the UK, California and Queensland are all promoting the use of renewable energy and they have all signed the Paris Agreement, which is an international treaty that aims to combat climate change by limiting global warming to below 2 degrees Celsius from pre-industrial levels as well as limit the temperature increase to 1.5 degrees Celsius. This shows the interest of the administrations in the mitigation of climate change. It has been proven that the use of renewable energy helps with this matter and therefore governments are encouraging its growth. Along with the Paris Agreement, the regions have established targets of renewable energy generation in order to achieve net zero emissions by 2050. The Spanish target for

2030 is a 74% of renewable generation, this is the most ambitious of the four, being the UK's a 65% and California's and Queensland's 50%. From this it can be concluded that the political aspect of the energy sector is more determined in Spain, where the goals of renewable energy generation is the highest.

In the economic subsection, it has been gathered that the clean energy sector does create job opportunities and that it is currently growing. It seems that the decrease in the exploitation of fossil fuels is a concern for unemployment, however, this can be compensated by the augment of renewable sources utilization.

The sociocultural chapter offers the latest data available of the population in each of the regions studied in this document and the conclusion is that the population in Queensland is substantially smaller which affect the study, as its energy generation, consumption number of initiatives and financial aid is all affected by this. Countries like the UK or Spain are not comparable with a state such as Queensland where the population is around 9 times smaller. Similarly, the information about this region's energy sector is less abundant and harder to access.

To continue, the technological aspects of the energy sector are clearly advancing, a special focus on energy storage and energy saving has been done. This has helped with the generation of renewable energy which thanks to the advancement of technologies that concern solar and wind sources. These natural resources are the ones that generate the most energy in the four jurisdictions of interest. From this we can conclude that governments should invest more capital in the investigation and research of technologies that deploy solar and wind installations.

A conclusion that can be drawn from the environmental section of the document is that Queensland is from the regions studied the one that most consumes renewable energy. It is interesting and apparent that in the four jurisdictions fossil fuels are the most consumed sources and natural gas is in the top two of Spain, the UK and California. With Australia's generation of coal, it is clear that that is one of the most consumed sources in Queensland

From these chapter, the analysis of the energy sector in Spain, the United Kingdom, California and Queensland it can be concluded that all these regions are encouraging the use and exploitation of renewables and that the decrease of the prices of these sources is helping it happen.

The fourth chapter of the document attends community energy specifically. Its regulation is studied first followed by the incentives. From the regulation analysis we can extract that it is not solid in Queensland and in the UK, as there is not a set legal framework for energy communities. The Spanish and the American government do count with particular laws for the concept, making it easier to regulate, explain to individuals and therefore, to promote the mechanism. The number of community energy for the case of California and Queensland is not available. It seems that in Queensland the term community energy is not as developed as in other administrations, as there is no actual regulation or much information about the subject. Along these lines, the Queensland guide on self-consumption is almost 10 years old and does not reflect the modifications that have been done in the matter of self-consumption or renewable resources that have been made since 2014.

The incentives for the implementation of a community energy take the form of income, property or consumption taxes. The deduction of taxes is one of the ways the government promotes the installation of renewable systems. It seems that the feed-in tariff was only successful in Queensland; Spain, the United Kingdom and California withdrew theirs around

2019. It could be that other forms of incentives are more reliable, for example the income taxes that reduce the tax to pay when installations of self-consumption are made. In Spain with the return of the tax *"Impuesto sobre la renta de las personas físicas"* and California with its Investment Tax Credit, the government encourages community energy to evolve.

Government schemes are also a way community energy is being incentivized. In the case of Spain there is a specific initiative that promotes community energy, called CE IMPLEMENTA. However, in the United Kingdom, California and Queensland no schemes have been launched that specifically target the mechanism of energy communities. Programs to encourage renewable energy generation do exist but in a more general way.

Finally, from the information gathered we can conclude that the growth of community energy heavily relies on the government of the region. The power to create a stable and concise regulation is in their hands and that would help and attract more customers. The government schemes to encourage implementation of community energy have room for improvement, even though they exist, a similar program like CE IMPLEMENTA offered in Spain would be powerful in the United Kingdom, California and Queensland. In conclusion, energy communities present financial advantages like tax deductions that would be worth the initial investment, however these advantages can still improve making this mechanism more attractive. By leveraging the lessons learned from these regions, a more sustainable and inclusive energy future can be realized through the implementation of community energy projects, benefitting both the environment and the local communities.

REFERENCES

[1] J. M. Sánchez y J. F. Gómez, «Comunidades Energéticas», *Cuad. Orkestra*, n.º 05/2022.

[2] Repsol, «Informe Gestión Integrado 2022», Repsol. Accedido: 15 de junio de 2023. [En línea]. Disponible en: repsol.com/content/dam/repsol-corporate/es/accionistas-e-inversores/informes-anuales/2022/informe-gestion-integrado-2022.pdf

[3] P. R. Shukla, J. Skea, A. Reisinger, y R. Slade, «Climate Change 2022 Mitigation of Climate Change», *Intergov. Panel Clim. Change*.

[4] Enerdata, «Intensidad de consumo energético del PNB | Datos de intensidad de consumo energético global | Enerdata». https://datos.enerdata.net/energia-total/intensidad-energetica-pib-datos.html (accedido 27 de febrero de 2023).

[5] J. Child, «Subject guides: Marketing: PESTLE Analysis». https://libguides.library.usyd.edu.au/c.php?g=508107&p=5994242 (accedido 14 de junio de 2023).

[6] J. Paul, W. M. Lim, A. O'Cass, A. W. Hao, y S. Bresciani, «Scientific procedures and rationales for systematic literature reviews (SPAR-4-SLR)», *Int. J. Consum. Stud.*, vol. 45, n.º 4, pp. O1-O16, 2021, doi: 10.1111/ijcs.12695.

[7] W. M. Lim, S. Kumar, S. Verma, y R. Chaturvedi, «Alexa, what do we know about conversational commerce? Insights from a systematic literature review», *Psychol. Mark.*, vol. 39, mar. 2022, doi: 10.1002/mar.21654.

[8] European Commission, «In focus: Renewable energy in Europe». https://commission.europa.eu/news/focus-renewable-energy-europe-2020-03-18_en (accedido 22 de marzo de 2023).

[9] European Commission, «Energy Efficiency Directive». https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en (accedido 23 de marzo de 2023).

[10] Á. Manso-Burgos, D. Ribó-Pérez, T. Gómez-Navarro, y M. Alcázar-Ortega, «Local energy communities modelling and optimisation considering storage, demand configuration and sharing strategies: A case study in Valencia (Spain)», *Energy Rep.*, vol. 8, pp. 10395-10408, nov. 2022, doi: 10.1016/j.egyr.2022.08.181.

[11] C. Carella, «The Clean Energy for all Europeans Package», *Florence School of Regulation*, 10 de junio de 2020. https://fsr.eui.eu/the-clean-energy-for-all-europeans-package/ (accedido 22 de marzo de 2023).

[12] N. Rezaei Sadr, T. Bahrdo, y R. Taghizadeh, «Impacts of Paris agreement, fossil fuel consumption, and net energy imports on CO2 emissions: a panel data approach for

three West European countries», *Clean Technol. Environ. Policy*, vol. 24, n.º 5, pp. 1521-1534, jul. 2022, doi: 10.1007/s10098-021-02264-z.

[13] W. Liu, W. J. McKibbin, A. C. Morris, y P. J. Wilcoxen, «Global economic and environmental outcomes of the Paris Agreement», *Energy Econ.*, vol. 90, p. 104838, ago. 2020, doi: 10.1016/j.eneco.2020.104838.

[14] European Commission, «Paris Agreement». https://climate.ec.europa.eu/eu-action/international-action-climate-change/climate-negotiations/paris-agreement_en (accedido 28 de abril de 2023).

[15] The Economist, «What is the European Green Deal?», *The Economist*. Accedido: 23 de marzo de 2023. [En línea]. Disponible en: https://www.economist.com/the-economist-explains/2021/06/01/what-is-the-european-green-deal

[16] European Commission, «A European Green Deal», 14 de julio de 2021. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en (accedido 23 de marzo de 2023).

[17] International Energy Agency, «EU Renewable Energy Financing Mechanism – Policies», *IEA*. https://www.iea.org/policies/11708-eu-renewable-energy-financing-mechanism (accedido 23 de marzo de 2023).

[18] European Commission, «EU renewable energy financing mechanism». https://energy.ec.europa.eu/topics/renewable-energy/financing/eu-renewable-energy-financing-mechanism_en (accedido 23 de marzo de 2023).

[19] European Council, «Fit for 55», 23 de marzo de 2023. https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/ (accedido 23 de marzo de 2023).

[20] W. H. Wang, V. I. Espinosa, y J. Huerta de Soto, «A Free-Market Environmentalist Enquiry on Spain’s Energy Transition along with Its Recent Increasing Electricity Prices», *Int. J. Environ. Res. Public. Health*, vol. 19, n.º 15, p. 9493, ago. 2022, doi: 10.3390/ijerph19159493.

[21] Plan de Recuperación, Transformación y Resilencia, «Despliegue e integración de energías renovables». https://planderecuperacion.gob.es/politicas-y-componentes/componente-7-despliegue-e-integracion-de-energias-renovables (accedido 23 de marzo de 2023).

[22] United Nations Framework Convention on Climate Change, «Renewable Power Remains Cost-Competitive amid Fossil Fuel Crisis | UNFCCC». https://unfccc.int/news/renewable-power-remains-cost-competitive-amid-fossil-fuel-crisis (accedido 26 de marzo de 2023).

[23] International Renewable Energy Agency, «Renewable Power Generation Costs 2020», *Int. Renew. Energy Agency*, 2020.

[24] European Commission, *Report from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions Energy prices and costs in Europe*. 2020. Accedido: 26 de marzo de 2023. [En línea]. Disponible en: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1602774170631&uri=CELEX:52020DC0951
[25] J. S. Duffield, «The politics of renewable power in Spain», *Eur. J. Gov. Econ.*, vol. 9, n.º 1, pp. 5-25, may 2020, doi: 10.17979/ejge.2020.9.1.5231.
[26] European Commission, «In focus: Employment in EU's renewable energy sector». https://commission.europa.eu/news/focus-employment-eus-renewable-energy-sector-2022-05-16_en (accedido 3 de abril de 2023).
[27] Instituto Nacional de Estadística, «INEbase. CONSUL», *Instituto Nacional de Estadística*. https://www.ine.es/consul/serie.do?d=true&s=CP335 (accedido 1 de abril de 2023).
[28] Centro de Investigaciones Sociológicas, «·CIS·Centro de Investigaciones Sociológicas·Ficha del estudio». https://www.cis.es/cis/opencm/ES/2_bancodatos/estudios/ver.jsp?estudio=11404 (accedido 1 de abril de 2023).
[29] Centro de Investigaciones Sociológicas, «·CIS·Centro de Investigaciones Sociológicas·Ficha del estudio». https://www.cis.es/cis/opencm/ES/1_encuestas/estudios/ver.jsp?estudio=14695 (accedido 1 de abril de 2023).
[30] British Petroleum bp, «Statistical Review of World Energy 2022», *Br. Pet.*, 2022.
[31] Red Eléctrica, «Informe del Sistema Eléctrico 2022.», 2022, [En línea]. Disponible en: https://www.sistemaelectrico-ree.es/sites/default/files/2023-03/ISE_2022.pdf
[32] G. San Miguel y B. Corona, «Economic viability of concentrated solar power under different regulatory frameworks in Spain», *Renew. Sustain. Energy Rev.*, vol. 91, pp. 205-218, ago. 2018, doi: 10.1016/j.rser.2018.03.017.
[33] P.-A. Parent, P. Mirzania, N. Balta-Ozkan, y P. King, «Post subsidy conditions: Evaluating the techno-economic performance of concentrating solar power in Spain», *Sol. Energy*, vol. 218, pp. 571-586, abr. 2021, doi: 10.1016/j.solener.2021.01.069.
[34] G. M. Cabello, S. J. Navas, I. M. Vázquez, A. Iranzo, y F. J. Pino, «Renewable medium-small projects in Spain: Past and present of microgrid development», *Renew. Sustain. Energy Rev.*, vol. 165, p. 112622, sep. 2022, doi: 10.1016/j.rser.2022.112622.
[35] J. López Prol y K. W. Steininger, «Photovoltaic self-consumption is now profitable in Spain: Effects of the new regulation on prosumers' internal rate of return», *Energy Policy*, vol. 146, p. 111793, nov. 2020, doi: 10.1016/j.enpol.2020.111793.

[36] International Energy Agency, «Energy Storage Strategy – Policies», *International Energy Agency, IEA*. https://www.iea.org/policies/12809-energy-storage-strategy (accedido 3 de abril de 2023).

[37] Gobierno de España, «PERTE Energías Renovables», Gobierno de España. [En línea]. Disponible en: https://planderecuperacion.gob.es/sites/default/files/2021-12/PERTE_Energias%20renovables_RE_14122021.pdf

[38] Red Eléctrica, «Red Eléctrica». https://www.ree.es/es/conocenos/ree-en-2-minutos (accedido 13 de mayo de 2023).

[39] Red Eléctrica, «Objetivos 2030». https://www.ree.es/es/sostenibilidad/compromiso-con-la-sostenibilidad/objetivos-2030 (accedido 13 de mayo de 2023).

[40] Comisión Nacional de los Mercados y la Competencia, «Energía». https://www.cnmc.es/en/ambitos-de-actuacion/energia (accedido 10 de mayo de 2023).

[41] Ministerio para la Transición Ecológica y el Reto Demográfico, «Funciones y estructura». https://www.miteco.gob.es/es/ministerio/funciones-estructura/default.aspx (accedido 13 de mayo de 2023).

[42] European Commission, «National Contact Points». https://climate.ec.europa.eu/eu-action/funding-climate-action/innovation-fund/national-contact-points_en (accedido 13 de mayo de 2023).

[43] Red Eléctrica, «Regulatory framework». https://www.ree.es/en/about-us/regulatory-framework (accedido 22 de junio de 2023).

[44] Ministerio para la Transición Ecológica, *Real Decreto 244/2019, de 5 de abril, por el que se regulan las condiciones administrativas, técnicas y económicas del autoconsumo de energía eléctrica*, vol. BOE-A-2019-5089. 2019, pp. 35674-35719. Accedido: 3 de abril de 2023. [En línea]. Disponible en: https://www.boe.es/eli/es/rd/2019/04/05/244

[45] Asociación Empresarial Eólica, «Wind energy in Spain», *Asociación Empresarial Eólica*. https://aeeolica.org/sobre-la-eolica/la-eolica-en-espana/ (accedido 4 de abril de 2023).

[46] International Energy Agency IEA, «Spain 2021 Energy Policy Review», *Int. Energy Agency*, 2021.

[47] Instituto Nacional de Estadística, «España en cifras 2023», INE, 2023. [En línea]. Disponible en: file:///C:/Users/usuario/Downloads/PUBLICACION_COMPLETA__EEC2023%20(1).pdf

[48] Government of the United Kingdom, «Net Zero Strategy: Build Back Greener», *GOV.UK*, 5 de abril de 2022. https://www.gov.uk/government/publications/net-zero-strategy (accedido 13 de abril de 2023).

[49] P. O'Beirne *et al.*, «The UK net-zero target: Insights into procedural justice for greenhouse gas removal», *Environ. Sci. Policy*, vol. 112, pp. 264-274, oct. 2020, doi: 10.1016/j.envsci.2020.06.013.

[50] E. Participation, «Climate Change Act 2008». https://www.legislation.gov.uk/ukpga/2008/27/section/32 (accedido 6 de abril de 2023).

[51] E. Participation, «Climate Change Act 2008». https://www.legislation.gov.uk/ukpga/2008/27/part/1/crossheading/carbon-budgeting (accedido 6 de abril de 2023).

[52] Government of the United Kingdom, «Clean Growth Strategy», oct. 2018, [En línea]. Disponible en: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf

[53] Committee on Climate Change, «Independent Assessment of UK's Clean Growth Strategy 2018», Committee on Climate Change CCC, ene. 2018.

[54] C. Kuzemko, M. Blondeel, y A. Froggatt, «Brexit implications for sustainable energy in the UK», *Policy Polit.*, vol. 50, n.º 4, pp. 548-567, oct. 2022, doi: 10.1332/030557321X16510710991392.

[55] National Audit Office, «Investigation into the 2017 auction for low-carbon electricity generation contracts», may 2018, [En línea]. Disponible en: https://www.nao.org.uk/wp-content/uploads/2018/05/Investigation-into-the-2017-auction-for-low-carbon-electricity-generation-contracts.pdf

[56] M. Welisch y R. Poudineh, «Auctions for allocation of offshore wind contracts for difference in the UK», *Renew. Energy*, vol. 147, pp. 1266-1274, mar. 2020, doi: 10.1016/j.renene.2019.09.085.

[57] Just Transition Commission Scotland, «Oil and Gas sector background information», Just Transition Commission Scotland.

[58] Government of the United Kingdom, «Trends in UK imports and exports of fuels - Office for National Statistics». https://www.ons.gov.uk/economy/nationalaccounts/balanceofpayments/articles/trendsinukimportsandexportsoffuels/2022-06-29 (accedido 13 de abril de 2023).

[59] International Energy Agency IEA, «Challenges and opportunities beyond 2021 – Renewable energy market update – Analysis», *IEA*. https://www.iea.org/reports/renewable-energy-market-update/challenges-and-opportunities-beyond-2021 (accedido 13 de abril de 2023).

[60] Enerdata, «United Kingdom Energy Information». https://www.enerdata.net/estore/energy-market/united-kingdom/ (accedido 13 de abril de 2023).

[61] Government of the United Kingdom, «National population projections - Office for National Statistics». https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/nationalpopulationprojections/2020basedinterim (accedido 12 de abril de 2023).

[62] Government of the United Kingdom, «Three-quarters of adults in Great Britain worry about climate change - Office for National Statistics». https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/articles/threequartersofadultsingreatbritainworryaboutclimatechange/2021-11-05 (accedido 12 de abril de 2023).

[63] K. Harris, «Energy Trends: UK total energy», *Gov. U. K.*.

[64] A. L. Taylor, S. Dessai, y W. Bruine de Bruin, «Public perception of climate risk and adaptation in the UK: A review of the literature», *Clim. Risk Manag.*, vol. 4-5, pp. 1-16, ene. 2014, doi: 10.1016/j.crm.2014.09.001.

[65] Department of Energy and Climate Change, «Community Energy in the UK: A review of the evidence», Department of Energy and Climate Change, jun. 2013.

[66] International Energy Agency IEA, «United Kingdom - Countries & Regions», *IEA*. https://www.iea.org/countries/united-kingdom (accedido 13 de mayo de 2023).

[67] C. Peñasco y L. D. Anadón, «Assessing the effectiveness of energy efficiency measures in the residential sector gas consumption through dynamic treatment effects: Evidence from England and Wales», *Energy Econ.*, vol. 117, p. 106435, ene. 2023, doi: 10.1016/j.eneco.2022.106435.

[68] Department for Business, Energy and Industrial Strategy, «Energy Consumption in the UK 2022», *Gov. U. K.*, 2021.

[69] J. I. Chowdhury, Y. Hu, I. Haltas, N. Balta-Ozkan, G. Jr. Matthew, y L. Varga, «Reducing industrial energy demand in the UK: A review of energy efficiency technologies and energy saving potential in selected sectors», *Renew. Sustain. Energy Rev.*, vol. 94, pp. 1153-1178, oct. 2018, doi: 10.1016/j.rser.2018.06.040.

[70] RenewableUK, «Wind Energy Statistics». https://www.renewableuk.com/page/UKWEDHome (accedido 13 de abril de 2023).

[71] UK Government, «Wind powered electricity in the UK», UK Government.

[72] G. Gosnell y D. McCoy, «Market failures and willingness to accept smart meters: Experimental evidence from the UK», *J. Environ. Econ. Manag.*, vol. 118, p. 102756, mar. 2023, doi: 10.1016/j.jeem.2022.102756.

[73] Government of the United Kingdom, «Community Energy», *GOV.UK*, 26 de enero de 2015. https://www.gov.uk/guidance/community-energy (accedido 13 de abril de 2023).

[74] Office of Gas and Electricity Markets, «Our strategy for regulating the future energy system», Ofgem.

[75] E. Participation, «Energy Act 2008». https://www.legislation.gov.uk/ukpga/2008/32/contents (accedido 28 de abril de 2023).

[76] V. Brummer, «Community energy – benefits and barriers: A comparative literature review of Community Energy in the UK, Germany and the USA, the benefits it provides for society and the barriers it faces», *Renew. Sustain. Energy Rev.*, vol. 94, pp. 187-196, oct. 2018, doi: 10.1016/j.rser.2018.06.013.

[77] O. Edenhofer, R. Pichs Madruga, Y. Sokona, y IPCC, Eds., *Renewable energy sources and climate change mitigation: summary for policymakers and technical summary*. Genf: International Panel of Climate Change, 2011.

[78] National Renewable Energy Laboratory, «Advancing Marine Energy Technologies Through NREL's Laboratory Validation Capabilities (Text Version)». https://www.nrel.gov/news/video/advancing-marine-energy-technologies-through-nrels-laboratory-validation-capabilities-text.html (accedido 28 de abril de 2023).

[79] World Bank, «World Bank Open Data», *World Bank Open Data*. https://data.worldbank.org (accedido 13 de junio de 2023).

[80] Government of the United Kingdom, «Offshore wind». https://www.great.gov.uk/international/content/investment/sectors/offshore-wind/ (accedido 28 de abril de 2023).

[81] International Trade Administration, «United Kingdom Offshore Wind». https://www.trade.gov/market-intelligence/united-kingdom-offshore-wind (accedido 28 de abril de 2023).

[82] United Kingdom Research and Innovation, «Harnessing offshore wind». https://www.ukri.org/news-and-events/responding-to-climate-change/topical-stories/harnessing-offshore-wind/ (accedido 28 de abril de 2023).

[83] United States Department of Energy, «Alternative Fuels Data Center: Key Federal Legislation». https://afdc.energy.gov/laws/key_legislation (accedido 27 de abril de 2023).

[84] J. B. Skjærseth, S. Andresen, G. Bang, y G. M. Heggelund, «The Paris agreement and key actors' domestic climate policy mixes: comparative patterns», *Int. Environ. Agreem.*, vol. 21, n.º 1, pp. 59-73, 2021, doi: 10.1007/s10784-021-09531-w.

[85] H.-B. Zhang, H.-C. Dai, H.-X. Lai, y W.-T. Wang, «U.S. withdrawal from the Paris Agreement: Reasons, impacts, and China's response», *Adv. Clim. Change Res.*, vol. 8, n.º 4, pp. 220-225, dic. 2017, doi: 10.1016/j.accre.2017.09.002.

[86] D. A. Mazmanian, J. L. Jurewitz, y H. T. Nelson, «State Leadership in U.S. Climate Change and Energy Policy: The California Experience», *J. Environ. Dev.*, vol. 29, n.º 1, pp. 51-74, mar. 2020, doi: 10.1177/1070496519887484.

[87] International Energy Agency IEA, «Renewable Portfolio Standard - California – Policies», *IEA*. https://www.iea.org/policies/3796-renewable-portfolio-standard-california (accedido 24 de abril de 2023).

[88] California Public Utilities Commission, «Renewables Portfolio Standard (RPS) Program». https://www.cpuc.ca.gov/rps/ (accedido 24 de abril de 2023).

[89] G. Petek, «Assessing California's Climate Policies—Electricity Generation», *Legis. Anal. Off.*, ene. 2020.

[90] California Public Utilities Commission Energy Division, «Net-Energy Metering Lookback Study», California Public Utilities Commission, ene. 2021.

[91] Department of Energy, «DOE Report Finds Energy Jobs Grew Faster Than Overall U.S. Employment in 2021», *Energy.gov*. https://www.energy.gov/articles/doe-report-finds-energy-jobs-grew-faster-overall-us-employment-2021 (accedido 25 de abril de 2023).

[92] US Energy and Employment Report, «USEER 2022 Executive Summary», USEER, 2022.

[93] California Government, «2020 California Energy and Employment Report», [bw] Research Partnership.

[94] California Energy Commission, «Renewable Tracking Progress», *Calif. Energy Comm.*, 2020.

[95] W. Lawhorn, «Solar and wind generation occupations: a look at the next decade : Beyond the Numbers: U.S. Bureau of Labor Statistics». https://www.bls.gov/opub/btn/volume-10/solar-and-wind-generation-occupations-a-look-at-the-next-decade.htm (accedido 25 de abril de 2023).

[96] M. Y. Abido, Z. Mahmud, P. A. Sánchez-Pérez, y S. R. Kurtz, «Seasonal challenges for a California renewable- energy-driven grid», *iScience*, vol. 25, n.º 1, p. 103577, dic. 2021, doi: 10.1016/j.isci.2021.103577.

[97] U. C. Bureau, «U.S. Population», *The United States Census Bureau*. https://www.census.gov/search-results.html (accedido 25 de abril de 2023).

[98] Census Bureau, «U.S. Census Bureau QuickFacts: California». https://www.census.gov/quickfacts/CA (accedido 23 de junio de 2023).

[99] U. C. Bureau, «California Remained Most Populous State but Growth Slowed Last Decade», *Census.gov*. https://www.census.gov/library/stories/state-by-state/california-population-change-between-census-decade.html (accedido 25 de abril de 2023).

[100] K. Maclay y M. relations|, «IGS poll: Californians support stronger climate-change rules», *Berkeley News*, 2 de septiembre de 2015. https://news.berkeley.edu/2015/09/02/igs-poll-californians-support-stronger-climate-change-rules/ (accedido 25 de abril de 2023).

[101] A. Leiserowitz, E. Maibach, S. Rosenthal, y J. Kotcher, «Climate Change in the American Mind», Politics&Policy, dic. 2022.

[102] J. R. Marlon *et al.*, «Change in US state-level public opinion about climate change: 2008–2020», *Environ. Res. Lett.*, vol. 17, n.º 12, p. 124046, dic. 2022, doi: 10.1088/1748-9326/aca702.

[103] Public Policy Institute of California, «PPIC Statewide Survey: Californians and the Environment», *Public Policy Institute of California*. https://www.ppic.org/publication/ppic-statewide-survey-californians-and-the-environment-july-2022/ (accedido 25 de abril de 2023).

[104] L. C. Kunkel, H. L. Breetz, y J. K. Abbott, «100% renewable electricity policies in U.S. cities: A mixed methods analysis of adoption and implementation», *Energy Policy*, vol. 167, p. 113053, ago. 2022, doi: 10.1016/j.enpol.2022.113053.

[105] C. E. Commission, «Electric Generation Capacity and Energy», *California Energy Commission*, current-date. https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/electric-generation-capacity-and-energy (accedido 25 de abril de 2023).

[106] California Energy Commission, «2021 Total System Electric Generation», *California Energy Commission*, 2021. https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2021-total-system-electric-generation (accedido 25 de abril de 2023).

[107] Energy Information Administration, «U.S. Energy Information Administration - EIA - Independent Statistics and Analysis». https://www.eia.gov/state/analysis.php?sid=CA (accedido 25 de abril de 2023).

[108] O. Usman, A. A. Alola, y S. A. Sarkodie, «Assessment of the role of renewable energy consumption and trade policy on environmental degradation using innovation accounting: Evidence from the US», *Renew. Energy*, vol. 150, pp. 266-277, may 2020, doi: 10.1016/j.renene.2019.12.151.

[109] S. A. Solarin, M. O. Bello, y A. K. Tiwari, «The impact of technological innovation on renewable energy production: accounting for the roles of economic and environmental factors using a method of moments quantile regression», *Heliyon*, vol. 8, n.º 7, p. e09913, jul. 2022, doi: 10.1016/j.heliyon.2022.e09913.

[110] J. Mitali, S. Dhinakaran, y A. A. Mohamad, «Energy storage systems: a review», *Energy Storage Sav.*, vol. 1, n.º 3, pp. 166-216, sep. 2022, doi: 10.1016/j.enss.2022.07.002.

[111] C. E. Commission, «Core Responsibility Fact Sheets», *California Energy Commission*, current-date. https://www.energy.ca.gov/about/core-responsibility-fact-sheets (accedido 25 de abril de 2023).

[112] California Independent System Operator, «California ISO - Our Commitment». https://www.caiso.com/about/Pages/OurCommitment/default.aspx (accedido 25 de abril de 2023).
[113] E. Baik, K. Siala, T. Hamacher, y S. M. Benson, «California's approach to decarbonizing the electricity sector and the role of dispatchable, low-carbon technologies», *Int. J. Greenh. Gas Control*, vol. 113, p. 103527, ene. 2022, doi: 10.1016/j.ijggc.2021.103527.
[114] California Public Utilities Commission, «Bill Text - AB-2316 Public Utilities Commission». https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB2316 (accedido 25 de abril de 2023).
[115] Energy Information Administration, «Total Energy Monthly Data - U.S. Energy Information Administration (EIA)». https://www.eia.gov/totalenergy/data/monthly/index.php (accedido 25 de abril de 2023).
[116] Energy Information Administration (EIA), «US Primary Energy Comsumtion», EIA.
[117] Energy Information Administration, «California Profile». https://www.eia.gov/state/print.php?sid=CA (accedido 22 de junio de 2023).
[118] Energy Information Administration, «U.S. Energy Information Administration - EIA - Ranking». https://www.eia.gov/state/rankings/?sid=CA#series/12 (accedido 27 de abril de 2023).
[119] J. L. Kafka y M. A. Miller, «A climatology of solar irradiance and its controls across the United States: Implications for solar panel orientation», *Renew. Energy*, vol. 135, pp. 897-907, may 2019, doi: 10.1016/j.renene.2018.12.057.
[120] California Energy Commission, «Offshore Wind Energy Development off the California Coast», *California Energy Commission*, agosto de 2022. https://www.energy.ca.gov/publications/2022/offshore-wind-energy-development-california-coast-maximum-feasible-capacity-and (accedido 25 de abril de 2023).
[121] T. Benedictos, «Australian Government Climate Change commitments, policies and programs», *Aust. Off. Financ. Manag.*.
[122] Australian Government, «Australia's nationally determined contribution», 2022, [En línea]. Disponible en: https://unfccc.int/sites/default/files/NDC/2022-06/Australias%20NDC%20June%202022%20Update%20%283%29.pdf
[123] M. K. Islam, N. M. S. Hassan, M. G. Rasul, K. Emami, y A. A. Chowdhury, «Green and renewable resources: an assessment of sustainable energy solution for Far North Queensland, Australia», *Int. J. Energy Environ. Eng.*, pp. 1-29, nov. 2022, doi: 10.1007/s40095-022-00552-y.

[124] A. Heidari *et al.*, «A comprehensive review of renewable energy resources for electricity generation in Australia», *Front. Energy*, vol. 14, n.º 3, pp. 510-529, sep. 2020, doi: 10.1007/s11708-020-0671-6.
[125] T. Maraseni y K. Reardon-Smith, «Meeting National Emissions Reduction Obligations: A Case Study of Australia», *Energies*, vol. 12, n.º 3, Art. n.º 3, ene. 2019, doi: 10.3390/en12030438.
[126] Queensland Government, «Queensland Climate Action», *Queensland Climate Action*, junio de 2021. https://www.des.qld.gov.au/climateaction/home (accedido 26 de abril de 2023).
[127] Queensland Government, «Cooler Cleaner Schools Program», *Department of Education*, 25 de noviembre de 2019. https://qed.qld.gov.au/programs-initiatives/department/building-education/major-projects/cooler-cleaner-schools (accedido 26 de abril de 2023).
[128] International Energy Agency IEA, «Exports – Coal Information: Overview – Analysis», *IEA*. https://www.iea.org/reports/coal-information-overview/exports (accedido 26 de abril de 2023).
[129] International Energy Agency IEA, «Total coal exports by major exporters, 2018 – Charts – Data & Statistics», *IEA*. https://www.iea.org/data-and-statistics/charts/total-coal-exports-by-major-exporters-1978-2020 (accedido 3 de mayo de 2023).
[130] R. Stutzer, A. Rinscheid, T. D. Oliveira, P. M. Loureiro, A. Kachi, y M. Duygan, «Black coal, thin ice: the discursive legitimisation of Australian coal in the age of climate change», *Humanit. Soc. Sci. Commun.*, vol. 8, n.º 1, Art. n.º 1, jul. 2021, doi: 10.1057/s41599-021-00827-5.
[131] J. Kemp, M. McCowage, y F. Wang, «Towards Net Zero: Implications for Australia of Energy Policies in East Asia», *Reserve Bank Aust.*.
[132] Parliament of Australia, «Employment trends in coal mining and the renewable energy sector», enero de 2023. https://www.aph.gov.au/About_Parliament/Parliamentary_departments/Parliamentary_Library/pubs/rp/rp2223/EmploymentTrendsCoalMiningRenewableEnergy (accedido 26 de abril de 2023).
[133] Australian Bureau of Statistics, «Employment in Renewable Energy Activities, Australia, 2018-19 financial year», 6 de abril de 2020. https://www.abs.gov.au/statistics/labour/employment-and-unemployment/employment-renewable-energy-activities-australia/latest-release (accedido 26 de abril de 2023).
[134] Australian Government, «Energy workforce». https://www.energy.gov.au/government-priorities/energy-workforce (accedido 26 de abril de 2023).

[135] M. Shahbaz, C. Raghutla, K. R. Chittedi, Z. Jiao, y X. V. Vo, «The effect of renewable energy consumption on economic growth: Evidence from the renewable energy country attractive index», *Energy*, vol. 207, p. 118162, sep. 2020, doi: 10.1016/j.energy.2020.118162.

[136] Australian Bureau of Statistics, «National, state and territory population, September 2022», 16 de marzo de 2023. https://www.abs.gov.au/statistics/people/population/national-state-and-territory-population/latest-release (accedido 28 de abril de 2023).

[137] Australian Bureau of Statistics, «Population Projections, Australia», 22 de noviembre de 2018. https://www.abs.gov.au/statistics/people/population/population-projections-australia/latest-release (accedido 28 de abril de 2023).

[138] N. Kachel, «Australia's attitudes to climate change», *ECOS*, 16 de diciembre de 2015. https://ecos.csiro.au/australias-attitudes-to-climate-change/ (accedido 28 de abril de 2023).

[139] Griffith University, «Climate Action Survey», Griffith University, abr. 2022.

[140] International Energy Agency, «Australia 2023 Energy Policy Review», *Int. Energy Agency*, 2023.

[141] Department of Energy and Public Works, «Queensland's Renewable Energy Target», Queensland Government. [En línea]. Disponible en: https://documents.parliament.qld.gov.au/com/TRC-645B/AGR5202122-D782/220314%20Tabled%20Paper%20-%20Queensland's%20renwable%20energy%20target.pdf

[142] Australian Government, «Australian Energy Update 2022», *Dep. Clim. Change Energy Environ. Water*, 2022.

[143] Australian Renewable Energy Agency, «ARENA Insights - Knowledge for Industry - Energy storage». https://createsend.com/t/t-81206210E94550422540EF23F30FEDED (accedido 27 de abril de 2023).

[144] Australian Government, «Australian Energy Regulator», *Australian Energy Regulator*, 22 de diciembre de 2014. https://www.aer.gov.au/about-us (accedido 26 de abril de 2023).

[145] Australian Energy Market Commission, «AEMC», *Australian Energy Market Commission*. https://www.aemc.gov.au/about-us (accedido 26 de abril de 2023).

[146] Australian Energy Market Operator, «AEMO». https://aemo.com.au/about/what-we-do (accedido 26 de abril de 2023).

[147] Australian Competition and Consumer Commission, «ACCC», 3 de abril de 2023. https://www.accc.gov.au/about-us (accedido 26 de abril de 2023).

[148] Queensland Government, «Electricity laws and regulations», 16 de junio de 2011. https://www.business.qld.gov.au/industries/mining-energy-

water/energy/electricity/regulation-licensing/regulatory-framework (accedido 22 de junio de 2023).
[149] Clean Energy Coulcil, «Clean Energy Australia Report 2023», Clean Energy Coulcil, 2023.
[150] Australian Government, «Australian energy mix by state and territory 2020-21 | energy.gov.au». https://www.energy.gov.au/data/australian-energy-mix-state-and-territory-2020-21 (accedido 22 de junio de 2023).
[151] Commonwealth Scientific and Industrial Research Organization, «Climate change in Australia». https://www.csiro.au/en/research/environmental-impacts/climate-change/climate-change-information (accedido 27 de abril de 2023).
[152] Australian Government Department of Health and Aged Care, «Climate change», *Australian Government Department of Health and Aged Care*, 5 de agosto de 2022. https://www.health.gov.au/topics/environmental-health/what-were-doing/climate-change (accedido 27 de abril de 2023).
[153] World Bank, «World Bank Climate Change Knowledge Portal». https://climateknowledgeportal.worldbank.org/ (accedido 27 de abril de 2023).
[154] Comisión Europea, *Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) (Text with EEA relevance.)*, vol. 328. 2018. Accedido: 9 de mayo de 2023. [En línea]. Disponible en: http://data.europa.eu/eli/dir/2018/2001/oj/eng
[155] A. X. Hearn y R. Castaño-Rosa, «Towards a Just Energy Transition, Barriers and Opportunities for Positive Energy District Creation in Spain», *Sustainability*, vol. 13, n.º 16, Art. n.º 16, ene. 2021, doi: 10.3390/su13168698.
[156] Comisión Europea, *Directiva (UE) 2019/944 del Parlamento Europeo y del Consejo, de 5 de junio de 2019, sobre normas comunes para el mercado interior de la electricidad y por la que se modifica la Directiva 2012/27/UE (versión refundida) (Texto pertinente a efectos del EEE.)*, vol. 158. 2019. Accedido: 9 de mayo de 2023. [En línea]. Disponible en: http://data.europa.eu/eli/dir/2019/944/oj/spa
[157] C. Gallego-Castillo, M. Heleno, y M. Victoria, «Self-consumption for energy communities in Spain: A regional analysis under the new legal framework», *Energy Policy*, vol. 150, feb. 2021, doi: 10.1016/j.enpol.2021.112144.
[158] Office of Gas and Electricity Markets, «Renewables Obligation: Closure of the scheme to small-scale solar PV», *Ofgem*, 1 de abril de 2016. https://www.ofgem.gov.uk/publications/renewables-obligation-closure-scheme-small-scale-solar-pv (accedido 9 de mayo de 2023).
[159] House of Commons Environmental Audit Committee, «Accelerating the transition from fossil fuels and securing energy supplies», *House Commons*.

[160] Queensland Government, «Climate action projects», *Queensland Climate Action*, 30 de julio de 2021. https://www.des.qld.gov.au/climateaction/projects (accedido 26 de abril de 2023).
[161] Queensland Council of Social Service, «Community Energy in Queensland», ago. 2018.
[162] Queensland Government, «Electricity Regulation 2006», *Qld. Gov.*, jul. 2022.
[163] Australian Energy Market Operator, «The National Electricity Market», Australian Energy Market Operator, dic. 2021.
[164] Office of Gas and Electricity Markets, «Energy policy and regulation, Ofgem», *Ofgem*. https://www.ofgem.gov.uk/energy-policy-and-regulation (accedido 10 de mayo de 2023).
[165] S. H. C. Collier, J. I. House, P. M. Connor, y R. Harris, «Distributed local energy: Assessing the determinants of domestic-scale solar photovoltaic uptake at the local level across England and Wales», *Renew. Sustain. Energy Rev.*, vol. 171, p. 113036, ene. 2023, doi: 10.1016/j.rser.2022.113036.
[166] P. D. Saundry, «Review of the United States energy system in transition», *Energy Sustain. Soc.*, vol. 9, n.º 1, p. 4, ene. 2019, doi: 10.1186/s13705-018-0178-8.
[167] Department of Energy, «Department of Energy US», *Energy.gov*. https://www.energy.gov/about-us (accedido 10 de mayo de 2023).
[168] California Public Utilities Commission, «About the CPUC». https://www.cpuc.ca.gov/about-cpuc (accedido 10 de mayo de 2023).
[169] Queensland Competition Authority, «Queensland Competition Authority», *QCA*. http://www.qca.org.au/ (accedido 10 de mayo de 2023).
[170] T. Meister, B. Schmid, I. Seidl, y B. Klagge, «How municipalities support energy cooperatives: survey results from Germany and Switzerland», *Energy Sustain. Soc.*, vol. 10, n.º 1, p. 18, 2020, doi: 10.1186/s13705-020-00248-3.
[171] Red Comunidades Energéticas, «Red de Comunidades Energéticas S.Coop.» https://comunidadesenergeticas.org/ (accedido 10 de mayo de 2023).
[172] Community Energy England, «Getting started with community energy». https://communityenergyengland.org/how-to-pages/getting-started-with-community-energy (accedido 10 de mayo de 2023).
[173] Cooperative Community Energy, «Cooperative Community Energy». http://www.ccenergy.com/ (accedido 10 de mayo de 2023).
[174] Instituto para la Diversificación y Ahorro de la Energía, «El IDAE publica el mapa de proyectos de más de 40 comunidades energéticas de España». https://www.miteco.gob.es/es/prensa/ultimas-noticias/el-idae-publica-el-mapa-de-proyectos-de-m%C3%A1s-de-40-comunidades-energ%C3%A9ticas-de-espa%C3%B1a-/tcm:30-552526 (accedido 23 de marzo de 2023).

[175] Community Energy Scotland, Community Energy England, y Community Energy Wales, «Community Energy | State of the sector report». Accedido: 13 de mayo de 2023. [En línea]. Disponible en: https://communityenergyengland.org/files/document/626/1655376945_CommunityEnergyStateoftheSectorUKReport2022.pdf

[176] Instituto para la Diversificación y Ahorro de la Energía, «Guia Profesional de Tramitación del Autoconsumo.», Accedido: 10 de mayo de 2023. [En línea]. Disponible en: https://www.idae.es/sites/default/files/documentos/publicaciones_idae/2023_01_10_Guia_Profesional_Tramitacion_autoconsumo_v.5.1.pdf

[177] California Public Utilities Commission, «Net Energy Metering». https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/net-energy-metering (accedido 12 de mayo de 2023).

[178] California Independent System Operator, «California ISO - Generation». http://www.caiso.com/participate/Pages/Generation/Default.aspx (accedido 12 de mayo de 2023).

[179] International Energy Agency, «Queensland Solar Bonus Scheme – Policies», *IEA*. https://www.iea.org/policies/3899-queensland-solar-bonus-scheme (accedido 12 de mayo de 2023).

[180] Ministerio para la Transición Ecológica y el Reto Demográfico, «Preguntas frecuentes sobre autoconsumo». https://energia.gob.es/electricidad/autoconsumo-electrico/Paginas/preguntas-frecuentes-autoconsumo.aspx (accedido 12 de mayo de 2023).

[181] Office of Gas and Electricity Markets, «Smart Export Guarantee (SEG)», *Ofgem*, 30 de marzo de 2023. https://www.ofgem.gov.uk/environmental-and-social-schemes/smart-export-guarantee-seg (accedido 12 de mayo de 2023).

[182] K. Hymes y J. Litwin, «Community Renewable Energy Proposal Workshop», *Calif. Public Util. Comm.*, 2022.

[183] California Public Utilities Commission, «California Solar Consumer Protection Guide 2021», *Calif. Public Util. Comm.*, mar. 2022.

[184] Department of Energy, «Guide to Community Strategic Energy Planning», mar. 2013. Accedido: 13 de mayo de 2023. [En línea]. Disponible en: https://www.energy.gov/scep/articles/guide-community-energy-strategic-planning-introduction

[185] Community Power Agency, «Community Energy how to guide», Community Power Agency. [En línea]. Disponible en: https://cpagency.org.au/wp-content/uploads/2019/07/Community-Energy-How-To-Guide.pdf

[186] Instituto para la Diversificación y Ahorro de la Energía, «Para Energías Renovables en autoconsumo, almacenamiento, y térmicas sector residencial (RD 477/2021. PRTR) | Idae». https://www.idae.es/ayudas-y-financiacion/para-energias-renovables-en-autoconsumo-almacenamiento-y-termicas-sector (accedido 6 de junio de 2023).
[187] Agencia Estatal Boletín del Estado, «BOE Diciembre 2021Orden TED/1446/2021», [En línea]. Disponible en: https://www.boe.es/diario_boe/txt.php?id=BOE-A-2021-21343
[188] Instituto para la Diversificación y Ahorro de la Energía, «Visor CCEE». https://informesweb.idae.es/visorccee/ (accedido 23 de marzo de 2023).
[189] Government of the United Kingdom, «Good Growth Strategies to Mitigate the Cost of Living - Find a grant». https://www.find-government-grants.service.gov.uk/grants/good-growth-strategies-to-mitigate-the-cost-of-living-1 (accedido 6 de junio de 2023).
[190] Office of Gas and Electricity Markets, «Domestic Renewable Heat Incentive (Domestic RHI)», *Ofgem*, 31 de marzo de 2023. https://www.ofgem.gov.uk/environmental-and-social-schemes/domestic-renewable-heat-incentive-domestic-rhi (accedido 6 de junio de 2023).
[191] California Public Utilities Commission, «Community Solar in California». https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/community-solar-in-california (accedido 6 de junio de 2023).
[192] California Energy Commission, «California Electric Homes Program», *Site Title*. https://caelectrichomes.com/ (accedido 6 de junio de 2023).
[193] Queensland Government, «Queensland's renewable energy target». https://www.epw.qld.gov.au/about/initiatives/renewable-energy-targets (accedido 9 de junio de 2023).
[194] Queensland Government, «Solar for remote communities». https://www.epw.qld.gov.au/about/initiatives/solar-remote-communities (accedido 9 de junio de 2023).
[195] Queensland Government, «Large-scale Renewable Energy Target and the Small-scale Renewable Energy Scheme | State of the Environment Report 2020». https://www.stateoftheenvironment.des.qld.gov.au/pollution/management-responses/policy-and-programs/large-scale-renewable-energy-target-and-the-small-scale-renewable-energy-scheme (accedido 12 de junio de 2023).
[196] Australian Government, «Small-scale Renewable Energy Scheme». https://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/How-the-scheme-works/Small-scale-Renewable-Energy-Scheme (accedido 12 de junio de 2023).

[197] R. Best, P. Burke, y S. Nishitateno, «Evaluating the effectiveness of Australia's Small-scale Renewable Energy Scheme for rooftop solar», *Energy Econ.*, vol. 84, p. 104475, ago. 2019, doi: 10.1016/j.eneco.2019.104475.

[198] Department for Business, Energy and Industrial Strategy, «The future for small-scale low-carbon generation», Department for Business, Energy and Industrial Strategy, mar. 2019.

[199] Office of Gas and Electricity Markets, «Smart Export Guarantee: Guidance for generators», *Ofgem*, 12 de diciembre de 2019. https://www.ofgem.gov.uk/publications/smart-export-guarantee-guidance-generators (accedido 9 de junio de 2023).

[200] N. R. Darghouth, G. Barbose, y R. Wiser, «The impact of rate design and net metering on the bill savings from distributed PV for residential customers in California», *Energy Policy*, vol. 39, n.º 9, pp. 5243-5253, sep. 2011, doi: 10.1016/j.enpol.2011.05.040.

[201] Queensland Government, «Connecting your solar system to the grid | Solar power for your home». https://www.qld.gov.au/housing/buying-owning-home/energy-water-home/solar/connecting-solar-to-the-grid (accedido 9 de junio de 2023).

[202] E. Matters, «Solar Overproduction: Net Metering vs Net Billing», *Energy Matters*, 24 de febrero de 2023. https://www.energymatters.com.au/renewable-news/solar-overproduction-net-metering-vs-net-billing/ (accedido 9 de junio de 2023).

[203] H. Lan, B. Cheng, Z. Gou, y R. Yu, «An evaluation of feed-in tariffs for promoting household solar energy adoption in Southeast Queensland, Australia», *Sustain. Cities Soc.*, vol. 53, p. 101942, feb. 2020, doi: 10.1016/j.scs.2019.101942.

[204] Queensland Competition Authority, «Solar feed-in tariffs in south east Queensland 2021–22», *Qld. Compet. Auth.*, 2022.

[205] California Public Utilities Commission, «Renewable FIT Program: ReMAT». https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-power-procurement/rps/rps-procurement-programs/rps-renewable-fit-program (accedido 9 de junio de 2023).

[206] SotySolar, «Deducciones IRPF por instalar Placas Solares 2023 ☼ SotySolar», *https://sotysolar.es/blog/irpf-paneles-solares*, 30 de mayo de 2023. https://sotysolar.es/blog/irpf-paneles-solares (accedido 12 de junio de 2023).

[207] London Government, «Removal of tax relief for community energy projects». https://www.london.gov.uk/who-we-are/what-london-assembly-does/questions-mayor/find-an-answer/removal-tax-relief-community-energy-projects (accedido 12 de junio de 2023).

[208] Government of the United Kingdom, «Tax on shopping and services», *GOV.UK*. https://www.gov.uk/tax-on-shopping/energy-saving-products (accedido 12 de junio de 2023).
[209] California Government, «Guidelines for Active Solar Energy Systems New Construction Exclusion», *Board Equal.*, 2012.
[210] California Public Utilities Commission, «California Solar Initiative (CSI)». https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/california-solar-initiative (accedido 12 de junio de 2023).
[211] Department of Energy, «Solar Investment Tax Credit: What Changed?», *Energy.gov*. https://www.energy.gov/eere/solar/articles/solar-investment-tax-credit-what-changed (accedido 27 de abril de 2023).
[212] Ministerio para la Transición Ecológica y el Reto Demográfico, «El Gobierno rebaja los precios energéticos y refuerza la protección de los consumidores». https://www.miteco.gob.es/es/prensa/ultimas-noticias/el-gobierno-rebaja-los-precios-energ%C3%A9ticos-y-refuerza-la-protecci%C3%B3n-de-los-consumidores/tcm:30-538752 (accedido 26 de marzo de 2023).
[213] E. C. van der Waal, «Local impact of community renewable energy: A case study of an Orcadian community-led wind scheme», *Energy Policy*, vol. 138, p. 111193, mar. 2020, doi: 10.1016/j.enpol.2019.111193.
[214] Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization, «Energy Communities IWG Summit», *Energy Communities*, 27 de abril de 2023. https://energycommunities.gov/past-event/white-house-energy-communities-briefing/ (accedido 25 de abril de 2023).

ANEXO I

Declaro, bajo mi responsabilidad, que el Proyecto presentado con el título Análisis comparado del marco y los incentivos a la creación de comunidades energéticas en Reino Unido, California (EE.UU.), Queensland (Australia) y España en la ETS de Ingeniería - ICAI de la Universidad Pontificia Comillas en el

curso académico 2022/2023 es de mi autoría, original e inédito y

no ha sido presentado con anterioridad a otros efectos. El Proyecto no es plagio de otro, ni total ni parcialmente y la información que ha sido tomada

de otros documentos está debidamente referenciada.

Fdo.: Mónica Fernández-Vega Escandón Fecha: 27/06/2023

Autorizada la entrega del proyecto

EL DIRECTOR DEL PROYECTO

Fdo.: José Pablo Chaves Ávila Fecha: ……/ ……/ ……

José Pablo Chaves

Firmado digitalmente por José Pablo Chaves
Fecha: 2023.06.29 14:13:08 +02'00'

Fdo.: Jesús José García Fernández Fecha: ……/ ……/ ……

45908046T JESÚS JOSÉ FERNÁNDEZ (C:Q1570003B)

Firmado digitalmente por 45908046T JESÚS JOSÉ FERNÁNDEZ (C:Q1570003B)
Fecha: 2023.06.30 21:31:20 +02'00'