Energy Justice as a lens in Green Hydrogen Transition challenges

An Exploratory Analysis in Western Macedonia, Greece

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TU Delft

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An Exploratory Analysis in Western Macedonia, Greece

by

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Executive Summary

As Greece pursues rapid decarbonisation and energy system transformation, green hydrogen is increasingly positioned as a cornerstone for achieving ambitious climate and energy targets. Nowhere are these dynamics more apparent than in Western Macedonia — the country's primary lignite region — which is undergoing profound economic and social restructuring as coal is phased out. This thesis critically examines the justice dimensions of Greece's green hydrogen transition, focusing on procedural, distributive and recognition justice in Western Macedonia.

To examine the identified research objectives, this study utilised a mixed-methods approach, including qualitative content analysis of documents that provide information about the policies and legislative framework that have been adopted to support energy transition through green hydrogen. In addition, nine semi-structured interviews were conducted with stakeholders among industry experts, policy advisors, energy community members and researchers. Thematic analysis was utilised as the primary approach for analysing the collected data. For the interview transcripts, the coding procedure was carried out using *Atlas.ti*, which helped in identifying recurring patterns in the energy justice framework dimensions. The study particularly focuses on the region of Western Macedonia, which provided valuable insights into how the energy transition process is being carried out in Greece and other EU Member states. The study explores the empirical data collected from the interviews, and the information was utilised to compare against an analysis of policy documents, which helped create a comprehensive understanding of the justice challenges that are currently being experienced in Western Macedonia.

The thematic analysis of the policy documents and empirical research led to the emergence of five key themes: the role of green hydrogen in the decarbonisation efforts, energy poverty, impact of the energy transition on employment, integration of stakeholders in energy policies and barriers to the development of green hydrogen technologies. Further, a thematic analysis of the semi-structured interviews revealed five key themes: lack of stakeholder inclusion, energy poverty and inequalities, lack of transparency, lack of communication and technology and economic barriers. These themes were used to relate the findings to the tenets of the energy justice framework. Overall, evidence shows that existing policies and legislative frameworks emphasise the need for a just transition, and they cover all three dimensions of the energy justice framework. In practice, however, these principles have not been upheld by the relevant government institutions. On procedural justice, evidence illustrated that the decision-making processes are typically centralised and top-down, which limits meaningful participation of the local communities. Concerning distributive justice, it was demonstrated that the benefits of the transition, including the creation of employment and development of infrastructure, are unevenly distributed, and the burden usually targets vulnerable social groups. On recognition justice, the analysis demonstrated that the needs and identities of marginalised groups have not been addressed, and there is a general lack of support in retraining and reskilling. The most critical barriers to the implementation of green hydrogen ecosystems include the high production costs, lack of adequate funding and regulatory flaws.

Based on the findings of the study, it is recommended that approaches that involve the local communities be adopted and ensure that they have meaningful participation in the design of the strategies. Policymakers and other stakeholders ought to ensure that there are sufficient funds to support energy communities and facilitate retraining and reskilling programs. It is also necessary for government institutions to enhance the transparency of the projects and ensure that there is accountability for those involved in the development stages. Moving forward, Greece should revise its existing policies and legislative framework with clear guidelines on how energy justice principles can be put into practice for the Western Macedonian's case.

Acknowledgments

Working on this thesis project has been an enjoyable experience for me as an engineer. It was by no means challenging my technically oriented mind to think in terms of the social context. Eventually, I had a great support team to help me overcome my doubts and fears. I would like to thank all the individuals and experts who participated in the interviews and provided me with the relevant information for the empirical analysis procedure for my thesis.

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Polychronia Angelidou
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List of Abbreviations

Abbreviation	Definition
CINEA	Climate, Infrastructure and Environmental Executive Agency
CluBE	Cluster of Bioeconomy & Environment of Western Macedonia
CRES	Centre of Renewable Energy Sources and Savings
E3G	Third generation Environmentalism
EEB	European Environmental Bureau
EC	Energy Community
EI	Expert Interviewee
EU	European Union
EUR	Euros (€)
GHG	Greenhouse Gases
GW	Gigawatt
HEDNO	Hellenic Electricity Distribution Network Operator
HT-PEM	High-Temperature Polymer Electrolyte Membrane
IEA	International Energy Agency
IPCEI	Important Project of Common European Interest
IPTO	Independent Power Transmission Operator
JDT	Just Development Transition
JTM	Just Transition Mechanisms
LHP	Large Hydropower Plant
LTS	Long-Term Strategy
MW	Megawatt
NECP	National Energy and Climate Plan
NSRF	National Strategy Reference Framework
NTUA	National Technical University of Athens
PPC	Public Power Corporation
RAE	Regularity Authority for Energy
RES	Renewable Energy Resources
R & D	Research and Development
S.A.	Société Anonyme (Anonymous Company)
SMEs	Small and Medium-Sized Enterprises
TRACER	Transition in Coal Intensive Regions

Contents

1

Introduction

Over the past three decades, significant progress has been made in renewable energy. In the European Union Member States, the share of renewable energy (RE) in total energy production increased from 8.7% in 2005 to 20% in 2020, representing a significant accomplishment (Lowitzsch, 2019). There has been growing pressure to minimise greenhouse gas emissions, and several institutions and individual countries have set specific targets that are seemingly attainable. Substantial progress has been made in several parts of the world, although the priorities for individual countries vary. The Energy Strategy and Energy Union set specific goals for all the Member States of the EU to transition to secure, competitive and sustainable energy. One of the goals is for the EU to collectively use renewable sources for 32% by 2030 (Mata Pérez et al., 2019). As one of the EU Member States, Greece has committed to reducing its emissions to meet the targets set by the Energy Commission (Karamaneas et al., 2023). Through the National Energy and Climate Plan (NECP) for 2030, Greece intends to reduce greenhouse gas emissions by 43% in 2030 compared to the 1990 level. Additionally, the country has enacted specific laws and policies to facilitate the transition to sustainable energy. In 2023, for instance, the parliament adopted the Climate Law that seeks to create incentives to regulate emissions, such as promoting the sale of electric vehicles (Karamaneas et al., 2023; Ministry of Environment and Energy, 2022). Furthermore, the energy supply in Greece is heavily reliant on coal and its products, such as lignite, and predominantly natural gas, for which the leading supplier is Russia. Therefore, Greece has grown its interest in green hydrogen development and implementation to transform its energy system and economy by adopting the National Hydrogen Strategy.

One reason hydrogen has gained momentum is that it can be domestically produced from renewable sources, thereby enhancing energy security. The other reason is that it is typically presented as a versatile energy carrier that can decarbonise the energy sector, industry, transport, and agriculture (Dembi, 2022). Currently, Greece's primary focus is to accelerate the energy transition, particularly the hydrogen transition, to reduce its dependency on Russian gas and meet the national and Paris Agreement's energy and climate targets. Indeed, countries such as Greece exhibit significant technical potential for variable renewable electricity generation and are particularly well-suited to developing a green hydrogen economy (International Trade Administration, 2024). Thus, Greece could realise its ambitious energy and climate objectives by utilising its green hydrogen potential while simultaneously leveraging the employment benefits of a green hydrogen economy (Regulatory Authority for Energy, Waste and Wate, 2023). Achieving a wide range of objectives, including social and macroeconomic goals, energy and climate targets, and the right pace of action, such as the penetration of clean fuels into the energy mix, is essential to achieving net-zero emissions, but formulating the right policies to get there is challenging (Energy Press Greece, 2024).

While hydrogen seems to be an option in the Greek context, the primary problem in today's energy system is to create one that is sustainable, secure and equal. Compared to other alternatives, hydrogen technology has been recognised as the most promising choice. Although discussions are typically centred around security and sustainability, the questions of justice and fairness are less discussed in the Greek context. Various scholars indicate that decision-making processes that follow a top-down ap-

proach frequently sideline local communities, intensifying socio-economic disparities and overlooking fairness in procedures, the distribution of benefits and burdens, and the recognition of local stakeholders, framing these as energy justice challenges (Tunn et al., 2024). In the Greek context, many cases are also indicative of that. For example, the “Green HiPo project” is often referred to as an exemplary project that failed for various non-technical reasons. The Green HiPo project is one of the first initiatives in Greece related to hydrogen production, with the first proposal submitted in 2021. The Green HiPo (Green Hydrogen Important Project of Common European Interest) is a €780 million green hydrogen initiative led by Advent Technologies and supported by the EU, as illustrated in Figure 1.1 aiming to develop high-temperature PEM (HT-PEM) fuel cells and large-scale electrolysis facilities in Western Macedonia—particularly Kozani—to transition the former lignite region toward a clean hydrogen economy, generate approximately 650 jobs, and strengthen Greece’s energy transition infrastructure. Whereas RES-based solutions are eligible for EU funding schemes in Europe, for four years after the

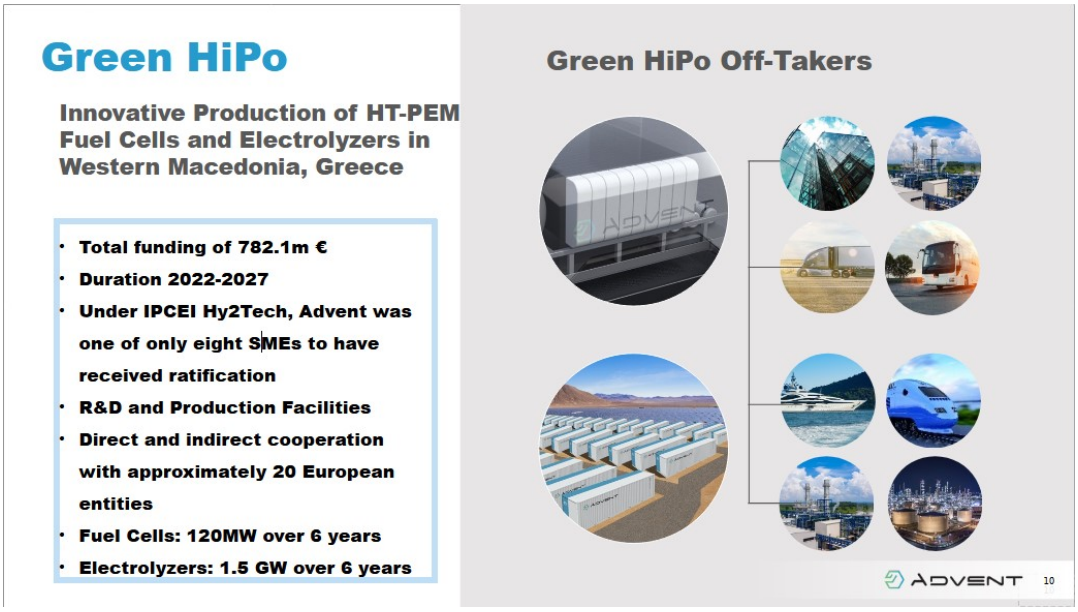

Figure 1.1: Overview of the Green HiPo Project in Western Macedonia, Greece. The Green HiPo project, led by Advent and recognised under IPCEI Hy2Tech. The project includes R&D and manufacturing facilities, with direct and indirect collaboration with around 20 European partners. The planned output is 120 MW of fuel cells and 1.5 GW of electrolysers over six years. The right side illustrates diverse Green HiPo off-takers, including buildings, transportation (trucks, buses, ships, trains), and industrial sectors, highlighting the broad impact and applications of green hydrogen technology. Adopted by: Advent Technologies presentation in Hydrogen and Gases Forum in 2023

“Green HiPo project” approval in Western Macedonia, the project remained incomplete due to the government, municipal & regional authorities and the Public Power Corporation (PPC) being unable to reach an agreement. Besides the delays and high installation costs, there are strong indications that this plan’s operating costs will also be excessive because of its dependence on fossil gas (Muller et al., 2022). These costs will burden lignite regions’ residents and all consumers nationwide. The less privileged members of society are frequently the most exposed to such systemic upheavals (Claar, 2022).

Furthermore, energy planning is characterised by a wide range of substantial trade-offs that a policy measure or strategy ought to make between conflicting objectives. Recent studies emphasise Greece’s notable advancement in clean energy adoption, marking 2023 as a record year for renewable integration (Independent Power Tranmission Operator (IPTO), 2024). Meanwhile, the process involves a variety of stakeholders, who may have opposing opinions and contrasting viewpoints (Koutsandreas et al., 2023). In the context of sustainable transitions, using the lens of energy justice to capture procedural, distributive, and recognitional challenges offers a more captivating approach to investigating the emergence of technological innovation systems and conflicts around them. Distributional justice, which pertains to distribution of benefits and burdens, recognition-based justice, which relates to the social groups and actors that are adversely affected by the energy transition but are nevertheless typi-

cally excluded, and procedural justice, which reflects how the addressed injustices can be alleviated or mitigated on the level of existing procedures, are the three principles of energy justice (Jenkins et al., 2016).

In Greece, the region of Western Macedonia accounts for over 75% of the country's energy consumption (Lampropoulos et al., 2025). This region has abundant natural resources, although it has been historically associated with environmental problems due to the substantial deposits of lignite. For this reason, it became the major centre for the generation of energy in the country since the 1950s. Although it has been instrumental in the economic development of the country, critics equally mention that it is one of the leading causes of environmental degradation and health issues. For this reason,

Figure 1.2: Area layout of Western Macedonia in Greece (left) and illustration of the Western Macedonian municipalities (right) where the lignite industry is utilised. Adopted by: CluBE presentation in Hydrogen and Gases Forum in 2023

Western Macedonia has embraced renewable energy to minimise the harm caused to the environment, and the government and the EU have channelled significant funding to facilitate its transition. For example, Hellenic Hydrogen is expected to commission a hydrogen production facility with a capacity of 100 MW by 2027 in Western Macedonia (Todorović, 2023). Based on the regulatory and other technical challenges that have been discussed in the broader case of Greece, I evaluated how these issues limit energy transition based on hydrogen, using a case study of Western Macedonia. According to the Just Transition Brief (JUSTEM), more than 25,000 jobs are estimated to be at risk in Western Macedonia as a direct result of lignite phase-out policies, and the region faces some of the highest unemployment and energy poverty rates in the country (Institute for European Energy and Climate Policy (IEECP), 2023). This context of rapid structural change and heightened vulnerability makes Western Macedonia not only emblematic of the challenges of a "just transition," but also an essential testing ground for whether new technologies—such as green hydrogen—can deliver tangible benefits for local communities and avoid reproducing existing inequalities.

Hence, through this master's thesis, I explored the impact of the green hydrogen transition in Western Macedonia, Greece, through the lens of energy justice. It sought to understand how procedural, distributive, and recognition justice are realised—or neglected—in the process of decarbonisation, particularly within lignite-dependent regions undergoing rapid socio-technical transformation. Greece's commitment to phasing out lignite and its embrace of green hydrogen technologies have positioned Western Macedonia as both a testing ground and a site of vulnerability. Although policy frameworks emphasise innovation, sustainability, and climate mitigation, less attention has been paid to how these ambitions translate into equitable outcomes for local communities, workers, and marginalised groups. This thesis aimed to bridge this gap by analysing how justice concerns are embedded in governance processes and infrastructure planning in the green hydrogen transition in Western Macedonia.

1.1. Barriers to the Green Hydrogen Transition in Greece

Although the literature indicates that attempts have been undertaken to identify the drivers and obstacles to the adoption of green hydrogen projects in Greece, a comprehensive knowledge of the case in Western Macedonia and its impact on the proliferation of the green hydrogen innovation system is lacking. Understanding dynamic behaviour elucidates the absence of dissemination and offers a chance to investigate variables that amplify the importance and fairness of green hydrogen initiatives in the Western Macedonian region.

Firstly, the use of green hydrogen technology in Greece encounters considerable technological barriers (O'Connor, 2024). Central to this issue is the insufficiency of infrastructure for hydrogen generation, storage, and delivery (Centre for Renewable Energy Sources and Saving (CRES), 2022). In contrast to traditional energy systems, hydrogen needs specialised pipes, storage tanks, and transportation infrastructure. The energy infrastructure of Greece, predominantly built for fossil fuels, is deficient in these capacities (Caglayan et al., 2021). The erratic nature of wind and solar energy interferes with the consistency of hydrogen production, which is a barrier to its incorporation into Greece's renewable energy system (Maestre et al., 2021; Manolopoulos et al., 2016). Advancements in energy storage technology and smart grid technologies are crucial to overcoming these restrictions.

Furthermore, the elevated expenses linked to green hydrogen generation constitute a substantial economic obstacle. The standard technology applied for hydrogen generation for electrification, by electrolysers, remains costly. Variable power rates, particularly those coming from renewable sources, make the cost worse (Durakovic et al., 2023). In Greece, economic budget cuts have further limited the availability of money for substantial infrastructure upgrades (Papada & Kaliampakos, 2016). The lack of a developed hydrogen market intensifies financial risks for stakeholders, deterring private-sector investment (Lagioia et al., 2023). Absent significant subsidies or monetary incentives, hydrogen is unlikely to attain cost parity with fossil fuels in the foreseeable future.

On the other hand, the regulatory environment in Greece is insufficient to facilitate the development of green hydrogen initiatives. The nation has adopted lofty renewable energy objectives; yet rules for hydrogen certification, standardisation, and market facilitation are still inadequately established (International Energy Agency, 2023; Nikas et al., 2024). According to Mazza et al. (2024), regulatory ambiguity is a result of differences in policy implementation and a lack of alignment with EU decarbonisation objectives. This makes investors less likely to risk making investments. Enduring policy stability, together with frameworks to include hydrogen into Greece's comprehensive energy plan, is essential for surmounting these barriers.

In addition, public opinion about safety, environmental consequences, and economic viability frequently impedes the execution of hydrogen initiatives. Insufficient public knowledge intensifies these problems, since the advantages of hydrogen technology are inadequately conveyed (Emodi et al., 2021). Apart from public opinion, the omission of local populations in the development and implementation of projects results in opposition and distrust (Gordon et al., 2024). Establishing trust by clear communication and showcasing concrete community advantages is essential for promoting public acceptance.

For all these years, Greece's geopolitical position has intensified the desire to become a hydrogen hub in the Mediterranean. The nation's strategic position renders it an appealing location for hydrogen production and export; nonetheless, it must contend with worldwide rivalry and regional interdependence (Nikas et al., 2024). The incorporation of hydrogen into transnational energy networks necessitates strong collaboration with adjacent nations and conformity with EU energy laws.

Although viewed as a crucial step in Greece's climate initiatives, it is inherently associated with the extensive deployment of renewable energy sources, which many currently see as a threat to its rich and varied natural environment. The coal-dependent areas in Greece are regarded as economically fragile, facing high unemployment rates, degrading economic growth, and significant emigration levels. Consequently, these regions may struggle to address the socioeconomic impacts of the energy transition due to their already fragile economic and social levels (Marinakis et al., 2020).

1.2. Research Objective and Knowledge gap

Despite the abundance of studies on worldwide hydrogen systems, there is a significant lack of studies specifically focused on Greece's distinct setting. Studies considering Greece's renewable energy capacity, geographical attributes, and socio-economic factors are few (Kourougianni et al., 2024). Customised feasibility studies are crucial for determining ideal locations for hydrogen production and evaluating the integration of hydrogen into Greece's current energy infrastructure (Zografidou et al., 2016).

The efficacy of prospective policy instruments, including subsidies, carbon pricing, and market-based incentives, remains inadequately examined within the Greek context. There is a deficiency of comparative evaluations that evaluate Greece's regulatory framework concerning effective overseas models

(Lagioia et al., 2023). Comprehending how policy interventions may promote green hydrogen uptake while mitigating financial and technological obstacles is essential for formulating successful laws.

Current studies primarily examine the technical and economic viability of green hydrogen initiatives, frequently neglecting essential justice-related factors such as fair distribution, inclusive processes, and acknowledgement of marginalised communities (Lindner, 2022; Muller et al., 2022).

In Greece, the obstacles to adopting green hydrogen are complex, involving high capital and operational expenses, regulatory shortcomings, and stakeholder conflicts. For instance, the Western Macedonian "Green HiPo" initiative illustrates the gap between policy goals and local circumstances, with delays and disputes arising from a lack of stakeholder engagement and disregard for community issues. These obstacles highlight the necessity for frameworks that tackle systemic inefficiencies and justice-related concerns (Carmona-Martínez et al., 2024; Tunn et al., 2024).

Additionally, the global perception of green hydrogen as a unique solution tends to obscure its socio-political and ecological consequences. Research indicates that its advancement can worsen inequalities, especially in areas that already face vulnerabilities, like Kozani and Amyntaio. Concerns like water scarcity, land conflicts, and socio-ecological risks are often insufficiently examined in academic and policy discussions, hindering the development of genuinely sustainable and inclusive green hydrogen systems (Patonia, 2025; Virens, 2024).

Regarding public perception and stakeholder involvement, national and regional research in Greece is limited. Global studies emphasise the significance of societal acceptability for hydrogen adoption; nevertheless, there is a lack of localised insights into public apprehensions, industry resilience, and community engagement (Gordon et al., 2024; Smith et al., 2023). Such investigations are essential for developing participatory frameworks synchronising stakeholder interests with project objectives.

An additional aspect yet inadequately examined is incorporating hydrogen technology into Greece's energy networks. Research on hydrogen blending, grid compatibility, and hydrogen's function in mitigating renewable energy intermittency is notably scarce (Hanto et al., 2024). Simultaneously, there is a scarcity of empirical research utilising energy justice as a framework in specific scenarios, such as the hydrogen transition in Greece. Key questions largely remain unresolved, including how to involve marginalised communities in decision-making, guarantee an equitable distribution of advantages and costs, and tackle historical and systemic inequities (Dembi, 2022; Lindner, 2022).

In this thesis, I aimed to fill the gap that has a two-fold structure by employing an energy justice framework to examine the obstacles and justice concerns related to green hydrogen development in Greece. Drawing on empirical evidence from policy document analysis and stakeholder interviews, the objective was to assess whether the transition's benefits and burdens are fairly distributed, how participatory the planning processes are, and whether local knowledge and identities are acknowledged in decision-making. By using Western Macedonia as a case study, I sought to offer actionable insights for incorporating justice considerations into green hydrogen strategies. The study builds upon established energy justice theory and aims to generate grounded insights on how justice frameworks can inform green hydrogen policy development. Ultimately, the current research attempted to contribute to more inclusive and equitable energy transitions in post-coal regions by identifying best practices, systemic gaps, and actionable recommendations for policymakers, local governments, and energy communities. The findings are expected to be relevant beyond the Greek context, informing broader debates on just transitions in similar post-extractive regions across Europe, particularly in the Southern East and Mediterranean.

1.3. Research Questions

From the societal viewpoint, studying the energy justice challenges of the green hydrogen project in Western Macedonia was essential. Henceforth, the main research question of this study was:

What are the energy justice concerns within the green hydrogen transition in Western Macedonia?

The research question can be further divided into the following sub-questions:

- What is energy justice, and why are the concerns about energy justice particularly relevant in the context of Western Macedonia's green hydrogen transition?
- What are the relevant policies on the green hydrogen transition in Western Macedonia, and what energy justice concerns are they raised?
- Who are the relevant stakeholders in Western Macedonia's green hydrogen transition, and what are their energy justice concerns ?

1.4. Research Approach

The research aimed to examine energy justice challenges in the development of green hydrogen technology in Western Macedonia, Greece. Using the energy justice framework as a guiding theoretical structure, the study focused on procedural, distributional, and recognition-based justice issues. Scientific literature, expert interviews with specialists about hydrogen production methods, and information regarding hydrogen use and transportation in Greece's electrical grid were examined in this study. The methods to be evaluated include hydrogen generation via electrolysis and renewable energy sources. Two complementary methodologies were reviewed to collect and analyse data in response to the study topics: primary and secondary research methodologies.

Primary research is direct data collection via interviews with industry experts and stakeholders to obtain personal perspectives. Secondary research entailed a methodical examination of existing literature, reports and pertinent documents to interpret results and enhance the current knowledge of the topic. To begin with, findings from the literature and a first phase of case studies were conducted to evaluate hydrogen adoption in other Mediterranean or European countries and provide comparative insights (Aditiya & Aziz, 2021; Panchenko et al., 2023). These findings were used to scope under the theoretical framework of energy justice and answer the first sub-research question.

The theoretical framework presents three core principles of energy justice that were used to guide this study. The first principle is procedural justice, which explores the need for inclusiveness and transparency when making decisions that affect different stakeholders. This dimension is essential since it ensures that marginalised groups are directly involved in the transition process. The second dimension is distributive justice, and it is concerned with the equitable distribution of the benefits and difficulties. Consequently, it evaluates factors such as the associated costs and advantages of the projects. Finally, recognition justice addresses the significance of recognising and honouring the rights and needs of various stakeholders. Again, this dimension primarily addresses the concerns of those who have been traditionally marginalised in energy governance (Jenkins et al., 2016; Muller et al., 2022).

At an empirical level, the research commenced with a thorough literature review to frame Greece's green hydrogen initiatives within the larger context of global and regional green hydrogen transition efforts. This review uncovered significant gaps, including the insufficient incorporation of justice-oriented frameworks in existing green hydrogen policies and initiatives (Lindner, 2022; Tunn et al., 2024). Western Macedonia, a key area of Greece's hydrogen strategy, was chosen as the primary case study due to its socio-economic and political importance.

The study utilised a qualitative approach, featuring semi-structured interviews with industry stakeholders and community representatives. These interviews captured a range of viewpoints regarding the systemic barriers and concerns of green hydrogen projects. Additionally, a document analysis of policy reports, regulatory frameworks and project evaluations provided valuable insights into institutional dynamics and decision-making processes (Patonia, 2025). By looking at these key points, it could be helpful for the case to explore to what extent any existing decision-making processes include local communities.

The analytical method utilised the framework of energy justice as has been discussed for analysis and interpretation of data, which will help illustrate appropriate patterns and connections with aspects of procedural, distributive and recognition justice. Further, a comparative analysis with other regions could help to improve the validity of the study's findings, which also contextualises the challenges of Greece in the global context.

Simultaneously, semi-structured interviews were conducted to identify the impact of the stakeholders' roles and actions. Conducting interviews with industry and community representatives could provide

diverse perspectives and the interplay between the recognition, procedural, and distributional justice aspects (Dudka et al., 2023; Mundaca et al., 2018; van Bommel & Höffken, 2021). Applying energy justice metrics can provide a spherical and comprehensive view of the challenges while enhancing stakeholder collaborations and equitable outcomes. Its principles, distributional, procedural and recognition-based, can illustrate a robust and comparative framework for the evaluation of the barriers and ethical considerations of the green hydrogen implementation (Dillman & Heinonen, 2022; Muller et al., 2022).

1.5. Relevance

The current thesis endeavoured to investigate the feasibility of a qualitative approach to investigate the rate at which new clean technologies, such as green hydrogen, can be incorporated into the Greek power sector fairly in the Western Macedonian region. The focus is on the penetration of green hydrogen during the 2030–2040 period. Although efforts have been made to identify the key factors that influence the adoption of green hydrogen projects (Muller et al., 2022; Nanaki et al., 2024), there is a dearth of research on the interactions, feedbacks, and delays of green hydrogen projects.

Nevertheless, the literature has only recently begun to address this aspect; the time perspective has typically been linked to the timing of achieving specific objectives, for example, net zero emissions, or the implementation of targeted policies (technology phase-out), rather than the intensity of action—particularly in the context of the adoption of new clean technologies. Energy justice presents an essential framework to confront these systemic barriers and concerns, highlighting the fair distribution of resources, participatory decision-making, and acknowledgement of marginalised populations. Nevertheless, green hydrogen initiatives, often characterised as the ”superman” of the energy transition, are at risk of perpetuating extractivist trends and socio-ecological challenges, especially in regions facing resource limitations (Lindner, 2022; Virens, 2024). For example, the commercialisation of land and water, the exclusion of vulnerable groups from decision-making, and the potential for environmental harm pose considerable threats to the energy justice tenets.

In Greece, incorporating energy justice principles into green hydrogen projects to facilitate a fair transition is crucial. It is vital to consider who stands to gain, who is impacted financially, and whose perspectives are included in decision-making processes. Semi-structured interviews with experts in renewable energy and hydrogen, project developers, academia, and citizens were utilised to configure the literature study. One of the primary outcomes of this research is that it is crucial to address and acknowledge the case study analysis in shaping the transition in decarbonising lignite-dependent regions in Western Macedonia from different perspectives. Still, the inclusion of the energy justice issues plays a vital role in understanding the transition process and thus increasing the chance of success. Therefore, this research could provide a valuable source of knowledge and hence represent a necessary part of the groundwork to be undertaken before designing the policies, strategies and socio-technical structure for implementing the green hydrogen project in Western Macedonia.

1.6. Thesis Structure

The current section outlines the thesis structure in six chapters. Firstly, the introduction that I explored throughout the project is presented (Chapter 1), followed by the research methodology (Chapter 2) and literature review of the implemented framework and the conceptual background(Chapter 3) to address the research questions. In Chapter 4, I implemented the steps for analysing the empirical data, as well as a presentation of the findings. In Chapter 5, I discussed the findings with the dimensions of the energy justice frameworks. In Chapter 6, I presented the research conclusions, along with the limitations of the research, and the recommendations for future research.

2

Research Methodology

This chapter describes the methodological technique used to explore how Western Macedonia, Greece's green hydrogen transition, integrates energy justice concepts. I employed a mixed-methods design, comprising a literature review, case study analysis, stakeholder mapping, semi-structured interviews, and qualitative content analysis. The provided flow diagram effectively illustrates how each methodological element addresses the specific research sub-questions. Academic publications, policy experts and industry analyses have been included in the literature review to explore the theoretical and contextual foundations. Additionally, interviews have been conducted with relevant stakeholders, including industry experts and organisational practitioners, to explore the qualitative insights related to governance factors, economic impacts and public opinions. This section also presents the stakeholder interests to illustrate the critical players in this sector, their responsibilities, and their roles in implementing green hydrogen projects.

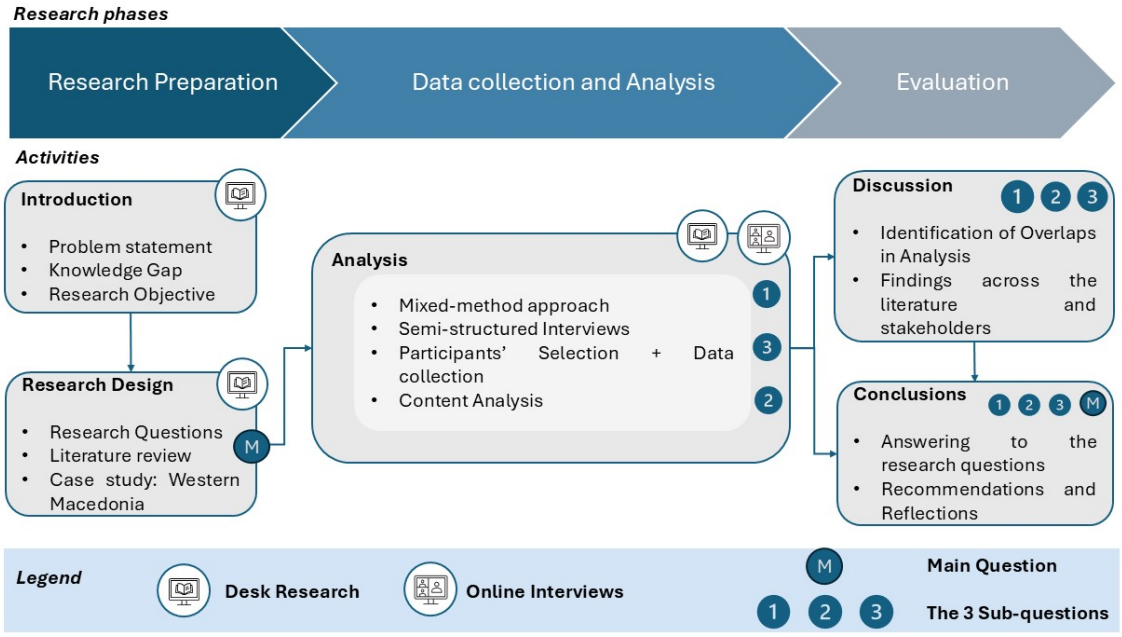

Figure 2.1: Research Methodology Flow Diagram for the thesis project

2.1. Data gathering

The empirical component of the thesis employed a dual-method approach, combining qualitative document analysis and semi-structured interviews. Data collection was strategically structured to incorporate policy and scholarly literature on hydrogen and energy justice, covering international, regional, and local levels. A corpus of 25 documents was analysed, including EU strategic frameworks (for example, the EU Hydrogen Strategy and REPowerEU), national-level plans such as the Greek National Energy and Climate Plan (NECP), and grey literature from NGOs, cooperatives, and think tanks. These include national strategies (e.g., Greece's Recovery and Resilience Plan), regional just transition development plans, European energy directives, and scientific publications. Key sources such as the Geopolitics of Hydrogen report offer valuable insights into the policy framing of hydrogen infrastructure in a few European countries (Quitzow & Zabanova, 2024). Documents were selected based on their relevance, authorship by key institutions or regional experts, and explicit references to justice, participation, or socio-economic transitions.

The scheduled interviews involved experts across academic, cooperative, public, and policy sectors, chosen through purposive and snowball sampling. Individuals, including hydrogen experts and representatives from *Ofelos* and the *Solarity Coop*, offered rich perspectives on the dynamics of the hydrogen transition in Greece and Europe. This combined dataset enabled triangulation between strategic documents and lived or professional experiences, enriching the inquiry into energy justice dimensions across hydrogen governance scales. The design phase included ethical review procedures, consent forms, and the development of an interview guide that aligns with the research questions. Interview data were audio-recorded, transcribed, and anonymised.

2.2. Qualitative Research Methods

This research employed a mixed-methods approach, combining the case study method, content analysis, and semi-structured interviews. In this study, mixed methods were used to elucidate not only what is happening, but also why and how different actors perceive and experience justice challenges within Western Macedonia's hydrogen transition. By integrating mixed methods, the research captured both the measurable patterns of stakeholder involvement and the underlying values, narratives, and power dynamics shaping the transition process through lignite phase-out.

According to Grossoehme (2014), qualitative research refers to "the systematic collection, organisation, and interpretation of textual material derived from talk or conversation" (p. 109). Essentially, qualitative methods are used when the objective of the researcher is to explore the meanings of a specific phenomenon based on a person's experiences. It is one of the most effective methods of studying social phenomena as it elicits people to provide their personal stories. The experiences can be presented using different types of media, including conversations, written texts such as journals or visual forms such as pictures. Further, it is worth acknowledging that there are various types of methods, including those presenting data from a single individual or case studies involving several participants.

Pathak et al. (2013) posit that qualitative research methods entail an approach to a problem using the humanistic approach. Some opponents of this approach argue that quantitative methods are more reliable since they are premised on numeric techniques that are relatively more objective. However, such methods cannot be utilised when the researcher's interest is to explore and understand the beliefs and experiences of the participants. There are three broad categories of qualitative studies: observational, interviews and textual analysis. Qualitative studies are preferred since they give a voice to the participants and provide them with an opportunity to share their individual experiences. In addition, the researcher has the opportunity to clarify issues during the interview. The subjects of the study are also empowered, considering that they play a direct and active role in the study. Therefore, one of the characteristics of these studies is that they are less formal compared to quantitative projects, where the researcher has minimal interaction with the participants.

The analytic framework was predefined to ensure methodological coherence and ethical transparency. Data was collected through semi-structured interviews with selected stakeholders and transcribed with accuracy. Anonymisation protocols were applied and data was imported into *Atlas.ti* for coding. The process began with preliminary 'open coding' where emerging phrases and concepts were tagged, followed by axial coding to identify relational structures between themes (Creswell, 2009). Codes were

grouped under the overarching justice dimensions. Following the *Atlas.ti* process, a semantic network was developed to visualise code co-occurrence and stakeholder discourse patterns. Attention was given to the intersection of justice concerns with themes such as “technological optimism,” “cooperative agency”, and “employment insecurity.” These patterns were used to interpret participant perceptions in the broader socio-political context of Greece’s hydrogen strategy. The analysis followed a grounded theory approach and was supported by *Atlas.ti* software to ensure systematic coding, memo writing and cross-case comparison (Creswell, 2009).

Codes were generated both inductively from interviews and deductively based on the justice framework. Data was anonymised and stored securely in compliance with the Tu Delft Human Research Ethics Committee (HREC) protocols. The codebook included descriptors, source types, representative quotes and inter-coder agreement metrics to ensure analytical rigour. These were integrated into *Atlas.ti* as part of the audit trail and informed the write-up of findings. The goal was not just to describe participant views, but to understand the underlying values and tensions shaping stakeholder engagement in hydrogen policymaking. Finally, this analysis further considered the balance between deductive (theory-informed) and inductive (data-emergent) reasoning, ensuring that predefined justice frameworks did not obscure the emergence of novel insights. This reflexive flexibility was essential to capture the dynamic and contested nature of energy transitions in post-lignite regions.

2.2.1. Western Macedonia's case study

This research adopted a case study approach, focusing specifically on Western Macedonia, a region facing severe socioeconomic challenges due to Greece’s ongoing energy transition from lignite (Mantzaris, Nikos, 2021). Case studies enable comprehensive analysis of complex socio-technical transformations by examining the real-life contexts within which these changes occur (Chapman et al., 2019). The selection of Western Macedonia is justified by its critical economic vulnerability resulting from lignite phase-out policies and the substantial EU-funded investments aimed at regional transformation through green hydrogen initiatives (European Commission, 2025). Previous studies emphasise that lignite regions frequently face delayed economic recovery and inadequate stakeholder participation, highlighting the necessity of context-specific justice assessments (Claar, 2022; Dudka et al., 2023; Marinakis et al., 2020). Empirical evidence from other European coal regions indicates that successful transitions depend heavily on clearly articulated policies and comprehensive stakeholder involvement, reinforcing the applicability of a detailed case study (Centre for Renewable Energy Sources and Saving (CRES), 2022). Furthermore, existing scholarship suggests that issues such as distributive justice, community resilience, and equitable allocation of transition funds remain inadequately addressed, making Western Macedonia an ideal case to investigate these justice dimensions (Bloomberg, 2025; Brauers & Oei, 2020; TREK development, 2025). Ultimately, employing the case study method facilitates a more profound understanding of energy justice dynamics, yielding insights transferable to similar lignite-dependent regions facing parallel energy transition challenges (Durakovic et al., 2023; Luka Dimitrov for ICIS, 2021).

2.2.2. Stakeholders' Interests in Green Hydrogen Projects

A complex network of stakeholders whose interests, influence and involvement levels shape both the direction and the outcomes of the region’s decarbonisation strategy. First and foremost, government stakeholders operate at multiple scales. The Greek national government (including the Ministries of Environment, Energy, and Economic Development) and local authorities (notably the Region of Western Macedonia and municipalities such as Kozani and Florina) serve as principal architects and implementers of transition policy. At the European level, the European Commission and CINEA are crucial for regulatory oversight and funding allocation, connecting local transitions to broader EU decarbonisation objectives.

The key industry actors are led by Greece’s Public Power Corporation (PPC), which plays a crucial role given its historical reliance on lignite extraction and generation and its current strategic pivot towards renewable energy. Additionally, renewable energy companies actively involved in developing solar, wind and storage technologies and infrastructure constitute essential stakeholders, alongside infrastructure operators, such as the Independent Power Transmission Operator (IPTO) and the Hellenic Electricity Distribution Network Operator (HEDNO). In the Western Macedonia’s case, as promising transition hub, the HellenicQ and Motor Oil are the main investors under the Hellenic Hydrogen S.A.

joint venture. The diversification of local businesses into green technologies further underscores the private sector's active participation in Western Macedonia's energy transition.

From the academic side, research institutions entities like the Centre for Renewable Energy Sources and Saving (CRES), National Technical University of Athens (NTUA), University of Western Macedonia, and European research consortia such as TRACER H2020 provide the analytical and technological foundation necessary for informed decision-making (Centre for Renewable Energy Sources and Saving (CRES), 2022). They inform policy design, technological innovation, and scenario modelling, often acting as mediators between public sector ambitions and practical feasibility.

Community stakeholders encompass local communities directly impacted by job displacement due to lignite mine closures, small and medium-sized enterprises (SMEs), environmental advocacy organisations such as Heinrich Böll Stiftung, the Green Tank and Greenpeace Greece, as well as workers' unions and other local organisations committed to ensuring equitable outcomes. In a broader manner, stakeholders characterised by high influence yet lower direct interest, including national regulators such as the Regulatory Authority for Energy (RAE), and European Union agencies like the European Environmental Bureau (EEB) and regional system operators, play a supervisory or consultative role. Although their direct interest in specific hydrogen projects may be moderate, their regulatory decisions and guidelines have far-reaching effects on project approval, financing, and technical standards (Independent Power Tranmission Operator (IPTO), 2024; International Energy Agency, 2023).

Conversely, stakeholders with high interest but lower direct policy influence, including local communities, civil society organisations and academic institutions, necessitate targeted informational engagement to address their concerns and ensure transparency and local support for transition initiatives. Finally, stakeholders possessing limited influence and interest, primarily the general public outside the directly affected region and unrelated local businesses, require only basic informational outreach efforts to sustain overall societal support.

2.2.3. Content analysis

The content analysis in this study conducted a systematic examination of academic literature, governmental reports, and policy documents to gain a comprehensive understanding of the energy transition in Western Macedonia.

2.2.3.1. Literature Review

The first phase of data collection for this study was a literature review, which examined existing body of evidence on energy transitions involving green hydrogen that is being adopted globally. The review also examined energy justice issues that have been addressed in other contexts. The objective was to identify knowledge gaps in existing literature and develop a theoretical framework that was utilised for the subsequent stages of the study. The first stage in the literature review was to search scientific databases for energy supply and demand, technology selection and dominant renewable energy resources using relevant keywords. Scopus and ScienceDirect were utilised as scientific databases for this research. Google Scholar was also used to find specific articles and reports from government organisations, such as the European Commission, the European Environment Agency (EEA) and the Greek Ministry of Environment and Energy (MoEE). These organisations' reports are frequently cited after reading fundamental scientific publications on current energy status, technology selection and up-to-date policies and directives.

The second part of the literature study aimed to investigate any correlation between developing green hydrogen production technologies in Western Macedonia within the scope of the energy-justice-based issues. At this stage, the applications of hydrogen plants in Greece and the significant aspects of the specific case were explored. Throughout the research, I acknowledged that these data sources were likely to present biased information compared with scientific literature. Consequently, significant insights from these studies were significantly limited.

2.2.3.2. Identification

The initial focus of the literature research was on different perspectives on the role of hydrogen in decarbonisation. Therefore, the literature search explored renewable energy sources, including hydrogen production technologies. A majority of the articles were selected from Google Scholar and Scopus,

which provided sufficient data for review. Other relevant academic publications, including those from organisations with reports on sustainable energy, were also included in the review. This information helped me to examine and illustrate the history of hydrogen use, production processes and the potential applications of green hydrogen.

Using the keywords “energy justice”, “Coal plants”, or “Green Hydrogen supply chain”, was the first interaction regarding the literature that existed in libraries and databases. The location filter was not activated initially; thus, the published results were more related to green colonialism in Global South countries and identifying the critical factors. The search resulted in more than 1600 articles from the areas of *Energy, Environmental and Social Sciences*. After applying the filter of *Energy* subject area, the result was around 750 journals. Further, the articles with abstracts provided an overview of the justice in the global green hydrogen transition, from both societal and economic perspectives. This was done to understand the injustices and identify the bottlenecks in it. After discussing with the supervisors the scope and direction of the project, the location-specific condition is necessary to be assessed to narrow down the research.

In the second stage, the scholar database focused more on identifying the barriers and challenges of Green Hydrogen development in Greece. The search terms: “Barriers to Power-to-Hydrogen”, “Energy justice Greece”, “Barriers to Green Hydrogen”, “Hydrogen economy Greece”, “Challenges to Power-to-Hydrogen Greece”, “Green Hydrogen in Greece”, “Challenges to Green Hydrogen” were searched separately. The fundamental requirements for the papers’ selection were:

- The publication year should be from 2015 onwards. This was done to identify barriers and concerns only relevant to the current time frame, which would account for the development of hydrogen technology, the change in regulations, and awareness of the technologies.
- The subject area is limited to “Green Hydrogen”.

In the third stage, the search criterion was narrowed to focus on the specific provinces in Greece, aiming for the development of green hydrogen use. It is important to formulate the research in a particular case study in the Greek power status quo and make it feasible for the thesis timeline. At this stage, I utilised Scopus, Google Scholar, and databases from local governmental authorities and ministries to find additional literature concerning vulnerable and displaced areas like Western Macedonia and the Southern Greek islands. The initial search terms used in Scopus included “Barriers and Challenges in green hydrogen” and “Energy justice in Western Macedonia,” but these yielded no results in the specified databases. To capture the key energy justice barriers and concerns specific to the Greek provinces, the relevant literature on the challenges to the development of green hydrogen was searched on Scopus and Google using the terms “socio-technical scenarios” and “socio-technical barriers to hydrogen future”

Apart from the energy justice framework and the literature research, the research paper by Marinakis et al. (2020) and Ziouzios et al. (2021) were the most significant in providing a backbone to this thesis. These studies provided a SWOT analysis of the main lignite plants in Megalopolis and Western Macedonia of the challenges related to perspectives concerning the energy transition. The studies start with a thorough assessment of the literature on electricity generation and the lignite phase-out legislation in Greece. The research then identifies relevant strengths and weaknesses by thoroughly designing a post-lignite master plan for the case of Megalopolis and Western Macedonia. Finally, it provides recommendations for overcoming the regional obstacles and becoming regionally resilient to lignite dependence.

2.2.3.3. Governmental and Policy Documents

The present study specifically focused on the energy justice considerations in the implementation of green hydrogen projects. A vital source included in this study was the National Energy and Climate Plan (NECP) of the Hellenic Republic Ministry of Environment and Energy. Additionally, reports from the European Commission and other empirical studies related to hydrogen infrastructure were considered as sources in the study. These publications provided an elementary understanding of the economic factors, techniques for involving the relevant stakeholders and existing policy frameworks that influence decarbonisation strategies in Greece, particularly Western Macedonia.

The socioeconomic impacts of this analysis were evaluated by incorporating reports on employment

transitions and economic restructuring according to Ketikidis et al. (2023) and examining challenges related to job displacement and reskilling requirements (Kruczek et al., 2025). Policy papers from The Green Tank (2019) and Mantzaris, Nikos (2021) also helped me to investigate the equity ramifications of the decarbonisation, especially in terms of ensuring local populations benefit from investments in green hydrogen projects.

As described in papers on Western Macedonia's hydrogen roadmap, the study also took into account obstacles to hydrogen project execution, such as bureaucratic inefficiencies, infrastructural deficiencies, and budgetary constraints. Reviewing stakeholder viewpoints from labour unions, private investors, and government agencies helps this study find synergies and conflicts in the policy execution. Comparative analysis of decarbonisation governance and societal adaptation measures also came from regional case studies from North Macedonia and Poland.

Following the thematic approach, this qualitative content analysis found in the examined material recurrent policy storylines, issues with energy fairness, and economic goals. It guided the research by stressing policy gaps, investment difficulties, and governance approaches required for a fair and sustainable hydrogen transition and by contextualising Western Macedonia's transition within broader European energy policies.

2.2.4. Semi-structured interviews

The interview questions used during the data collection process are divided into two primary categories. The first category of questions sought to evaluate the position of the stakeholders on the diffusion of green hydrogen projects. The second category evaluated their perceptions about the distributional and recognitional tenets of the energy justice framework. Applying an exploratory research approach would provide a deeper understanding of the regional situation in which the proposed system would be located, which is required to evaluate the major actors involved, their current roles, and how they will be impacted.

The study was categorised into four key phases to illustrate the relationship between theory and practice, as well as to create a framework and apply it to practice: identification, investigation, synthesis and comparison. This framework was adopted since it helped identify existing knowledge gaps. The first step helped answer the primary research question concerning the involvement of various stakeholders in Western Macedonia, and the following sub-questions are addressed by the following two steps involving data collection from interviews and assessing stakeholder and public discussions on hydrogen feasibility.

The first stage entailed gathering information on the approaches that should be used to manufacture, store and transport green hydrogen. The present government approaches to incentivising people to switch to this energy source. Additionally, this stage helped me to explore existing barriers in the literature. The second step involved conducting interviews to evaluate the stakeholders' roles and discernment in introducing justice concerns. The third step portrayed the interview data by discussing responsibilities and levels of influence in decision-making.

2.2.4.1. Interviewee Selection

To address the reflections that might inform growing concerns about the exclusion of local stakeholders and uneven distribution of benefits, the level of analysis included both local actors operating in the research area and nearby European states. During the search for participants in this study, it was established that the most appropriate interviewees were hydrogen experts, energy community members and university' staff. This is because they have more practical and real-life industry experience. Additionally, scholars or other personnel working in universities would contribute to this study by providing relevant theoretical knowledge. Based on the information provided by the experts, a purposive sampling approach was used to select each interviewee based on specific criteria.

Firstly, the interviewee ought to be a member of an engineering group or community-focused group (a group whose business serves or works within the energy sector). The second criterion was that the participant ought to have been in the industry for at least 2 years to ensure they had enough time and experience to have depth of knowledge. Thirdly, they ought to have been involved in a hydrogen or RES-focused project (of whatever duration) either as coordinators and/or participants. From these criteria,

most of the interviewees selected were executives and high-level officials with in-depth knowledge of their business, as well as an understanding of the professional language of transition or green energy. They were also active applicants, thus having an intimate knowledge of the just transition and situation of the area from actual life experience. The criterion of participation in the interview was chosen here in particular because it is the most common format for information transactions between expat experts and facilitators in Greece.

A total of nine interviews were carried out. This number is within the range of 7 to 9 participants for in-depth interviews for qualitative research as recommended by multiple academic publications (Dworkin, 2012). The final selection of interviewees included two hydrogen experts in the production process, one policy advisor regarding green hydrogen initiatives, one local government representative and a resident of the area, and energy community members operating in the Western and Central Macedonian areas and Attica, and an energy poverty expert with experience in the research area. Their contacts were acquired through one of the interviewees, who was in the industry and was involved in Just Transition Mechanisms for coal-lignite regions. In Appendix B, there is a complete list and description of experts and interviewees. For reasons of confidentiality, the names of the interviewees have been anonymised.

2.2.4.2. Data Collection Method

A total of nine semi-structured interviews were conducted, and I aimed to have a balanced sample of participants. Therefore, the recruiting sample targeted experts, scholars, policy advisors, technical practitioners, community leaders and other members associated with energy cooperatives. This diversity was deemed necessary to ensure that the backgrounds of the interviewees helped provide a balanced overview of the energy transition process, especially in terms of the justice perspectives.

It is also worthwhile to mention that since I targeted practitioners who are currently engaged in practice, it was deemed convenient to conduct the interviews online using video or telephone calls. Importantly, all the participants were sufficiently informed about the interview process, and they provided their consent to the recording and use of the information for the present study. The recorded interviews were subsequently transcribed verbatim for analysis. It is also necessary to observe that, whereas I had a list of themes that guided the interviews, the specific questions asked were tailored depending on the expertise and role of each participant. Therefore, all interviews examined similar themes, particularly concerning the energy justice dimensions. *Atlas.ti* software was used to facilitate the coding and thematic analysis, allowing me to identify recurring patterns, thematic links, and significant divergences across the transcripts.

The method of interviews is ideal as it can capture more complex thoughts and perspectives of the stakeholders on the green hydrogen initiatives and their impact. Particularly, online interviews allow for easier access to the participants, irrespective of the location of the interviewees and the interviewer. All interview audios were recorded (only with the permission of the interviewee) and kept for further analysis after all interviews were conducted.

2.2.4.3. Interview questions

The interview guide was developed based on the energy justice framework, their background and the gaps I explored through this project. Key areas explored included:

1. Stakeholder roles and perceptions of justice in the hydrogen transition
2. Procedural justice: Participation, transparency, and inclusiveness in planning
3. Distributive justice: How benefits and burdens are distributed among groups
4. Recognition justice: Whose voices are included or marginalised
5. Forward-looking perspectives on scaling community ownership
6. Reflections on prior renewable energy projects in Greece

The questions were open-ended to elicit narrative responses and allow participants to raise emergent topics relevant to their experience and context.

2.2.4.4. Interview procedure

Multiple studies have examined the energy transition based on green hydrogen production. However, the study of existing literature alone did not provide sufficient understanding of the topic, particularly based on the energy justice dimensions. For this reason, interviews were conducted to investigate the opinions of relevant stakeholders and the practical experiences of industry experts. The semi-structured technique of conducting interviews was utilised in the present study as it helped acquire relevant data from the participants. The open-ended questions were employed to ensure that the participants provided their perspectives without being restricted. Additionally, the element of divergence during the process of conducting the interviews was upheld to acquire data based on the individual perspectives of the participants, which helped generate data relevant to the subject that would not have been generated otherwise (Sekaran & Bougie, 2016)

The following steps are followed at this stage:

2.2.4.5. Participants' selection

This was the starting point for the interview procedure, and the core topic heavily influenced the choice of specialists. The key energy justice challenges for Western Macedonia's case in Green Hydrogen development were the core focus of the study. Individuals in the best position to offer information from different perspectives were selected.

Selection criteria	Parameters
Research topic correlation	Green Hydrogen, Renewable Energy Resources (RES), Energy Justice (EJ), Energy Poverty (EP)
Educational Background	Academic level (Master's or PhD)
Work experience	At least 2 years in the field
Position	Junior or Senior
Country	Ideally from Greece. Otherwise, based on the background and experience
Provinces	ideally from Northern Greece, or from a coal-lignite-dependent region

Table 2.1: Expert selection parameters

The experts were selected based on the criteria outlined in Table 2.1 and gathered from multiple sources. The experts were identified and approached through personal networks and LinkedIn. I also relied on the snowball sampling technique, which involves asking existing participants to assist in identifying other potential subjects (Sekaran & Bougie, 2016). After identifying potential participants, I sent an invitation via their contact information or LinkedIn messages. During the design of the interview procedure, my target was to contact between 9 and 10 people. Initially, key informants from regional industrial bodies, energy companies and NGOs were identified based on their involvement in hydrogen-related decision-making processes. Additional participants were recommended by initial respondents, thereby broadening the scope of insights to include community-level viewpoints.

2.2.4.6. Preparation and planning

Before designing or conducting the interviews with the experts, I first conducted an extensive literature review. The objective was to ensure that I gained sufficient understanding of the topic being investigated. Following the findings from the review of existing studies, it was determined that the interviews would focus on the following themes:

- Green Hydrogen's potential uses and major developments.
- Influence on the government's policies to promote the development of green hydrogen.
- The expectations regarding the hydrogen transition in the region.
- Implications regarding unfair conditions in the transition process.
- Potential distributional and/or recognitional justice concerns related to this transition.

Other empirical studies informed the selection of these themes. Additionally, it was determined that focusing on these topics was important to achieve the intended objectives of the present study. They

specifically addressed aspects related to the use of green hydrogen in Greece, the influence and roles of various stakeholders and the need for inclusivity when developing such projects. The themes also explore existing barriers that have limited the full implementation of green hydrogen projects, as well as the recommendations of industry experts.

Affliction	Code in text	Date	Duration (in minutes)
Hydrogen Energy Expert	EI1	30.05.2025	60
Energy community co-founder	EI2	30.05.2025	60
Climate Policy Advisor	EI3	30.05.2025	50
Process Engineer	EI4	04.06.2025	50
Energy community co-member	EI5	05.06.2025	40
Local government	EI6	12.06.2025	40
Academic Researcher	EI7	12.06.2025	50
Energy community member	EI8	12.06.2025	60
Energy Poverty Expert	EI9	17.06.2025	60

Table 2.2: Overview of conducted interviews

2.3. Data Analysis

The data analysis was structured around two complementary methods: content analysis of published documents and qualitative analysis of interview data. Both were designed to extract meaning from textual materials by identifying patterns, contradictions and thematic emphases. The process of conducting the interviews is further explained in detail in the following sections.

2.3.1. Content Analysis

Documents were selected based on their influence on policy (e.g., Recovery and Resilience Plan, Just Transition Development Plan of Western Macedonia), their focus on hydrogen deployment (Kavadias et al., 2018), or their empirical grounding in regional experiences (Pavloudakis et al., 2023). The document-based content analysis was conducted by thematically analysing 20 policy reports, strategy documents, academic papers, and grey literature. Thematic categories were informed by both theory and empirical relevance, with a particular emphasis on energy justice aspects.

To strengthen the content analysis, it is vital to recognise the multilevel interplay of international, European, national, and local policy efforts in shaping the hydrogen transition in Western Macedonia. At the international level, climate agreements such as the Paris Agreement have provided overarching decarbonisation mandates. At the same time, the European Green Deal and the EU Hydrogen Strategy have articulated ambitions for a low-carbon hydrogen economy by 2030 and beyond (European Commission, 2020). These strategies are supported by funding mechanisms like the Just Transition Mechanism (JTM) and Horizon Europe, which aim to align innovation with equity, sustainability, and technological scalability.

At the EU level, the Clean Hydrogen Alliance and the Fit-for-55 legislative package define priorities in terms of infrastructure, green hydrogen certification, and energy system integration (Espitalier-Noël et al., 2025). These mechanisms influence national strategies such as Greece's updated National Energy and Climate Plan (NECP), which envisions hydrogen as a key tool for hard-to-abate sectors and the transition of former lignite regions (The Green Tank, 2019). Member-state level efforts, such as Germany's H2Global and Spain's Hydrogen Roadmap, demonstrate how national policy nuances contribute to a patchwork of progress and tensions across the EU (Energy Press Greece, 2024). Simultaneously, the EU Hydrogen Strategy (2020) and REPowerEU Plan envision hydrogen as a key enabler of decarbonisation for industry and transport, with associated economic benefits (European Commission, 2020). However, critiques from NGOs such as the European Environmental Bureau (ten Brink, 2025) and think tanks like Third Generation Environmentalism (E3G) note the risk of replicating extractive economic models. These analyses reveal that hydrogen's role is often embedded in economic growth narratives, sidelining social and participatory considerations.

At the same context, the Hydrogen Strategy is framed as *"the heart of the European Green Deal,"*

promising climate neutrality and market leadership (European Commission, 2020). Official communications repeatedly assert that *"broad stakeholder participation will be ensured at every stage"* (European Commission, 2020). However, recent independent analyses point to a clear bias in EU-level lobbying: *"Business interests are better organised and better represented than diffuse public interests, and civil society is largely underrepresented in consultations"* (Flath & Quittkat, 2025). The EU Court of Auditors' 2024 report goes further, stating: *"The Commission did not undertake robust analyses before setting the EU's renewable hydrogen production and import targets... The EU targets turned out to be overly ambitious... not all member states set their targets. When they did, these national targets were not necessarily aligned with the Commission's targets"* (European Court of Auditors, 2024).

In Greece, policy gaps persist in stakeholder inclusion and equitable distribution. Although hydrogen is increasingly visible in strategic documents, legal frameworks remain underdeveloped, particularly in terms of incentivising community participation (Institute for European Energy and Climate Policy (IEECP), 2023). Research shows that regional hydrogen initiatives disproportionately empower large industrial players over local cooperatives or municipal governments (Papada & Kaliampakos, 2016). These gaps are evident in the case of Western Macedonia, where initiatives like the Hydrogen Valley have gained support; yet, municipal leaders and civil society representatives report exclusion from high-level planning processes (Kaldellis, 2025; Kitsikopoulos & Vrettos, 2023). Greece's NECP Ministry of Environment and Energy (2022) primarily integrates hydrogen as a technological transition pathway for former coal regions, such as Western Macedonia. Despite this alignment with EU-level ambitions, gaps persist in enabling participatory governance and inclusive benefit-sharing. The documents of The Green Tank (2021) and Espitalier-Noël et al. (2025) emphasise that funding and permitting regimes favour large consortia over cooperatives or municipalities. Proka et al. (2018) and Papada and Kaliampakos (2016) underline that energy cooperatives are still marginal players in the hydrogen landscape.

The Just Transition Development Plan (JTD Plan) set ambitious targets: *"A central priority is to ensure a fair development transition... based on three pillars: employment protection, compensation of the socio-economic impact of the transition, and energy self-sufficiency..."* (Master Plan for Western Macedonia, 2021).

But labour market analysis from the World Bank reveals: *"With unemployment rates already more than twice as large as those experienced in other coal regions of the EU, the social impact will undoubtedly be high if an additional 15 to 20 percent of the active population becomes directly unemployed... Many do not expect much of a future in Western Macedonia, with most of the better-skilled seeing themselves move to other regions, also because of the substantial skills mismatch which already exists"* (World Bank, 2020).

The Just Transition Plan claims to support *"all affected workers and communities,"* but vulnerable groups (youth, women, low-skilled workers) face persistent exclusion. The World Bank's labour market study stresses: *"The employment indirectly generated by the mines and power plants is... much larger... Many do not expect much of a future in Western Macedonia, with most of the better-skilled seeing themselves move to other regions"* (World Bank, 2020). Zervas (2020) argue: *"It is estimated that the deadline set for de-lignification in 2023, is too early… to allow the economic transition of the Region, and to exclude the possibility of a massive wave of migration"* (Zervas et al., 2021).

Locally, Western Macedonia's role in the Just Transition mechanism and the "White Dragon" project highlights how hydrogen is positioned as a development panacea. Yet empirical assessments Boemi et al. (2020) show that community consultation is limited, and social equity considerations are peripheral. NGO reports from EmpowerMED Consortium (2023) and Initialising Towards Energy Balance Zero(INZEB) (2021) stress the intersectional impacts, particularly on women, youth, and energy-poor households.

The content analysis identifies key trends:

1. Decision-making remains centralised and technocratic, undermining procedural justice.
2. Distribution of benefits (jobs, infrastructure) favours established actors, with limited inclusion of vulnerable populations.

3. Cultural and socioeconomic recognition is often absent in hydrogen strategies, despite rhetoric on inclusivity.

Expert commentaries from scholars such as Patonia (2025) and Proka et al. (2018) reinforce the above findings, advocating for decentralisation, greater accountability, and energy citizenship. These findings have informed the coding framework for interviews and highlight significant justice concerns across policy tiers. Academic studies such as those by Kaldellis et al. (2023) and Proka et al. (2018) offered critical perspectives on the role of local actors and energy communities.

An initial research revealed an overemphasis on economic and technical metrics—such as emissions reduction and hydrogen supply potential—while procedural justice elements were largely absent. For example, the *" Green Transition and Electricity Sector Decarbonisation study"* frames Western Macedonia as a hydrogen "hub," yet offers no detailed mechanisms for stakeholder consultation or public involvement in infrastructure planning (Kaldellis et al., 2023). ENA Institute for Alternative Policies (2024) recent policy review concludes: *"Despite the quantitative growth of energy communities, qualitative and procedural shortcomings persist—most notably the lack of systematic support and the difficulties in accessing funding and permits"* (Skapoula, 2024).

Zervas (2020) notes: *"While the NECP highlights ambitious climate and social targets, there is a lack of concrete scenarios and sectoral plans for regions most affected by the lignite phase-out. The plan emphasises economic growth, but the mechanisms for local participation remain underdeveloped"*. Additionally, content from the study "Between Green Extractivism and Energy Justice in South Africa" was used for comparative framing (Kalt et al., 2023). It demonstrated similar justice tensions, suggesting that the hydrogen transition, if left unchecked, risks perpetuating new forms of inequality and centralised control under the guise of green innovation. Documents such as *the Social Impact of Energy Communities in Greece* (Kitsikopoulos & Vrettos, 2023) explicitly argue that cooperatives are not adequately recognised as legitimate actors in the hydrogen economy, despite their legal formation and social capital. The inclusion of engineering-focused studies Kaldellis (2025) and Katsaprakakis et al. (2022) revealed that socio-political considerations are often excluded from energy systems modelling. This lack of interdisciplinarity reflects a broader issue in transition governance, where concerns about justice are often treated as peripheral rather than foundational.

2.3.1.1. Analysis Procedure

After collecting all the interview data, the data analysis was conducted. Following the suggestion of combining narrative analysis and content analysis to ensure a thorough and meaningful analysis of qualitative interview data, the data analysis is divided into two parts (Sekaran & Bougie, 2016). The first part was the per-interview (within-case) analysis, where each interview's data recording is analysed and the narratives answering each interview question are extracted. The second part is the cross-case interview analysis, where all the collected answer narratives from the first part are compared, and common themes are identified.

2.3.1.2. Per interview analysis

For each of the nine in-depth interviews conducted, the recorded data was analysed. This was done using narrative analysis, in which the different topical stories the interviewees tell in answer to the interview questions are extracted. The narrative analysis is suitable for situations where the interviewee tells a story to help interpret their lived experience and answer the question (Figgou & Pavlopoulos, 2015). Data analysis began with transcribing the relevant narratives from the recorded interviews regarding each factor. As interviews were guided by the interview questionnaire, in which the questions were organised according to each factor, recognising the narratives that answered the questions relating to each factor was not difficult. These narratives for each question were collected in an Excel file for each interviewee.

The table 2.3 below shows an example of how the themes were extracted from the narrative answers of interviewees to interview question 6 (Q6) (see Appendix A), which addresses the factor of the most pressing justice issue in the hydrogen initiatives.

A Venn Diagram, as illustrated in Figure 2.2, illustrates a structured lens for interpreting the narratives provided by the interviewees involved in or affected by the hydrogen transition projects in Western

Interviewee number	Collected answer narratives to Q6
Interviewee 1	*"Hydrogen must be developed in a way that doesn't replicate the inequalities of the past fossil fuel era. The biggest challenge is making sure the benefits do not go to the same powerful actors again."*
Interviewee 2	*"The major issue is that local communities are not genuinely included in the decision-making process. Everything is top-down."*
Interviewee 3	*"We risk building a green economy that mirrors the injustices of the brown economy. Ownership and control need to shift, not just the energy source."*
Interviewee 4	*"Without community benefit-sharing mechanisms, there is no real justice in energy transition"*
Interviewee 5	*"We have to build energy literacy first. Justice can't exist if people do not know their rights"*
Interviewee 6	*"The most pressing issue is structural inequality. Some areas receive all the funds and projects while others get left behind"*
Interviewee 7	*"The lack of inclusive planning and clear communication is the greatest threat. Transition is becoming a buzzword without real change"*
Interviewee 8	*"The challenge is replicating past mistakes; Where innovation is centralised and citizens are spectators"*
Interviewee 9	*"Energy justice is not only about technology or funding. It's about power, voice, and community resilience"*

Table 2.3: Collected answer narratives to Q6 from the interviewees

Macedonia. The viewpoints of the interviewees align with one or more energy justice pillars, as demonstrated in the results section of the semi-structured interviews.

On the right side, hydrogen expert's perspective (EI1) , positioned at the intersection of distributional and recognition justice, reflects a measured and critical stance. He cautions against uncritical "hype" and emphasises that technical feasibility does not guarantee social fairness:

> "We try to bring a grain of realism into the discussion. Just because something is green does not automatically mean it is just or feasible for everyone." International disparities in water and renewable resource access are central to his concern for equitable outcomes.

Continuing from the right to the left side, the researcher's perspective (EI8) is located at the intersection of recognition and procedural justice, the interviewee contextualised the region's current challenges in the broader sweep of historical transitions:

> "We were among the first to see that the transition is a one-way street, but participation, transparency, and distribution of benefits must be ensured."

The academic's statement (EI7) straddles distributional and recognition justice. This interviewee discussed technical and institutional barriers to equitable access and the limited impact of research without community integration:

> "If your research does not have an immediate application, it loses much of its relevance."

Walking on to a more technical narrative, the process engineer insights (EI4) occupy the recognition justice circle, noting methodological shortcomings in current assessment tools:

> "Industrial ecology tools are much more advanced for tracking material and economic flows than for capturing social justice metrics,"

thus underscoring challenges in measuring social impacts and ensuring under-represented groups are recognised.

The Policy Advisor's (EI3) viewpoint is situated firmly within procedural justice, emphasising authentic stakeholder involvement over symbolic participation. As he noted,

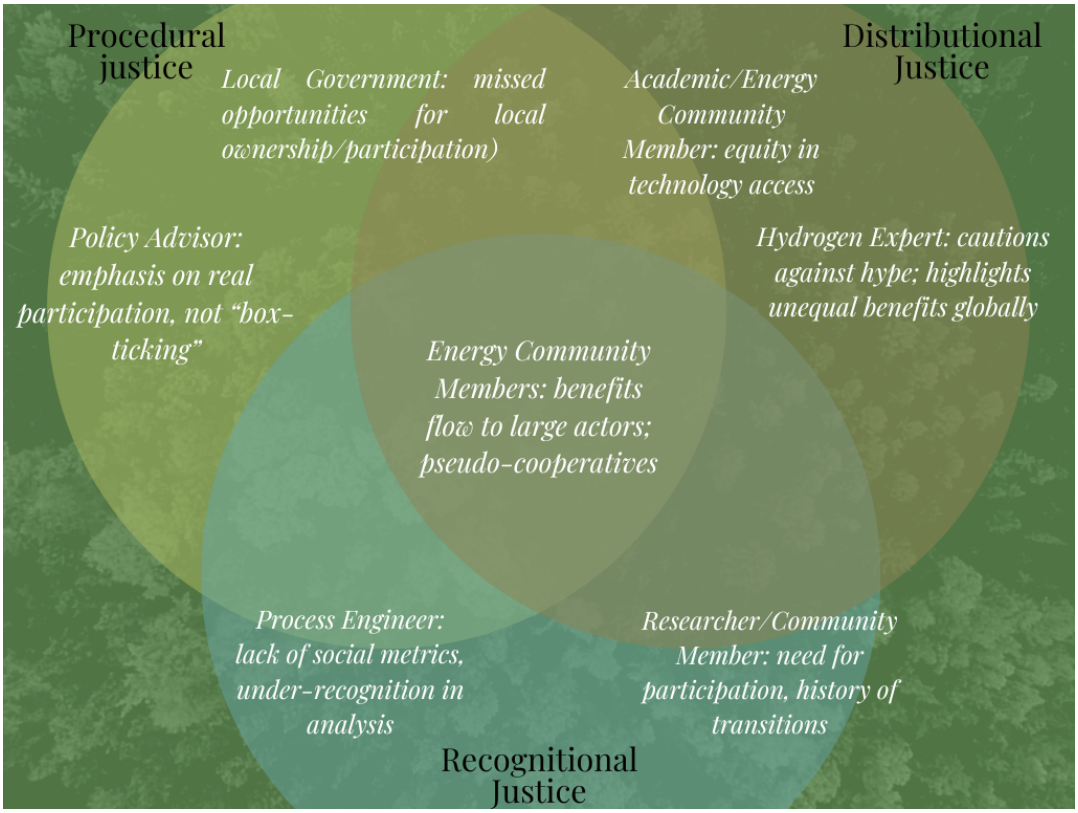

Figure 2.2: Three-circle Venn Diagram—blue for procedural justice, green for distributional justice, and gold for recognition justice—which visualise how each stakeholder's perspective located onto the main tenets of energy justice. The placement of comments within or at the intersections of these circles illustrates the complexity and overlap of justice concerns voiced during the interviews. The visual is designed by the author adapted for clarity from qualitative data and analysis in this research.

> "It is important to have them in during the whole duration of the project, to act as feedback mechanisms and not only as symbolic participants."

The interviewee also observed the influence of shifting political priorities on regional support for hydrogen projects.

The political voice in these interviews (EI6), the politician figure, highlighted gaps in procedural justice and missed opportunities for local participation, this respondent remarked,

> "The transition is happening, but the dimension of justice is still missing. Citizens and households have not had any real plan to participate or benefit."

Lastly, Energy Community Members experiences (EI2 and EI5), placed at the overlap of procedural and distributional justice, highlight bureaucratic and legal obstacles impeding citizen-led efforts. One observed,

> "The reality is that the institution does not operate as it should… there are huge gaps that harm genuine citizen communities, who lack the capital, personnel, or support needed to thrive."

Both denounced the rise of "pseudo-cooperatives" that subvert the intended distributional fairness of energy community policies.

2.3.1.3. Across Interview Analysis

In the Table 2.4, the alignment between stakeholder interview data and the three core pillars of energy justice are summarised. The table's columns group participant observations under procedural, distributive, and recognition justice, clarifying where major challenges lie. Representative quotes from interviews and thematic bullet points support the argument that, while procedural and distributive gaps

remain most acute, recognition justice is also significantly at risk, especially for marginalised groups. The bottom of the table highlights methodological limitations and the cautiously optimistic outlook expressed by interviewees regarding the future of hydrogen policy and practice in Greece.

Table 2.4: Key Findings from Stakeholder Interviews by Energy Justice Dimension

Procedural Justice	Distributive Justice	Recognition Justice
• Agreement on participation gaps: "Meaningful participation is still largely symbolic." • Dominance of experts and companies; lack of true community input. • Policies and processes driven by shifting political priorities.	• Unequal distribution of benefits: "Most energy communities in Greece are not authentic…the real ones are less than a hundred." • Regulatory loopholes favour large players. • Gaps between policy rhetoric and distributive outcomes.	• Under-representation of rural/small/non-profit actors. • Lack of mechanisms for visibility/voice. • Need for better justice metrics and social indicators. • Political/regulatory flux as a barrier to recognition.
Methodological notice: current frameworks often miss social impacts; need for better justice metrics across all pillars. Positive Outlook: Cautious optimism if future policies address participation, distribution, and recognition gaps.		

There was strong agreement on participation gaps: across all interviews, mechanisms intended to foster public involvement were widely seen as insufficient, either dominated by technical experts, large companies, or shaped by shifting political priorities. As one policy advisor noted, "Meaningful participation is still largely symbolic," while an energy community member observed, "Genuine community initiatives struggle to compete." These concerns reflect shortcomings in both procedural and recognition justice.

All stakeholders flagged the unequal distribution of benefits—be they financial returns, job opportunities, or access to infrastructure. Regulatory loopholes often favour larger, well-capitalised actors, and as one community member put it, "Most energy communities in Greece are not authentic… the real ones are less than a hundred," highlighting a significant gap between policy rhetoric and distributive outcomes.

Recognition justice was challenged by the under-representation of rural residents, smaller cooperatives, and non-profit actors. The lack of mechanisms for these groups to be heard and included in decision-making was a recurring theme. Additionally, methodological reflections from academic and technical respondents underscored that existing frameworks are better suited to tracking technical and economic flows than social impacts, pointing to the need for more robust justice metrics and indicators.

The political and regulatory environment—including regional and national political shifts, evolving laws, and changing corporate strategies—was identified as a further determinant of justice outcomes. Despite these substantial challenges, most interviewees expressed a cautiously optimistic outlook, believing that the long-term potential for hydrogen and community energy could be realised if future policies actively address the highlighted justice gaps.

2.3.1.4 Data analysis and interpretation

Upon identifying the key themes to be addressed during the interviews, I formulated the minutes, which were sent to each interviewee for their approval. Additionally, the participants were informed that the data they provided would be used for the present study. More specifically, they were informed that the recorded interviews would be used as excerpts. The minutes were categorised into the themes identified in the previous section.

Nine semi-structured interviews were conducted to gather primary qualitative data. Depending on the interest and availability, the total number of participants was assessed. Participants, including local

stakeholders and energy experts, were recruited through existing stakeholder networks and public announcements. Interviews lasted approximately 1 hour and covered issues such as perceptions of fairness, inclusivity, and procedural transparency in energy transitions. Ethical considerations, including informed consent review and participant anonymity, were strictly adhered to following the guidelines provided by the TU Delft Human Research Ethics Committee (HREC).

Data collected from the interviews were analysed using *Atlas.ti* software. *Atlas.ti* software was used for qualitative data analysis, involving coding procedures, thematic analysis, and the identification of patterns related to energy justice principles. Data interpretation focused on correlating quantitative trends with qualitative insights, enriching the understanding of regional dynamics in energy transitions.

The design of the questions required the respondents to respond on the specified scale.

- Could you briefly describe your organisation's or your involvement in the green hydrogen transition in Western Macedonia?
- From your perspective, what are the main drivers motivating the shift from lignite-based energy to green hydrogen?
- How would you describe the current decision-making process for green hydrogen projects in Western Macedonia? Do you consider this process transparent and inclusive? Why or why not?
- Have you or your organisation had adequate opportunities to participate in discussions or decision-making processes regarding the transition? Can you describe any specific examples or incidents?
- To what extent have local employment and retraining programs been effective in supporting workers affected by the transition from lignite-based industries? Could you provide specific examples of successful or unsuccessful initiatives?

2.3.1.5. Data handling, processing, and storage

The interview method is an effective option for collecting in-depth insights pertinent to the case study in primary data research. Specifically, the interviewees were asked whether stakeholders can influence the relevant tenets, and if so, who and how they could influence them while co-existing with the needs of local communities. The questions from each round are detailed in the Appendix A section.

One vital requirement for the interviews is that any potential participant was approached to determine their willingness to cooperate with the research project. There were some criteria for the interviewees. The interviewees' backgrounds should include involvement in hydrogen production technologies and applications, as well as residents involved in any energy-community initiatives. They should also possess knowledge about governmental and legislative directives regarding energy use, hydrogen generation, implications, and supply-and-demand side management. The prospective experts were chosen by first obtaining recommendations from the responsible thesis supervisors and then by searching for contact details from energy companies, institutions, and process and manufacturing industries in Greece. The interviews were anonymous, so I didn't publish any personal data.

Data collected from interviews were handled with strict adherence to ethical guidelines provided by the Human Research Ethics Committee of TU Delft, ensuring privacy and confidentiality. The audio recordings of the interviews were transcribed verbatim and immediately anonymised by removing personally identifiable information and assigning pseudonyms to each participant. Transcripts were securely stored in password-protected digital formats, accessible only to authorised research members. Data processing involved systematic thematic coding using *Atlas.ti* software to facilitate rigorous qualitative analysis. Upon completion of the research, all primary data, transcripts, and coding files were securely archived under university protocols, ensuring long-term confidentiality and integrity.

2.4. Research Reliability and Validity

It is paramount to evaluate the quality of a study, especially if the results of the research are intended to be utilised in practice. The process of examining the reliability of research necessitates the researchers or practitioners to make subjective judgements pertaining to the soundness of the study in relation to set criteria on the methods that should be undertaken when collecting and analysing the data (Noble & Smith, 2015). This is especially important in qualitative studies, which are often criticised for lacking

scientific rigour and transparency in the methods that are adopted when collecting and analysing the data.

According to Noble and Smith (2015), reliability is a measure of the "consistency of the analytical procedures, including accounting for personal and research method biases that may have influenced the findings" (p. 34). In other words, it measures the extent to which the adopted research method can provide consistent findings when done repeatedly. To ensure the reliability of the present study, certain steps were followed. Firstly, an initial discussion was conducted with three individuals, including engineers and an energy community member. This was deemed necessary to ensure that I targeted the appropriate personnel to provide their insights to inform the research questions. Secondly, I discussed and strictly followed proper data collection and analysis procedures. Thirdly, the selection of the documents that were used for analysis followed specific criteria, including the requirement that they ought to be reliable publications from government institutions or peer-reviewed articles. Additionally, specific criteria were developed and followed when recruiting the interviewees.

Noble and Smith (2015) define research validity as the accuracy of the findings with the collected data. The measures that were adopted to ensure the validity of the research included an explanation to the interviewees about the objective of the study. Additionally, I sought to evaluate the understanding of the participants towards specific items, and this was done to ensure that they had the appropriate information regarding the case study context. Also, triangulation of sources was performed during the analysis step, which involved using different sources. By using more than one source of data, I minimised inaccuracies in the collected data. Internal validity measures the extent to which the observed results represent the truth in the population being studied (interviewees). The strategy that I adopted to evaluate this aspect involved me repeating the interviewees' answers or summarising their answers after they answered each question. This was to ensure they clarified what their intentions were, corrected errors and provided additional information if necessary.

The third element of research validity and reliability is generalisability, and it refers to the extent to which the findings of the present study can be generalised to other settings or applied in different contexts (Noble & Smith, 2015). Generally, I sought to conduct interviewees with a diverse group of participants in different settings and experience. However, considering that this study is primarily a qualitative study that relied on data from a purposive sample, the generalisability of the findings is largely limited.

3

Conceptual Background & Literature Review

3.1. Energy Transition and Decarbonisation

Recent concerns about climate change and the increase of carbon dioxide emissions globally have set the pace for energy transition. It is important to mention that whereas there has been a substantial increase in the share of renewable energy, recent reports indicate that all countries have to enhance their efforts to decarbonise their sectors (Papadis & Tsatsaronis, 2020). Indeed, evidence indicates that the past two decades have been the warmest (Lindsey & Dahlman, 2025). Some parts of the world have experienced severe weather phenomena. Today, more than ever, people are increasingly worried about climate change, especially due to the risk of experiencing floods, decades and rise of seal levels. Such phenomena often affect people's livelihoods and causes displacement. Undoubtedly, the combustion of fossil fuels is primarily accountably for the climate change that has occurred over the past few decades. For this reason, the conversation about decarbonising major sectors, including energy, transport and manufacturing, has attracted attention from various stakeholders. There is a general consensus that the most effective and convenient way of decarbonisation is shifting to renewable energy. Consequently, many countries have increasingly explored other alternative sources of energy, such as wind, geothermal and hydrogen. Climate policies, such as the Paris Agreement and European Green Deal have been enacted to propel the transition to alternative sources of energy.

Compared to other EU Member States such as Germany, Greece is not heavily industrialised. However, there are many energy-intensive industries and smaller firms. Currently, the power and heat sectors are primarily accountable for the most substantial, share of greenhouse gas emissions in the country (Carmona-Martínez et al., 2024). It is also interesting to note that these sectors have significantly cut their emissions over the past 10 years (Carmona-Martínez et al., 2024). This represents efforts by the country to decarbonise its major sectors. It was the first Balkan country to declare a coal phase-out date by pledging that it would phase out lignite-fired power stations by 2028 (European Commission, 2025). This transition is significant for the region of Western Macedonia, which has remained as the main centre for the country's lignite sector. Despite the known benefits, decarbonisation presents significant difficulties, including infrastructure adaptation, worker displacement and economic restructuring. Mainly wind, solar, and green hydrogen, the Greek National Energy and Climate Plan (NECP) details ways to substitute Renewable Energy Resources (RES) for lignite (Zervas et al., 2021).

3.2. Green Hydrogen as a Decarbonisation Strategy

There has been renewed interest in hydrogen as one of the potential solutions in the energy market to reach the carbon neutrality goal. Generally, hydrogen is considered sustainable because it does not emit greenhouse gases or other potential pollutants (Noussan et al., 2021). It is also regarded as a versatile energy carrier because it can be utilised in different applications across several sectors, including manufacturing, power and construction. Therefore, hydrogen produced using renewable means is

expected to play a fundamental role in the energy transition, as it will replace fossil fuels.

According to a report by the International Energy Agency, hydrogen production in 2023 reached 97 million tonnes (International Energy Agency (IEA), 2024). It is essential to note that the current volume of hydrogen production is primarily derived from fossil fuels, with no control over emissions, accounting for at least 48%. Another 30% of production was from heavy oils, and naphtha and coal accounted for 18% of the total volume (Lagioia et al., 2023). These figures indicate that only 4% is produced through water electrolysis, and renewable energy accounts for only 1%. The production of hydrogen, which is mainly utilised in refineries and the fertiliser sector, is responsible for the production of nearly 830 million tonnes of carbon emissions (Lagioia et al., 2023). This suggests that, while there is a growing momentum towards hydrogen as a replacement for fossil fuels, it is essential for countries to invest in the production of hydrogen from renewable energy sources.

Generally, there are five primary categories of hydrogen, which are based on the generation technologies. The first is brown or grey hydrogen, which is produced using fossil fuels. In the case that this hydrogen involves carbon capture and storage technologies, then it is considered blue hydrogen (Lagioia et al., 2023). The third category is turquoise hydrogen, which is produced through the pyrolysis of a fossil fuel, and carbon is typically a by-product. The fourth category is yellow or purpose hydrogen, which is obtained from nuclear power plants. The last category, which is the focus of the present study, is green hydrogen that is produced using renewable sources. A review of existing literature indicates that there is no widely accepted standard concerning hydrogen typology. This has resulted in key institutions limiting their ability to address these standards in energy policy. For example, there has been confusion about whether the EU should recognise or invest in low-carbon hydrogen projects to achieve its aim of transitioning to sustainable energy. Another concern is that hydrogen is more expensive to produce compared to natural gas or electricity, primarily since significant costs are incurred to support production, storage, and transport (Lagioia et al., 2023).

In Greece, green hydrogen has been recognised as a critical component to support the country's plan to substitute fossil fuels in several sectors, including industry, transport and power generation (European Commission, 2025). Produced by electrolysis using renewable energy sources (RES), it is a zero-emission energy carrier that supports national decarbonisation initiatives (Luka Dimitrov for ICIS, 2021). Green hydrogen is expected to play a fundamental role in energy security, economic diversification, and technical innovation as Greece phases out lignite by 2028 (Zervas et al., 2021).

Greece's lignite hub, Western Macedonia, is currently positioned as the nation's hydrogen-producing centre because of its substantial renewable energy potential and access to EU Just Transition financing. In line with the Important Projects of Common European Interest (IPCEI), the Greek Hydrogen Strategy prioritises massive hydrogen projects aimed at attracting foreign capital (European Climate, Infrastructure and Environment Executive Agency, 2023). As part of Greece's more significant decarbonisation path, the area is scheduled to house a 100 MW electrolysis plant (Mantzaris, Nikos, 2021).

Legislative delays, financial uncertainties, and regulatory shortcomings still present significant implementation challenges; however, these are minor issues (Kruczek et al., 2025). One of the key questions is whether producing hydrogen is a profitable endeavour. All of which help explain hydrogen's current higher cost compared to fossil fuels, including high infrastructure costs, a lack of specialised pipes, and market immaturity (Luka Dimitrov for ICIS, 2021). Greece is obligated to implement competitive pricing regulations, offer subsidies, and promote industrial integration to increase hydrogen production effectively. Public acceptability is also another essential element influencing the success of Greece's hydrogen shift. Many Western Macedonian municipalities are reluctant, based on the notion that hydrogen projects will not provide enough employment to offset the lost jobs related to lignite mining (The Green Tank, 2021). The Hellenic Republic's Ministry of Environment and Energy emphasises that all of these elements are essential to ensure a fair transition: open stakeholder participation, public awareness campaigns, and retraining programs. Furthermore, environmental issues such as land utilisation, water use and hydrogen leakage hazards have to be carefully addressed.

Despite existing obstacles, it is essential for the government to support investment in green hydrogen, as it will significantly reduce the country's emissions, strengthen energy resilience, and enhance Greece's reputation based on its sustainability initiatives (Luka Dimitrov for ICIS, 2021). For the energy transition to succeed, it is necessary to consider several key aspects, including creating effective

policies, expanding existing infrastructure, and engaging various stakeholders.

3.3. Energy Justice framework

Energy justice serves as a critical framework for assessing the equity, inclusivity and societal impact of Greece's energy transition, particularly in Western Macedonia. There are three core elements that guarantee that the advantages and costs of the transition are equitably shared, which are distributional, procedural justice and recognition justice (Jenkins et al., 2016). Concerns regarding regional economic downturn, labour displacement, and lack of community involvement under Greece's phase-out of lignite draw attention to the need for a fair transition.

Distributional justice is primarily concerned with ensuring fair access to benefits and mitigating adverse socioeconomic impacts. In their examination of distributional justice, Pellegrini-Masini et al. (2020) focus on examples of spatial costs associated with specific forms of energy generation, and they particularly demonstrate how disadvantaged persons in society are more likely to be targeted and host undesirable energy plants than wealthier persons. (Jenkins et al., 2016) further explore the distributional justice components and argues that it is not only characterised by spatial inequalities; it also addresses access to energy services. In other words, the authors emphasise that specific populations experience energy and fuel poverty. Pellegrini-Masini et al. (2020) noted that distributional justice should also consider the distribution of energy services and the adverse effects of the production of energy. According to Sovacool and Dworkin (2015), distributional justice deals with three core elements. Firstly, it concerns the goods, such as wealth or power, that are to be distributed. The second element constitutes the entities to which the goods are to be distributed. The third element describes the appropriate mode of distributing the goods, which is premised on needs, merit or property rights. Distributive justice posits that if physical security is a core right, then all the conditions that create that good should also be a right for the entities. In the context of energy justice, the conditions that support the establishment of the projects, including employment, unpolluted air and land rights, should be equally considered as rights to the entities. Concerns have been raised in Western Macedonia about potential employment losses that could impact the local community. Therefore, it is necessary to consider both the interests of the locals and the corporate profits of the firms that will be building the projects (Kruczek et al., 2025). Ensuring justice requires open benefit-sharing systems, robust labour rights, and focused reskilling initiatives.

In any pursuit of social goals, it is crucial to evaluate the process of decision-making, which is addressed by the procedural justice component (Sovacool & Dworkin, 2015). According to the authors, the primary focus of this tenet is the parties involved in the decisions and their level of influence. There are several factors that influence the decision-making process, including accessibility to information. Indeed, when people lack sufficient information about the effects of a specific action, even their limitations in the decision-making process are meaningless. Another essential element of procedural justice is access to and meaningful participation in the process (Sovacool & Dworkin, 2015). Notably, the authors emphasise that decision-makers should portray no bias. Finally, it is vital to have legal alternatives that can be pursued if the decision reached is not satisfactory to specific parties. Studies indicate that there has been minimal public engagement in Greece regarding the hydrogen projects that have been implemented. It has been illustrated that government institutions and other corporate entities have primarily influenced the decisions and shaped the discussions. There is a probability that excluding certain stakeholders will likely widen economic disparities and lead to opposition to these projects (Kostis Moussouroulis, 2020). For the long-term sustainability of green hydrogen projects, it is recommended that policies be developed to account for the needs of local communities. The initiatives should be significantly influenced by the needs of the communities, and relevant economic strategies should seek to preserve the identity of the regions.

Recognition fairness guarantees that transition programs respect regional identities and economic interdependence, thereby addressing historical and cultural factors. In the discussion of recognition justice, van Uffelen (2022) present four dimensions for exploring this tenet. The first dimension begins with a recognition of specific social groups, and the researchers argued that it concerns "who" is recognised, affected or impacted. The question of who is recognised intertwines with the tenets of distributive and procedural justice. The second dimension for recognition justice entails recognising the rights and qualities of actors by assigning specific legal rights. Typically, this applies to human actors but may also be

used to non-human actors, such as animals or the environment. The third dimension for recognition of justice focuses on the decision-making processes. More specifically, it emphasises the need for fair representation, freedom from potential threats and comprehensive political rights. Ideally, the needs of every entity that is affected by a specific action should be recognised and integrated into the policy-making process. The final cluster integrates the cultural status of society, and it is hypothesised that misrecognition occurs when specific patterns that have been accepted by society are institutionalised in a way that they hinder the participation of particular groups, especially the vulnerable. For decades, Western Macedonia has been primarily dependent on lignite both economically and culturally. Therefore, the switch to hydrogen marks a significant socio-economic change (Mahmudi, 2022). Ignoring regional viewpoints and workforce issues may exacerbate economic inequalities and foster hostility to renewable energy sources. Long-term sustainability depends on appreciating these processes through localised policy interventions, community-led projects, and financial models that conserve legacy.

The EU Just Transition Mechanism offers financial support; however, issues related to the transparency and equity of fund distribution remain a concern (Kostis Moussouroulis, 2020). Experts caution that extensive investments in hydrogen could favour international investors over local businesses, potentially exacerbating economic disparities. An equitable transition should prioritise local job creation, financial stability, and sustainable social benefits in hydrogen development strategies (Jenkins et al., 2016).

Table 3.1: Summary of Energy Justice Dimensions

Dimension	Core Focus	Relevance in Western Macedonia
Distributional Justice	Fair access to energy and equitable distribution of burdens	•Labour displacement •Air and land degradation •Energy/fuel poverty •Regional inequality
Procedural Justice	Inclusiveness, transparency and fairness in decision-making	•Limited involvement of the public •Centralised decision-making •Lack of accessible information and legal recourse
Recognition Justice	Acknowledgement of identities, rights and cultural values	•Neglect of local identity and culture •Lack of legal recognition •Institutional bias against vulnerable groups

3.4. Stakeholder Perspectives in Energy Transition

In the past decade, different studies have explored the role of stakeholders in energy transition and how to involve them in projects. (Höfer & Madlener, 2020) acknowledge that one of the main challenges in any project is that different stakeholders always have diverse opinions and interests. Therefore, a key role for policymakers is to integrate the views of different stakeholders in the implementation of the projects. Based on a study where the researchers evaluated the perspectives of stakeholders in the energy transition process of a port, they identified five main steps for stakeholder management (Alamoush, 2024). These steps are identification, prioritisation, visualisation, engagement and monitoring. After the policymakers build a list of all affected stakeholders by a project, there are various approaches used in the prioritisation step. One of the most popular approaches is based on the stakeholders' power, proximity and urgency. According to the authors, the power dimension concerns the capacity of stakeholders to take influential actions, whilst proximity pertains to how close the individual is to the everyday activities of the project. The problem with this approach, as reported in several studies, is that the interests of the community are less prioritised.

Research on the management of stakeholder transitions in energy transitions has indicated that the interests of the local community have to be addressed for any project to be implemented successfully. For

instance, a study by Wüstenhagen et al. (2007) established that there are levels of social acceptance that ought to be considered: socio-political, market and community. The researchers demonstrated that the proximity of the public to the energy projects has a strong influence on their perceptions and ultimate acceptance. Energy transition projects provided an opportunity for the community to take ownership, and positive perceptions of the economic advantages of such projects will most likely lead to support (Burke & Stephens, 2018). Ideally, it is assumed that renewable energy projects create opportunities for the locals and have significant benefits. However, when the community understand that such projects may not necessarily lead to a democratic energy future, they are likely to oppose implementation.

In the Greek context, there are multiple stakeholders who are directly or indirectly involved in the energy transition process. They include government institutions, commercial businesses, local communities, NGOs and research institutes. Fundamentally, the Greek Ministry of Environment and Energy creates policy frameworks and regulatory guidelines, and regional authorities are also involved. Most importantly, the ministry makes important decisions about the financial resources allocated to green hydrogen projects. With the aim of incentivising Member States to transition to sustainable energy, the EU Just Transition Fund played a fundamental role in mobilising financial resources to lignite areas such as Western Macedonia (Kafetzis et al., 2023). However, sluggish policy implementation and bureaucratic inefficiencies have caused project delays and insufficient cash distribution.

Private sector actors fuel infrastructure development and technological innovation, including global investors and energy companies. Often in conflict with local employment demands and socioeconomic stability, companies give profit-driven objectives first priority (Vrontisi et al., 2024). Large-scale hydrogen projects risk aggravating regional inequities should corporate-led investments fail to include fair benefit-sharing systems and community engagement (Hermwille et al., 2023).

Direct economic and social effects of the change fall on local communities and labour unions. Western Macedonia's economic uncertainties and high unemployment rates resulting from the change away from lignite reflect. Many former lignite workers see hydrogen investments with mistrust as they believe retraining initiatives are underfunded, and job development claims are exaggerated (Ketikidis et al., 2023). Public opposition to renewable projects might compromise Greece's green hydrogen objectives without significant stakeholder participation.

Academic institutions and environmental NGOs support sustainable policies, technical research and legal systems. Companies such as The Green Tank and Apollon advocate more openness, environmental protection and equitable transition policies. However, it is equally important to note that their capacity to influence policy decisions is limited by the fact that they primarily focus on industry interests, and they do not often consider environmental and social concerns.

For a successful energy transition, it is important to acknowledge and balance the needs of various stakeholders, including the government, businesses and local communities. There is a need for cooperation amongst these stakeholders, particularly in policy creation, economic planning and workforce integration. In other case studies of energy transition in EU Member States, it has been demonstrated that some of the core elements include participatory governance, transparent policy mechanisms and economic incentives for the local firms.

3.5. Challenges and Opportunities in Western Macedonia

Several studies have examined the challenges and opportunities for energy transition in Western Macedonia. Indeed, there is a rapid transition ongoing, and significant resources have been channelled to transition this region from the lignite-dependent economy. One of the key strengths of this region is that it has excellent infrastructure that was developed to support high voltage energy transmission networks (Tranoulidis et al., 2022). This infrastructure provides the region with a competitive advantage compared to other regions in Greece. Another key advantage is that it has a highly qualified and trained workforce who are experienced in the energy sector. Additionally, the existing workforce has incomparable skills for persons working in the fur sector, which has been one of the leading industries with significant export potential. It is also important to mention that the geographical location of Western Macedonia is vital on the basis that it borders Albania and North Macedonia. It also features two ports that provide convenient access to Thessaloniki and Igoumenitsa. These factors make this region ideal

for energy transition projects.

One of the most profound challenges of the region is that its entire economy primarily depends on lignite (Tranoulidis et al., 2022). This suggests that a significant percentage of people who are employed in this region rely on the energy sector, and the transition to another energy source constitutes a threat to the employment of the current workforce. Again, the lignite dependence affects other economic activities and regions, including the suppliers and companies that depend on this economy. Tranoulidis et al. (2022) acknowledged that even with the growing momentum to transition Western Macedonia, there are poor foreign investments, which are attributed to diminished interest in relevant investments. According to the authors, this has emerged due to the absence of organised investment sites or incentives. Another factor that explains the low investment concerns the problems related to current spatial and urban planning, which necessitates urgent solutions. Also, research and development in this region is relatively low compared to other regions in Greece and the EU in general. As of 2022, 11% of energy transition projects were privately funded, and the rest of the projects were being supported by the government. Though the EU Just Transition Fund (JTF) offers financial support for retraining and job creation, bureaucratic bottlenecks and low private-sector engagement have slowed its deployment.

Still, economic stagnation causes great concern. The area's reliance on lignite generation has traditionally spurred local growth; its phase-out leaves voids in industrial activity and investment. Although green hydrogen generation has a major financial potential, the high capital costs and doubtful market feasibility prevent quick large-scale implementation. There are several opportunities for the energy transition, including the fact that the region has significant capacity for renewable energy, including solar and wind sources. It is anticipated that these resources will be utilised for the generation of hydrogen in large scale. By investing in hydrogen projects, this will attract foreign investment and lead to the creation of new industrial ecosystems, which will promote the diversification of the region's economy into agricultural technology, bioeconomy and high-tech manufacturing.

3.6. Integrating Energy Justice into the Transition

A rapid transition from a lignite-dependent economy to a renewable-based economy is currently underway in the region, with a particular emphasis on green hydrogen initiatives. Job losses, economic instability and infrastructural constraints accompanying this change call for thorough policy interventions and focused expenditures.

There is extensive literature exploring the role of energy justice in transition projects globally. Early studies primarily focused on the pace of energy transition, but recent studies have since evolved to examine the variations in transition pathways. Additionally, scholars have increasingly investigated the positive and negative effects of the transition on the local communities. Most importantly, a growing body of evidence indicates that there are those who benefit and others who are disadvantaged from energy transition, and it is necessary to ensure that there is inclusivity and that the benefits are distributed across all associated stakeholders (Carley & Konisky, 2020). According to the authors, research has consistently shown that specific groups of people do not enjoy the benefits of energy transitions and are instead disadvantaged. More specifically, they report that people who are vulnerable, including persons of colour and those from low socioeconomic status, experience more burdens from energy transition projects. Even in cases of low-carbon energy projects, there are negative consequences, such as noise disruptions or pollution of the air for those who reside near the projects. The authors emphasise that the negative impacts of implementing such projects disproportionately affect specific populations.

Given the concerns about a just transition, it has been argued that there is a need for a new political norm that embeds the democratisation of energy where the citizens play an active role. However, Ryghaug et al. (2018) mention that the issue with this perspective is that the role of the citizens is reduced to the idea of public acceptance. In other words, their contribution to the energy transition projects is limited to whether they accept or reject. The problem with his perspective is that the local community are considered a passive consumer, which is further strengthened by the top-down decision-making model that is characteristic of energy transition projects. This also implies that they are passive recipients of the technology in a centralised structure. Again, this makes the citizens be considered as potential barriers to the progress of implementing energy transition projects, especially since their concerns are

considered criticism of new developments.

In the context of Western Macedonia, the projects aiming to transition the region pose a significant threat to the citizens, particularly in terms of employment. Again, whereas it was observed that there is an existing skilled workforce in the energy sectors, there is a possibility that the existing personnel may lack the required skills to secure employment in the renewable energy projects. The objective of retaining employment through the EU Just Transition Fund may not necessarily be effective. Notably, bureaucratic bottlenecks and low private-sector engagement have slowed deployment.

Based on their research on the role of energy justice in the transition process, Heffron and Sokołowski (2024) make several recommendations. One of the key findings from their studies is the need for openness and real dialogue amongst various stakeholders who are affected by the implementation of the new projects. They argued that it is likely necessary to establish new public institutions that will evaluate existing policies and evaluate their effectiveness. Existing policies have to be evaluated based on the possibility that they might fail in the future. Still, it is important to consider the national context, as the approach of applying policy frameworks from other regions may not be relevant to a specific region. The authors further recommend the establishment of a platform that facilitates the exchange of views and knowledge on energy policies. Again, this indicates that in many countries, it would be necessary to establish an institution that specialises in energy transition projects.

Another recommendation that would help to integrate the energy justice dimensions is creating a new social contract. This would involve various stakeholders collaborating to establish a new way of working together in the energy sector. Energy justice ought to be the core of the contract, and it should feature specific details on how the relationship among various stakeholders should be constructed and managed.

3.7. Summary of findings

This chapter has reported current findings on the issue of energy justice as the world progresses towards sustainable energy. It specifically explores the energy justice framework, which covers elements of procedural, distributive and recognition justice. This framework emphasises the significance of addressing the social elements of energy transition projects. As evidenced by studies reviewed in this chapter, it is demonstrated that principles of energy justice are being neglected. More specifically, it has been demonstrated that the implementation of energy projects creates inequalities on the basis that there is a disproportionate burden on vulnerable groups. Again, research has shown that the participation of the local community is limited to the acceptance or rejection dichotomy, which fundamentally undermines their participation as key stakeholders. Evidence also shows that such inequalities exist in the context of the energy transition in Western Macedonia.

Procedural justice is an important concern, as various studies have demonstrated that fair and inclusive decision-making processes have not been prioritised. There is limited participation of stakeholders as their involvement usually occurs through one-off consultations. This is further complicated by the fact that marginalised stakeholders are not involved in the planning process. The implication for empirical analysis is that the attention has to focus on how participatory mechanisms are structured, how transparent and responsive governance structures are, and whether stakeholders have real opportunities to shape decisions that affect them.

In parallel, distributive justice is repeatedly highlighted as a key area of contestation. Although policy documents frequently refer to the equitable sharing of benefits and burdens, empirical studies indicate that outcomes remain deeply unequal. Recognition justice also emerges as a critical but often overlooked dimension. The literature underscores that a lack of explicit recognition for diverse needs, identities and knowledge systems can erode both the legitimacy and the effectiveness of the energy transition. The empirical analysis had to assess not only whether such groups are mentioned in official documents, but also whether meaningful efforts are made to integrate their voices and knowledge into transition planning and implementation. Gathered them into consideration, these insights from the literature provide the foundation for operationalising energy justice in the empirical phases of this research. By translating theoretical concepts into concrete indicators, this study will systematically evaluate whether, and how, these tenets are embedded in Western Macedonia's green hydrogen transition.

4

Analysis and Results

For this study, an in-depth literature review was conducted on existing literature regarding the energy justice impact of the green hydrogen transition in Western Macedonia. This chapter presents the key findings from the study, including qualitative content analysis of academic publications and policy documents, as well as data that was collected from semi-structured interviews with industry experts and practitioners. The participants of the study included stakeholders who have been involved in or are indirectly affected by the energy transition to green hydrogen in Western Macedonia. The aim is to demonstrate how the transition to sustainable energy, specifically hydrogen, and other decarbonisation efforts have unfolded, as well as how some of these issues relate to energy justice and the involvement of stakeholders. The findings of the content analysis are organised thematically, which primarily involves presenting the underlying patterns that emerged from the interviews and analysis of documents. The findings of the semi-structured interviews are also presented based on the underlying patterns that emerged during the analysis using Atlas.ti software

4.1. Findings from content analysis

The transition toward green hydrogen is occurring in Greece, and it aligns with the broader EU agenda to decarbonise major sectors. Indeed, it has become evident that it is necessary to adopt the appropriate policies to support the transition to green hydrogen, particularly in former lignite regions such as Western Macedonia. The process of policymaking requires the contribution of stakeholders and the adoption of relevant institutional strategies. The analysis of publications that have reported on the transition process in the EU and Greece identified five key themes that recur in both contexts. These themes offer an overview of the priorities, tensions and the evolving dynamics in the transition process. They help illustrate the social, political and infrastructural factors that continue to influence the transition process, and these are necessary for the success of the decarbonisation of Western Macedonia, as well as to ensure that there is fairness in the process. Table 4.1 and Table 4.2 provide the overview of the evolving dynamics in the transition process.

4.1.1. The role of hydrogen in decarbonisation efforts

A key theme that emerged during the analysis of the publications is the positioning of hydrogen in the decarbonisation efforts of EU Member States. A report by REPowerEU establishes that hydrogen will play an important role in replacing natural gas, coal and oil in several sectors, including manufacturing and transport. The report further mentions that the goal of the EU is to teach at least 10 million tonnes in the production of renewable hydrogen and 10 million tonnes of imports of renewable hydrogen (European Commission, 2020). To achieve this target, the report indicates that it is necessary for the European Parliament to develop sub-targets in the short term. Also, it indicates that more investment is needed (200 million EUR) to increase the volume of hydrogen valleys. There is also a need for the industry to enhance the progress towards hydrogen standards, especially concerning production, infrastructure and end-use appliances. It is anticipated that the European Commission will collaborate closely with the Member States to enhance the use of renewable energy in industries and transport.

Table 4.1: Summary of the Document Analysis Themes (I)

Theme	Document Analysed and Data Contributed
The role of hydrogen in decarbonisation efforts	• Fit-for-55 legislative package – Set of laws • EU Hydrogen Strategy – replacing fossil fuels, renewable electricity • REPowerEU – EU goals for hydrogen production • Kafetzis et al. (2023) – Greek's commitment to hydrogen as a means of decarbonising the industries
Energy poverty	• Szemző and Gerőházi (2024) in ComActivate – Definition of Energy Poverty, and Directive EU 2024/1788 for eradication • EmpowerMED Consortium (2023) – Addressing the gender aspect in Energy Poverty • NECP • Papada and Kaliampakos (2016) – higher amongst low-income people • Kitsikopoulos and Vrettos (2023) – the role of energy communities • Zervas (2020) – structural issues leading to energy poverty
Impact of the Energy Transition on Employment	• Just Development Transition – loss of jobs • EU Hydrogen Strategy – creation of jobs • RePowerEU – partnership to address loss of jobs, skills shortages in RE involving hydrogen • Christiaensen and Ferré (2020) in World Bank Group – Loss of jobs
Stakeholders' Integration in Energy Policies	• EU Hydrogen strategy – cooperation with stakeholders • RePowerEU – wide consultation with stakeholders • Flath and Quittkat (2025) – Lack of NGOs involvement as stakeholders • EU Parliament - Citizen engagement • Negative perceptions of large hydropower developments in Greece – Kaldellis et al. (2023) • The Green Tank – centralised governance system that limits participation of local communities and civil society • NECP - Energy communities and the participation of the locals

Table 4.2: Summary of the Document Analysis Themes (II): Barriers to Hydrogen Development

Theme	Document Analysed and Data Contributed
Barriers to the development of hydrogen technologies	**a. Infrastructure and investment** • Kerneïs and Jacques Delors Institute (JDI) (2024) in Sun4All - Financing and investment – ECs lack funding • Fit for 55 - On Financing and investment in infrastructure • NECP – Infrastructural developments • EU Hydrogen Strategy – infrastructure and need for investment • RePowerEU – infrastructural needs and need for financing • Johnston and Revest (2025) – Problems with developing the infrastructure **b. Other barriers** • ten Brink (2025) High Production costs; Court of Auditors • Johnston and Revest (2025) - Definition of renewable energy • European Court of Auditors (2024)- *The stakeholders we met indicated that the lack of rules defining renewable hydrogen had delayed investment decisions*. • European Court of Auditors (2024) – Time lag (permitting and investment)

Further, the report indicates that the EU will specifically support the development of key import corridors of hydrogen via the North Sea area, Mediterranean and Ukraine. It is also indicated that "Green Hydrogen Partnerships will facilitate the imports of green hydrogen while supporting the decarbonisation in the partner countries".

The EU Hydrogen Strategy similarly recognises the significance of hydrogen in the decarbonisation efforts across its Member States. The report mentions that whereas it is projected that renewable electricity will help to decarbonise a significant share of the energy consumption of EU before 2050, it will not be able to bridge the entire gap. Consequently, hydrogen has strong potential as "a vector for renewable energy storage, alongside batteries, and transport, ensuring back up for seasonal variation and connecting production locations to more distant demand centres" (European Commission, 2020). The publication also mentions that hydrogen has the potential of replacing fossil fuels in certain industrial activities, such as the steel and chemical sectors. This will reduce GHG emissions and "strengthen global competitiveness for those industries" (European Commission, 2020). The Fit for 55 package is a set of laws that were adopted to minimise the volume of GHG emissions by 55% before 2030 and achieve complete neutrality before 2050. The package consists of market regulations for renewable energy, and they intend to establish a regulatory framework that supports the development of hydrogen infrastructure and markets (European Council, 2024). Essentially, they acknowledge the role of hydrogen in the decarbonisation process of EU Member States.

Similar observations can be observed in Greece, which is planning to lead in the energy transition process. It is important to mention that the EU has recognised the need for establishing hydrogen ecosystems, which cover production, storage, distribution and utilisation. Consequently, hydrogen valleys have been acknowledged as a key milestone towards the establishment of a hydrogen economy. Several hydrogen valleys have been developed in various Member States, such as the Hydrogen Energy Application in Valley Environments in the Netherlands (Kafetzis et al., 2023). The authors also mention that in Greece, there are two hydrogen valleys that are being constructed, including the Crete-Aegean Hydrogen Valley and the TRIERES valley. The development of these valleys illustrates an acknowledgement by the Greek government of the role of hydrogen in the decarbonisation efforts.

4.1.2. Energy Poverty

The concept of energy poverty emerged as an important issue in the policy discourse. European and Greek publications emphasise that the transition to sustainable energy should not create more inequalities, especially by disadvantaging the low-income groups. Szemző and Gerőházi (2024) acknowledge that energy poverty is a profound issue in the EU, and "it occurs when people cannot afford essential

energy services, such as heating, cooling or lighting, negatively impact health, well-being and social inclusion" (p. 4). According to the publication, at least 41 million of the population on the European continent were unable to keep their houses warm in 2022. It is further mentioned that the most affected are low-income groups, and there is also an element of gender, as more women struggle with paying their energy bills. The authors further discuss Directive (EU) 2024/1788 of the European Parliament, which was adopted to support the transition to a decarbonised energy system. Article 26 of this directive emphasises the need for protecting vulnerable consumers: "Member States shall protect especially vulnerable customers and those in fuel poverty regarding disconnections, transparency of contractual terms and conditions, general information, and dispute settlement mechanisms". The directive further indicates that vulnerable consumers should not be barred from accessing energy resources. It particularly mentions that Member States should consider integrating people residing in remote areas, who are often disconnected from state resources. EmpowerMED Consortium (2023) explores the element of gender equality in the conversation about energy poverty. They cite articles 21 and 23 of the Charter of Fundamental Rights that prohibit any form of discrimination on the basis of sex, urging that it is necessary to promote equality between men and women in all settings. However, they also note that the high level of women's poverty increases the risk of energy poverty. Therefore, they posit that it is necessary to create specific policy measures that will guarantee that low-income households can easily access affordable utilities, especially targeting older women and single mothers. According to the authors, one of the most profound threats is right-wing governments in the EU Member States, who are likely to show reluctance in implementing policies that prioritise the needs of women in the distribution of energy resources.

At the Greek level, the National Energy and Climate Plan (NECP) represents a strategic plan that was adopted by the government and presents the pathway for attaining specific energy and climate objectives by 2030. The NECP equally acknowledges that energy poverty has worsened in recent years, thereby necessitating urgent actions to address this problem. The NECP indicates that it is vital to adopt policy measures that seek to reduce the prevalence of energy poverty in vulnerable social groups. One of the proposed solutions is to develop infrastructure that provides a safe energy transition in remote areas and those that are typically associated with high rates of energy poverty. For regions such as Western Macedonia, the NECP indicates that "targeted measures should be taken to support and empower the residents of areas where lignite units are currently installed, which in the near future will be withdrawn, units that have for many decades provided jobs and high growth rates in those areas". Despite such commitments in policy, empirical evidence suggests that the spread of energy poverty, especially amongst low-income households, is a structural issue. In their study, Papada and Kaliampakos (2016) explain that the Greek government has supported energy saving solutions since 2011 through a programme regarded as "Energy Saving at Home". Ideally, the objective of the government was to improve the energy performance of citizens in their households by providing subsidies for interventions such as replacing heating systems. Indeed, the objective of the programme was to benefit the low-income households. However, this programme necessitates cooperation with banks, and "low-income people are usually regarded as uncreditworthy by the banks, so they are finally the first ones excluded from the Programme" (p. 165).

An alternative to the individual household interventions is energy communities, which are a collaborative model that involves the direct participation of citizens in energy management (Kitsikopoulos & Vrettos, 2023). However, the efficacy of these communities will be limited due to the structural issues embedded within proposed policies. Zervas et al. (2021) explain that the only solution to minimise the prevalence of energy poverty is either a substantial increase in income or a significant decrease in the price of energy. However, current projections do not indicate the possibility of either of these two alternatives. More specifically, Greece's GDP growth is not projected to recover to the 2008 level until 2030. Current policy frameworks and action plans, such as the NECP, suggest that the price of renewable energy that is utilised in the production of green hydrogen will decrease in the coming years. These action plans fail to indicate the final prices or the actions that will be undertaken to decrease the prices.

4.1.3. Impact of the Energy Transition on Employment

Another important theme that emerged during the analysis of the collected data pertains to the socioeconomic impacts of the energy transition, especially in areas where structural changes will be implemented. There are two strands of literature under this theme: on the one hand, some publications posit

that the transition will lead to the creation of more employment opportunities; on the other hand, others argue that it will lead publications to the loss of jobs in regions that have traditionally relied on lignite for power generation. The EU Hydrogen Strategy indicates that the "emergence of a hydrogen value chain serving a multitude of industrial sectors and other end uses could employ up to 1 million people, directly or indirectly" (European Commission, 2020). The report further indicates that renewable hydrogen should remain as a key priority for the EU, especially since it is the most convenient option to attain the EU goal of climate neutrality. It suggests that since the EU already has the infrastructure for electrolyser production, the production of renewable hydrogen will help create new jobs and foster "economic growth within the EU". The REPowerEU publication acknowledges that the development of renewable hydrogen depends on a skilled workforce and effective supply chains. It specifically states that "the clean energy transition offers ample job market opportunities and helps ensure reskilled jobs for transition sectors" (European Commission, 2021a). It recommends partnerships with various authorities to address the skill gap that will be created by the transition process.

By contrast, the 2021 just transition plan of Western Macedonia estimates that the energy transition plan will have a direct impact on at least 5,700 jobs by 2029, and this number concerns persons who are directly employed in the generation and extraction of lignite in the region (European Commission, 2021b). This suggests that the multiplier effects will be even worse as other economies that depend on the lignite extraction will similarly be affected. Therefore, it is estimated that the transition will have led to a loss of 10,600 jobs, directly and indirectly. In this region, people aged between 15 and 24 years record the highest level of unemployment rates at 60%, which is double the national unemployment rate (European Commission, 2021b). In addition, Western Macedonia has one of the highest poverty levels in Greece, and the loss of jobs will further worsen the situation in this region. The report also notes that lignite independence will "have a positive impact on the health and safety of workers and citizens, provided that the necessary land restoration works in the lignite fields are carried out" (European Commission, 2021b). Christiaensen and Ferré (2020) challenges the narrative that the production of renewable hydrogen will result in the creation of new employment opportunities. The authors argue that there is insufficient data that indicates that the supply of jobs will increase to meet the new demand that will be created. They indicate that although temporary employment may be provided in land repurposing and reclamation, this is not sustainable in the long term.

4.1.4. Stakeholders Integration in energy Policies

The documents analysed in this study emphasised the need for integrating stakeholders in the energy transition process. The EU Hydrogen Strategy states that the Commission must invite various stakeholders, including the Parliament, the Council, EU institutions and social partners to contribute to the discussion about the deployment of hydrogen projects in Member States. Similarly, the REPowerEU recognises that it is important to *"engage in a wide consultation process during the preparation of their REPowerEU chapters, in particular with local and regional authorities, social partners as well as stakeholders from the agricultural sector, to ensure broad ownership that will be key for the successful implementation of the measures"* (European Commission, 2022). Amongst other stakeholders, the European Parliament dictates the need for engaging the citizens as one of the core stakeholders. It is anticipated that engagement of citizens is vital for the execution of a *"fair, success, participative and inclusive energy transition"* (Geier, 2021). It is specifically observed that energy communities will play a critical role in hydrogen production, and this necessitates the creation of a framework that follows the laws and regulations. The European Parliament also acknowledges the need for persons with specialised skills to support the development of hydrogen production technologies. It is further indicating that important tenets of a just transition have not been upheld thus far, especially since the citizens have not been provided with opportunities for training, upskilling and reskilling. The recommendation is that Member States have to consider persons with the potential for training in technical skills to be involved in training to support existing industries.

In the energy transition process in Greece, the NECP acknowledges that there have been consultations with relevant stakeholders. In 2018, a workshop was held that was attended by representatives of unions, universities and research centres, companies and non-government organisations, energy and environmental practitioners and local citizens to present the proposal for energy planning (Ministry of Environment and Energy, 2022). The NECP further provides details on other press conferences and workshops that have been attended by different stakeholders. Additionally, the Greek government has

also had consultations with other Member States to ensure that the policies align with the EU's expectations and standards. Interestingly, evidence also indicates that there has been limited participation of local communities and civil society. A report by The Green Tank (2021) establishes that whilst the Greek government and EU institutions call for stakeholder engagement, this has not been sufficiently applied. The report indicates that the proposed governance system is a centralised, top-down structure that limits the participation of local communities and civil society in participating in decision-making (The Green Tank, 2021). Flath and Quittkat (2025) observe the absence of civil society in lobbying for hydrogen production. Again, the authors mention that the NGOs that participate in energy transition projects are only a small fraction compared to business stakeholders. They mention that the exclusion of NGOs occurs because of structural and procedural factors, which is attributed to the fact that the debate about hydrogen transition has mostly been "dominated by established actors in politics, industry and science" (Flath & Quittkat, 2025).

Whilst most existing studies emphasise that the lack of engagement of citizens in hydrogen transition projects occurs because of structural and governance issues, the study by Kaldellis et al. (2023) provides contradicting evidence. The author argues that the lack of investment in hydrogen ecosystems in Greece is a result of negative attitudes of the public towards large hydropower projects. This is attributed to the significant environmental and social effects of developing hydrogen projects. The opposition of local citizens has resulted in the failure of hydropower plants, such as the Glystra-Mesochora LHP plant (Kaldellis et al., 2023). The negative perception of the local people is also likely to have emerged because of their lack of involvement in the development stages, which has created distrust.

4.1.5. Barriers to the development of hydrogen technologies

There are several barriers limiting the development of hydrogen technologies in EU Member States and Greece in particular. One of the major issues that emerged during the analysis is a lack of adequate financing to support the development of infrastructure for hydrogen production. The Fit for 55 package indicates that the success of sustainable energy and alternative fuels depends on the development of infrastructure. For example, the EU's new rules that aim to reduce carbon footprint in the transport sector will require the installation of recharging stations for electric vehicles every 60 kilometres. The REPowerEU reports indicate that to meet the set objectives, the Commission will acquire funding by auctioning the allowances of the Emissions Trading System. Additionally, grants will be sought to raise the required funding of around €300 billion. This funding is needed to support the development of gas infrastructure, including storage facilities.

As has been established in this study, energy communities play a fundamental role in facilitating the involvement of the local community in the energy transition. In a review on the deployment of energy communities in Greece, the researchers found evidence that the lack of available funding sources significantly limits the energy communities (Kerneïs & Jacques Delors Institute (JDI), 2024). More specifically, it was demonstrated that members of the energy communities were unable to access loans from banks and other financial institutions, especially as a result of the perception of risk in investing in value-driven projects. Therefore, the researchers recommend that Member States ought to support energy communities by assisting them to secure initial investments. In addition, such communities should be supported with the technical capacity and expertise to enhance the success rate of the community-driven projects. Johnston and Revest (2025) acknowledge that several mechanisms have been adopted to support the development of hydrogen projects in the EU. They mention, however, that the adopt structure constitutes a *"complicated web of funding sources and lack targeted prioritisation of specific applications"* (p. 9). In other words, policymakers have failed to adopt a strategic approach to channelling the current investments, and this leads to a missed opportunity in ensuring that the available funding supports the decarbonisation efforts. It is recommended that the investment mechanisms can only be successful through a strategic approach that prioritises high-value hydrogen applications and developing the appropriate infrastructure in the right locations (Johnston & Revest, 2025). Therefore, it is necessary to have *"better planning and more transparent funding mechanisms"*.

Another barrier that warrants attention is the high production costs of hydrogen. As reported by the ten Brink (2025), the cost of hydrogen production is extremely high, and it will be challenging for hydrogen to *"compete with electricity for all use-cases for which direct electrification is an option"*. It is further acknowledged that the cost of hydrogen is four times higher than fossil gas in industrial use

cases. Although it is anticipated that the costs will reduce in the coming years, projections indicate that hydrogen costs will still be twice as expensive as fossil gas in 2050. This means that consumers and plants will have to make strategic decisions before investing in hydrogen. A review by European Court of Auditors (2024) established that *"companies may be compelled to accept higher costs or slow down the hydrogen ramp-up phase to succeed in this balancing act"* (p. 37).

Another barrier is that there remains confusion in the definition of low-carbon hydrogen, and this makes it challenging for EU Member States to invest in production. The EU Court of Auditors reported that the lack of regulations defining what constitutes renewable hydrogen has caused delays in investment decisions in the past. Also, it was observed that the significant time taken in approving hydrogen projects often discourages investment decisions. The report from the auditors indicated that *"the stakeholders we met singled out the permitting process as one of the factors which leads to delays in project implementation"* (p. 40).

4.1.6. Justice Dimensions from the document findings

Procedural justice is a foundational principle in European and Greek policy rhetoric, with the EU Hydrogen Strategy declaring that "broad stakeholder participation will be ensured at every stage" (European Commission, 2020). Greece's National Energy and Climate Plan (NECP) and the Master Plan for Western Macedonia echo this commitment, setting out frameworks for consultation and feedback.

However, the practical implementation of these mechanisms is uneven and frequently insufficient. As highlighted by Flath and Quittkat (2025), "business interests are better organised and better represented than diffuse public interests, and civil society is largely underrepresented in consultations" (p. 28). Interview data and civil society reports echo this gap: local authorities and NGOs are often informed only after major decisions are made, and the structure of consultations tends to favour large-scale industrial or governmental actors (Skapoula, 2024; World Bank, 2020).

Distributive justice, or the fair allocation of benefits and burdens, is highly contested in the case of Western Macedonia. Policy frameworks—including the NECP, the Just Transition Development Plan, and EU funding programs—promise significant investment in hydrogen infrastructure and job creation. As stated in the Master Plan: "A central priority is to ensure a fair development transition... based on employment protection, compensation of socio-economic impact, and energy self-sufficiency" (Master Plan for Western Macedonia, 2021, p. 23).

Policy targets, NGO analyses from The Green Tank (2021), and employment statistics World Bank (2020), revealing a concentration of benefits among large industrial consortia and established public institutions. Meanwhile, local cooperatives, small and medium-sized enterprises, and vulnerable groups face significant barriers to accessing funding, permits, and employment opportunities (Espitalier-Noël et al., 2025).

These distributive inequities are further underscored by empirical evidence. The World Bank (2020) reports, "With unemployment rates already more than twice as large as those experienced in other coal regions of the EU, the social impact will undoubtedly be high if an additional 15 to 20 % of the active population becomes directly unemployed due to the closure of the mines." Skills mismatches and outmigration are recurring problems, with younger and better-educated individuals seeking opportunities elsewhere. Table 4.1 and related policy analyses highlight that, while headline investment numbers are impressive, the mechanisms to ensure local benefit—especially for marginalised populations—are weak or lacking.

Recognition justice remains the most underdeveloped pillar. Policy rhetoric—such as "leaving no one behind"—is common in both the NECP and the Just Transition Plan, but actual mechanisms to address the needs of historically marginalised groups are sparse. Vulnerable groups such as former lignite workers, youth, women, and energy-poor households are routinely acknowledged in principle but rarely incorporated into project design or benefit-sharing schemes (Skapoula, 2024; Zervas, 2020).

NGO and think tank reports (EmpowerMED Consortium, 2023; Initialising Towards Energy Balance Zero(INZEB), 2021) and international comparisons reinforce the pattern that technical and economic priorities override social recognition. Recognition justice indicators such as "targeted retraining programs," "consultation with marginalised groups," and "gender inclusion" are either absent or under-

developed in both national and regional frameworks. For example, direct community engagement is limited, and intersectional impacts are often overlooked, despite evidence from comparative cases from Kalt et al. (2023) that a lack of recognition risks replicating extractive patterns and undermining trust in transition policies.

Governance Level	Procedure	Distribution	Recognition
European	Consultations, strategic frameworks	Funding tools like JTM	Marginal attention to vulnerable groups
National (Greece)	NECP consultations; limited stakeholder reach	Focused on macroeconomic benefit	Energy poverty not well-integrated
Regional (Western Macedonia)	Limited municipal participation	Few local employment guarantees	Little engagement with youth/women

Table 4.3: Governance Levels and Types of Justice

A comparative framework to evaluate the presence and depth of justice-related mechanisms at the EU, national, and regional levels is depicted on Table 4.3. Each cell was filled by coding the explicit and implicit justice language found in policies (e.g., consultation requirements, distribution of subsidies, participation mandates) and then verifying these with critical commentary from academic and NGO sources, e.g., Skapoula (2024) and Zervas (2020). This table is not simply descriptive—it was built to highlight both strengths and systemic gaps, justifying claims with direct textual evidence from the policy corpus and stakeholder observations.

Recognition justice is the least developed pillar. While policy documents acknowledge vulnerable and under-represented groups, meaningful inclusion is limited in practice (Skapoula, 2024; Zervas et al., 2021). Stakeholders repeatedly highlight that policy-making is dominated by economic and technical logic, with social concerns relegated to the margins. The content analysis exposes a disconnect between the promises of a “just” hydrogen transition and on-the-ground realities in Western Macedonia. These findings point to the need for more participatory governance, targeted distributive mechanisms, and robust recognition of local and marginalised voices.

4.2. Findings from the semi-structured interviews

To systematically assess the dynamics of stakeholder involvement in the green hydrogen initiatives and activities in the Western Macedonia region, a stakeholder map was developed and presented in Figure 4.1. The map classifies key actors according to two key criteria: their level of influence over the hydrogen transition process (vertical axis), and their level of interest in its outcomes (horizontal axis). Stakeholders include governmental agencies, industry representatives, NGOs, academia, community groups and local businesses. By mapping these actors, the figure provides a clear overview of the diversity and complexity of interests and power structures present in the region. The stakeholder map is based on the findings from the document analysis and a study conducted by Battulga and Dhakal (2024). In their study, they evaluated the roles of various stakeholders, including the government, providers, municipality, academia, companies, NGOs, donors and the local community. The findings of this study informed the development of the stakeholder map as illustrated in Figure 4.1.

The purpose of this stakeholder map is to visually clarify which groups are most influential in shaping policy and project outcomes, and which have the greatest stake in the transition, but perhaps less decision-making power. The visualisation of this process is essential for identifying potential gaps in potential energy justice concerns, as it highlights stakeholders who may be highly interested but underrepresented in governance processes. Also, it provided me a first image to whom I can approach regarding the justice concerns for the interview selection in the case study region and might be interested in the research.

In Appendix B there are details of the interviewees who were recruited to participate in the study. Personal information that may be used to identify the participants was removed, and I, instead, used a systematic ranking in figures. The table contains information about their professional role, and this is important to illustrate their relevance to this study.

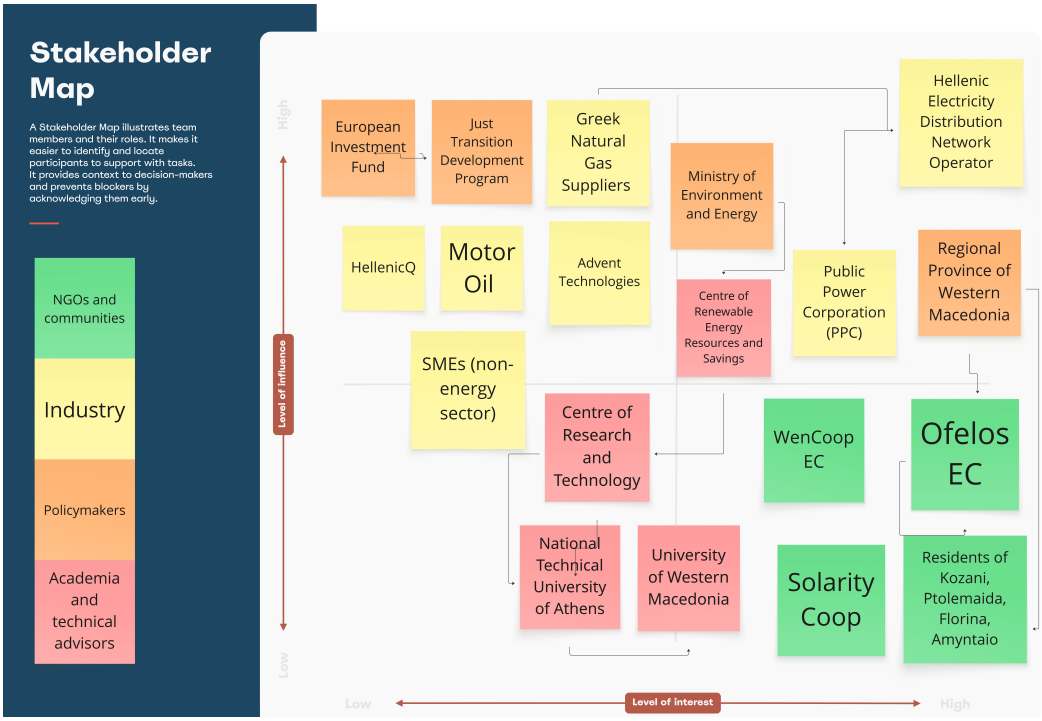

Figure 4.1: Stakeholder map for the green hydrogen transition in Western Macedonia. The map positions stakeholders based on their level of influence (vertical axis) over transition decision-making and their level of interest (horizontal axis) in project outcomes. Stakeholder groups—such as local communities, government entities, industry actors, NGOs, and academic institutions—are placed accordingly, making visible those with significant power, those with high interest but limited influence, and those at risk of being marginalised. This visualisation supports the identification of justice concerns and informs strategies for more inclusive stakeholder engagement.

A thematic analysis was performed on the interview transcripts, and the codes that emerged from the analysis were grouped into sub-themes. These sub-themes were subsequently categorised into five major themes. The coding of the interview transcripts was done manually using the *Atlas.ti* software. The themes were framed based on the data that was provided by the interviewees. Table 4.4 presents a summary of the themes and sub-themes that emerged from the interviews, and relevant quotes are also illustrated to support the findings.

4.2.1. Lack of Stakeholder Inclusion

The first theme that emerged from the interview analysis was the fact that the local communities have been traditionally excluded and do not actively participate in the decision-making processes involving energy transition projects. The interviewees expressed that there was a general lack of consultation or engagement with the local communities. The first interviewee observed cases such as Colombia and Chile where the indigenous communities are targeted for hydrogen projects but they are not actively consulted. The first interviewee (EI1) states:

> "In most cases, as mentioned in Colombia and Chile, the indigenous group are not really actively participating or not really an active part of the society. They are those groups whose voices are rarely heard. Just because you know they are not really actively participating in a life of what someone would call the civilised world, you know they are living their own life."

The second interviewee (EI2), who is actively involved in energy communities, observed the tendency of large corporations to exploit the existing legislative framework to create fake energy communities. He mentioned that this has resulted in the side-lining of authentic energy communities. Another interviewee, who primarily works as a policy advisor, referred in Table 2.2 as the third energy expert (EI3), acknowledged that the engagement of stakeholders is merely a checkbox exercise and there is no meaningful participation of the locals.

Another sub-theme that emerged is that the existing legislative framework has created conditions that

Table 4.4: Summary of Themes and Sub-themes from the Semi-structured Interviews

Theme	Sub-theme and quotes
Lack of stakeholder inclusion	• Exclusion of local communities - *"In most cases, as mentioned in Colombia and Chile, the indigenous group are not really actively participating or not really an active part of the society."* • Legislation supporting exclusion of local citizens • Limited citizen involvement • Social acceptance
Energy poverty and inequalities	• Rural vs urban disparities - *There is a big, big problem when comparing cities and the countryside. Cities are in a favourable position due to district heating"* (Interviewee 6). • Vulnerability of certain social groups • Limited affordability of new technologies • The role of energy communities in alleviating energy poverty
Lack of transparency	• Opaque decision-making processes - *But most of these models are not proprietary. Most of them are not really easily accessible by the public and you don't know what assumptions they make and so forth. So, you know, in this sense, this is a justice issue to me because the outcomes of the model affect people's choices because it gives them a set of choices around which they have to make the right decisions. But you cannot really question the choices like you cannot ask: 'Okay, why this was not there or that was not there'."* (Interviewee 7). • Lack of accessible information • Mistrust caused by limited information of projects
Lack of communication and awareness	• Poor dissemination of information - *What is needed for knowledge to reach the common people is to upload stories, to make reports, to make narratives more understandable and simpler, let's say a translation of the technical thing that has been done in "vox populi", a story that is easily understood and that the other person can relate to."* (Interviewee 9). • Lack of local campaigns and education • Lack of awareness on the rationale for transitions
Technology and economic barriers	• Hydrogen is a high investment technology • Current technology is immature • Lack of infrastructure • Limited funding to support hydrogen development

provide opportunities for corporations to limit the participation of the local communities. The second interviewee states that whereas incentives are encouraging the participation of local communities, large companies occupy public areas with the support of the state. He states that this happens because *"there is relevant legislation that allows anyone to occupy any location and create conditions that ultimately alter the environmental heritage, or basically just destroying it"*(EI2).

The residents are often not provided with opportunities to participate in renewable projects, such as hydrogen-related investments. The second interviewee explains that the existing legal framework in Greece supports the need for financial resources for special communities. He states that there is an existing National Strategy Reference Framework (NSRF) which is meant to address energy communities, including those in Western Macedonia and the islands of the North Aegean. However, genuine energy communities like those of the interviewee have not been included or provided with financial support. He states that they asked questions to the NSRF team but no answers were provided. He recommends the provision of funding to create energy communities and provide an opportunity for vulnerable households to participate.

The lack of inclusion in the energy transition projects created scepticism and resistance towards green hydrogen projects. The first interviewee states that some of the most profound challenges associated with hydrogen include its storage, transportation and ultimate use, which have limited its application. He emphasises the need for social acceptance and inclusion of the local communities for such projects to become successful:

> "It also means that it should be stored and transported in a very specific way. It can be transported using pipeline networks, but if it is transported in this manner as with the case of natural gas, there will be issues with people and social acceptance of the transportation method. I think I have mentioned that every time you build a huge pipeline, there will always be people who will not be happy about it" (EI1).

4.2.2. Energy Poverty and Inequalities

This theme is related to the social justice aspect of the decarbonisation strategy with green hydrogen implementations. It specifically addressed the persons who are affected by the energy costs, as well as those who are likely to benefit from the innovation and hydrogen technologies. It was apparent from the interviews that energy poverty remains a key problem in specific regions, and certain social groups are more exposed and vulnerable compared to others. The ninth interviewee (EI9), who works as a coordinator for an NGO, expressly indicates that certain groups are more adversely affected by energy poverty. She states:

> "They are certainly families, they are women because this groups are not homogenous, or elderly women even more so because they are disadvantaged due to their age" (Interviewee 9).

The eighth participant (EI8) similarly acknowledged that there are specific social groups that are more exposed than others. The researcher and community member state that the elderly, women and people with disabilities were more disadvantaged in the energy transition projects. Another participant, who is an academic researcher from India, indicated that he has conducted several case studies in the region, including one related to coal mines. He mentions that the local community in the regions where there are installations of wind and solar are adversely affected by noise pollution from the drilling activities. Additionally, he mentions that the activities of large corporations affect the environment in the sense that the forest land has to be cleared to support the activities of the companies in setting up the plants.

It was also demonstrated that there are significant disparities when comparing the rural versus urban regions. More specifically, people living in the cities can benefit from district heating and enhanced infrastructure, but those who reside in remote areas encounter higher expenses and limited access to affordable alternatives. The sixth participant (EI6) explained:

> "There is a big, big problem when comparing cities and the countryside. Cities are in a favourable position due to district heating" (Interviewee 6).

Despite the overemphasis in press conferences and certain publications about the role of hydrogen, the participants also provided information that hydrogen-based systems are likely to be costly and

inaccessible to most people, especially the ones who are already struggling with energy poverty. The EI6 explained:

> "In general, however, it seems that hydrogen is an interesting prospect for the future; still, as a technology, it has a long time before it matures in order to be commercially, economically and technically viable, especially when compared to alternative technologies… I think this is the inception stage and hydrogen are not yet at a mature stage for mass production" (Interviewee 6)

Energy communities have the opportunity of providing potential solutions to address the problem of energy poverty and inaccessibility for a majority of households. The sixth participant mentioned that policymakers are actively collaborating with energy communities since they can potentially help in integrating all the citizens in the transition process.

4.2.3. Lack of Transparency

The participants expressed that there was a general lack of transparency in the planning processes and the decision-making involving energy transition. Although green hydrogen projects have been presented positively and are associated with multiple benefits, they are often managed by specific actors who do not provide sufficient information to the public about the actions and underlying rationale. This essentially limits the accountability of specific actors who are involved in the decision-making processes. One of the key findings in the study was that decision-making is mostly centralised and the local communities are generally not provided the opportunity of participating. The seventh participant (EI7) explained:

> "But most of these models are not proprietary. Most of them are not easily accessible by the public and you don't know what assumptions they make and so forth. So, you know, in this sense, this is a justice issue to me because the outcomes of the model affect people's choices because it gives them a set of choices around which they have to make the right decisions. But you cannot really question the choices like you cannot ask: 'Okay, why this was not there or that was not there'".

EI3 similarly observed that a majority of green hydrogen projects that are funded or managed by private firms do not have any oversight, and this leads to distrust from the local community. Additionally, the participant criticised policies such as the Just Transition Mechanism (JTM) which primarily adopts a top-down approach.

The lack of transparency also resulted in planning issues, especially since the interviewees reported that there was poor coordination between institutions at the national and regional levels. This often led to inefficient or complex planning procedures. The sixth participant (EI6) revealed that the PPC was involved in building a large photovoltaic plan, where there was limited participation of the citizens. More importantly, he mentioned that *"the problem is that the plans for both PPC and the region did not align"* (Interviewee 6). The risk of this approach is that whereas there were plans to privatise the project, there is a high probability that the cost of restoring the project would be borne by the public sector and the Recovery Fund, which was attributed to the lack of harmonised planning.

As a result of the lack of transparency, the implementation of green hydrogen projects and alternative fuels often creates mistrust. The second participant (EI2) indicated that the locals typically learn about large-scale projects when it is too late, and this creates resentment and protests. The ninth participant similarly reported that there was a lot of local scepticism emerging when the projects were advertised as being beneficial without clear evidence. EI9 indicated that since the benefits were not clearly outlined, this created mistrust amongst the workers and locals.

4.2.4. Lack of Communication and Awareness

This theme is closely linked to the previous one on the need for transparency when implementing hydrogen projects. The lack of communication and awareness theme explores the absence of outreach by relevant stakeholders and education of the local communities about the transition to green hydrogen and the anticipated benefits. This can be primarily attributed to the fact that the updates of the projects are often not communicated effectively to the public, and this implies that a majority of the people do not have sufficient information about hydrogen. The ninth participant, who is a coordinator for an NGO,

acknowledged that the public has limited information about the energy transition process, especially involving green hydrogen. EI9 explains:

> "What is needed for knowledge to reach the common people is to upload stories, to make reports, to make narratives more understandable and simpler, let's say a translation of the technical words that has been done in 'vox populi', a story that is easily understood and that the other person can relate to" (Interviewee 9).

The seventh participant observes that in the Netherlands, there are certain programmes that are being carried out in an attempt to educate the public. He mentions that whenever people are invited to meetings, *"there is usually an expected crowd that features the same people time and again"* (Interviewee 7). The same group of people are the most active and interested in the discussion about decarbonisation projects, and it primarily comprises elderly persons. The participant suggests that younger people, who are similarly affected by decarbonisation projects, often fail to attend the information meetings. Therefore, EI7 recommends alternative strategies to educate more people about green hydrogen and energy transition projects.

Policymakers and other relevant stakeholders have the responsibility of conducting local campaigns and education initiatives to help the communities understand the transition process to new energy technologies, such as hydrogen. People lack an understanding of the rationale behind the transition, and this is because they lack sufficient information about this process and the underlying reasons. EI6, for example, mentions that young people are leaving the region since they do not see any prospects in the energy transition. Also, she mentions that there is a deliberate effort to educate the local communities. EI3 similarly states that to address the uncertainties that people have towards green hydrogen, it is necessary to enhance education and training.

4.2.5. Technology and economic barriers

During the interviews, I noticed that there are multiple technical and financial challenges that undermine the development of the green hydrogen infrastructure. An important point that emerged is that hydrogen projects are typically costly and risky. EI3 cited a situation where a green hydrogen project was abandoned as a result of its inefficiency, despite the high costs incurred. EI3 further illustrated that small and medium-sized enterprises are not able to participate in the development of hydrogen initiatives due to the high costs. A majority of private firms are forced to rely on EU and state funding to support the development of hydrogen ecosystems.

EI1 explained that some countries and individuals lack understanding of hydrogen technology or exaggerate its potential. He emphasises that the current technology of hydrogen production has yet to attain maturity. Describing a programme in Azerbaijan, EI1 explains:

> "They are developing their hydrogen strategy, but it's not really comprehensive. They claim that they can produce green hydrogen in specific amounts and volumes, but they never mentioned water, and Azerbaijan is a country where there is water scarcity, especially during the summertime."

The same participant mentioned the case of Chinese experts who have had laboratory breakthroughs in terms of *"electrolyser technology that can potentially work with salt water, but that technology has not yet been commercialised. So, currently, to run your electrolysers in water, it should be fresh water"* (Interviewee 1).

4.2.6. Findings and Comparative Reflections

The content analysis provided a comprehensive understanding of existing policies at the broader level. The analysis revealed existing policy frameworks, institutional strategies and barriers to the development of green hydrogen ecosystems. The interviews further provided valuable insights related to the concerns and experiences of people who have been affected by the lignite independence in Western Macedonia. This section compares the data from the two analyses, including some of the similarities and differences in how the principles of energy justice have been addressed.

The findings from both approaches addressed stakeholder inclusion and participation. In content analysis, it was demonstrated that policy frameworks emphasise the need for citizen engagement in the

entire process of developing the green hydrogen transition projects. Evidence from the content analysis, which was based on empirical studies, however, illustrated that there was limited involvement of the public in the decision-making processes. This same finding emerged in the analysis of the semi-structured interviews. The participants observed that there was a general exclusion of the local residents when making important decisions, and the government would often initiate projects without engaging with the public to provide a rationale for their decisions. Even in cases where there were consultations, the participation of the citizens was not meaningful. Additionally, evidence demonstrated that existing legislative frameworks support the activities of large corporations and neglect the needs of energy communities. The lack of involvement is characteristic of the procedural justice tenet, which was found to have been neglected in both approaches.

Another observation was that the theme of energy poverty and inequalities was prevalent in both approaches. During the analysis of publications, it was mentioned that energy poverty is a structural problem created by government systems. It was further illustrated that there is a disproportionate burden on specific vulnerable groups, including the low-income earners, women and people residing in rural areas. Whereas the documents acknowledged that this is a fundamental problem, the existing policies have not provided sufficient information on how these issues can be addressed. The participants confirmed the existence of energy poverty and inequalities, and they specifically noted that there was a significant gap in the experiences of people residing in rural areas compared to those living in urban locations. They also mentioned that specific groups in society, including elderly women and indigenous groups, experience higher rates of energy poverty. The data from the two approaches illustrates that distributional justice has not been upheld in practice considering that the benefits of green hydrogen projects will not be distributed equally to all parties. The benefits particularly favour large corporations at the expense of the local communities residing in rural areas, such as in Western Macedonia where companies can run their operations without involving the citizens, and with the support of the existing legislative framework.

Another common theme from both techniques utilised to collect data was the presence of technological and economic barriers that have slowed the deployment of energy transition projects. Existing policy frameworks acknowledge that the production of green hydrogen is relatively expensive, and existing technology to produce hydrogen remains immature. There are also multiple challenges in the development of infrastructure, and the solution to this problem is to invest more resources to support the development of the infrastructure. In the interviews, the participants provided examples of projects that have been abandoned in the past due to their inefficiency. The reliance on funding sources, such as the EU, is not an effective solution, especially since the participants illustrated that there is a lack of fairness in allocating the resources. More specifically, large corporations were prioritised over energy communities, which are better positioned to ensure the participation of the citizens in the energy transition projects.

An important difference in the findings of the two approaches pertains to the impact of the energy transition on employment opportunities. Policy documents at the EU level indicate that the transition will help create more employment opportunities. They indicate that people who will lose their jobs as a result of the transition will be retained and reskilled to ensure that they can sustain their livelihoods. The interviews, however, expressed scepticism about the job creation narrative. The participants specifically expressed their concerns about the retraining programs and the actual benefits for persons who will be displaced due to land acquisitions.

Another key difference is that the participants who were interviewed provided detailed insights about their experience in authentic energy communities. At the policy level, energy communities have been recognised as playing a key role in the transition process by ensuring that the citizens are involved and can participate in energy projects. However, one of the participants mentioned that the premise of energy communities was significantly undermined by a lack of funding to support their activities, as well as their exclusion from policies. It was demonstrated by the interviewees that there were unfair practices, which explains the drastic rise in the number of energy communities in Greece in recent years. SMEs tend to take advantage to benefit from the funding that was initially set aside to benefit the energy communities.

4.2.7. Integrating Patterns Across Interviews

Across the interview data, a few consistent patterns have been noted among stakeholder groups, yet it also highlights important divergences in expectations and lived experiences. At first, procedural justice emerges as the area with the most consensus: virtually all interviewees described processes of stakeholder engagement as largely formalistic—engineered to satisfy external requirements rather than to support genuine co-ownership or participatory decision-making. As one participant succinctly put it, *"Participation is mostly symbolic."*. Despite the presence of public consultations and regulatory consultation procedures, most local actors reported feeling that their input rarely translated into meaningful influence over outcomes or the distribution of resources.

Turning to distributive justice, the majority of respondents identified persistent structural barriers to fair benefit-sharing. Although some policy and industry stakeholders expressed cautious optimism that the current imbalance may gradually improve as hydrogen projects mature, community members and NGO representatives remained more skeptical. They described entrenched obstacles for smaller cooperatives and local SMEs, pointing to complex administrative processes and a policy environment that often favours well-capitalised industry players. This perspective is vividly captured by the assertion, *"Big companies have access to funds and information. Smaller groups and cooperatives get left behind."*

Recognition justice was universally acknowledged as underdeveloped, though interviewees differed in their views on prospects for progress. While a few saw hope in increased EU scrutiny and the rise of local advocacy groups, most cited a lack of concrete mechanisms to identify, include, or support vulnerable populations. The prevailing sentiment was aptly summarised by one participant: *"Recognition is still rhetorical, not operational."*. These justice gaps patterns observed in previous energy transitions, reinforcing the need for targeted, context-sensitive strategies to address them.

Table 4.5 summarises these cross-cutting themes, mapping the principal justice challenges identified in the interviews alongside representative quotations. The table visually distills the core findings from stakeholder testimonies, providing a structured reference point for both within-case analysis and comparison to documentary sources.

Justice Dimension	Main Issues Identified	Illustrative Quote
Procedural	Symbolic participation; centralisation	"Participation is mostly symbolic."
Distributive	Concentration of benefits; barriers for SMEs/communities	"Big companies have access to funds and information. Smaller groups and cooperatives get left behind.
Recognition	Lack of inclusion of vulnerable groups	"Recognition is still rhetorical, not operational."

Table 4.5: Main energy justice identifications from Interview Analysis

4.2.8. Justice Dimensions in the Hydrogen Transition

The interview results give a more detailed picture of how the principles of energy justice play out in Western Macedonia's green hydrogen transition.

Procedural justice was a problem that kept cropping up in both the execution of policies and the experiences of the interviewees. People kept bringing up the difference between official consultation processes and real participatory government. One person who was interviewed said that the current method typically only goes as far as consultation, with little progress towards real co-creation or shared decision-making authority. This situation not only threatens to keep current hierarchies in place, but it also lowers local trust in the transition process, which makes people question if participatory systems really make a difference in project outcomes.

When it comes to distributive justice, the facts show that fairness in sharing benefits and burdens is still hard to find. Institutional inertia and complicated administrative procedures frequently make it hard for real energy communities and small local players to get involved, which gives entrenched sector

stakeholders an edge. People who were interviewed urged for real changes, such as making it easier for community cooperatives to get started, making it obvious how jobs are given out in the community, and making sure that community benefits are reported on in a clear and public way. Without these kinds of specific rules, there is a good chance that additional hydrogen investments would make existing inequities worse, which means that the promise of a fair and inclusive regional change will not be kept.

Recognition justice was also seen as very important, especially for making sure that hydrogen initiatives are seen as legitimate and socially acceptable in the long run. People who have a stake in the situation said that the present frameworks don't do enough to recognise and empower people who are most likely to be affected by the transition, such former lignite workers, women, youth, and low-income families. Without clear, actionable plans for inclusion, these groups are at risk of being left out, even while there are verbal promises to "leave no one behind." To remedy the aforementioned, the people who were interviewed suggested specific steps like setting quotas or reserved shares for vulnerable groups in projects, offering targeted retraining programs, and starting regular social impact monitoring to make sure that recognition goes beyond merely an ideal to a real matter.

4.3. Comparisons across the energy justice tenets

The integration of content analysis and qualitative interviews reveals both significant alignments and notable gaps between formal policy intentions and the lived experiences of stakeholders in the hydrogen transition of Western Macedonia. This "overlap" section unpacks these patterns along the three energy justice dimensions—procedural, distributive, and recognition justice—thereby clarifying where documentary evidence and local narratives reinforce or contradict one another.

4.3.1. Procedural Justice

Both the policy documents and interview findings acknowledge participation as a central tenet of a just hydrogen transition. The EU Hydrogen Strategy (European Commission, 2020), the National Energy and Climate Plan (Ministry of Environment and Energy, 2022), and the Master Plan for Western Macedonia (2021) all formally stress the importance of "broad stakeholder engagement" and "transparent decision-making processes." However, the content analysis notes that these commitments are primarily articulated in aspirational terms; actual mechanisms for inclusive participation are either poorly specified or inconsistently implemented (European Court of Auditors, 2024; Zervas, 2020).

Interview data not only confirmed these procedural gaps but also sharpened them. Across multiple interviews, stakeholders—especially community representatives and the local governmental representative—express frustration that formal participatory mechanisms often amount to "box-ticking" rather than genuine influence (EI2, EI3, EI6). As one interviewee observed, "Participation is nominal, not substantive. People feel that decisions are already made before their input is even sought" (EI6). This sense of exclusion is less evident in the documents, where public consultation is described as an achievement rather than a challenge. Thus, while both sources recognise the principle of procedural justice, only the interview data fully expose its routine shortcomings in practice.

4.3.2. Distributive Justice

Policy frameworks and official reports strongly emphasise distributive justice, promising the fair allocation of financial support, employment, and infrastructure (Master Plan for Western Macedonia, 2021; Ministry of Environment and Energy, 2022). The content analysis illustrates that resources are theoretically earmarked for a wide range of stakeholders, from large industrial actors to local communities. Nevertheless, the empirical reality, as captured in interviews, diverges from this policy narrative.

Multiple interviewees—particularly those active in energy communities—underscore the discrepancy between headline commitments and actual benefit-sharing. They describe a context in which regulatory loopholes, administrative burdens, and capital requirements privilege larger consortia at the expense of smaller cooperatives and marginalised groups (EI2, EI5)). As one participant noted, "The real energy communities are fewer than the official numbers suggest; most local groups lack the means to access funding or permits." These findings reinforce, but also nuance, the content analysis: while documents enumerate distributive mechanisms, stakeholders question their practical accessibility and equity. The interviews, therefore, reveal a deeper layer of distributive injustice, highlighting who is actually able to benefit from transition policies.

4.3.3. Recognition Justice

Recognition justice receives the least concrete attention in policy documents, often relegated to generic statements about “leaving no one behind.” The content analysis notes a lack of explicit mechanisms for incorporating the needs of historically marginalised groups—such as former coal workers, youth, women, or energy-poor households—into project planning or benefit-sharing (Skapoula, 2024; Zervas, 2020). NGO reports and independent analyses echo this concern, pointing to intersectional impacts that are largely absent from formal policy frameworks (EmpowerMED Consortium, 2023; Initialising Towards Energy Balance Zero(INZEB), 2021).

The interview findings validate and extend this critique. The majority of the interviewees directly attest to the lack of meaningful recognition for diverse community experiences and identities, noting that policy processes are often technocratic and “one size fits all.” Interviewee 8 (EI8), for example, described recurring patterns of local expertise and lived experience being overlooked: “Each time, the rhetoric says, ‘this is for everyone,’ but in practice, the same groups are left out or even harmed.” This first-hand testimony illustrates the persistence of recognition gaps that are only partially acknowledged—if at all—by policy documents.

5

Discussion

5.1. Summary of the problem, purpose and findings

This study utilised an integrated methodology of qualitative content analysis of policy documents and semi-structured interviews with nine stakeholders, including industry experts, policy advisors, community representatives, engineers and researchers. *Atlas.ti* was used to code and analyse the interviews, supporting both the identification of common themes and nuanced divergences.

The principal findings reveal that whereas there is a strong commitment to uphold the tenets of energy justice, this does not translate to practice. The dimension of energy justice, such as procedural justice are undermined by the enactment of a centralised, top-down decision-making structure. Additionally, distributive justice has not been upheld. Th tenet of recognition justice remains largely rhetorical, with few concrete mechanisms to support the participation or benefit of vulnerable groups such as former lignite workers, women and youth. These findings mirror and extend those observed in comparable EU energy transitions, where ambitious policy often collides with entrenched institutional and socio-economic barriers.

Now I will discuss each operationalises conceptual anchor point on tenets of energy justice in light of my analysis and results. After that, I will reflect on the broader scholarly and policy contexts.

5.2. Energy Justice Framework

The objective of the study was to evaluate how tenets of the energy justice framework have been addressed in the lignite phase-out process in Western Macedonia involving green hydrogen. The framework, which entails distributional, procedural and recognition justice, provide an important lens to evaluate the transition process of lignite-dependent regions to sustainable energy. The thematic analysis of the documents that were selected to evaluate existing policies and how they integrate energy justice elements led to the identification of five major themes. By evaluating these themes, the researcher was able to illustrate how the primary dimensions of the energy justice framework have been addressed. Further, the thematic analysis of the nine semi-structured interview resulted in five major themes and several sub-themes.

5.2.1. Procedural Justice

Evidence from the thematic analysis broadly illustrated that procedural justice has been considered and integrated in the development of policies and legislative framework to facilitate the transition to green hydrogen. According to Sovacool and Dworkin (2015), procedural justice addresses the process of decision-making and recommends that relevant stakeholders should be involved and be allowed access to information. In their study, the authors had mentioned that lack of sufficient information about a topic limits the participation of people in important decisions. A review of the documents outlining the policies of EU and Greece indicates a commitment to citizen engagement in the decision-making process. A report by the European Parliament had emphasised that citizens should be involved in

the entire process, which was also echoed by the Greek National Energy and Climate Plan (NECP) where various stakeholders had been offered the opportunity to attend conferences in the process of developing the strategic plan for 2020 to 2030. However, evidence from a report by The Green Tank (2021) indicates that the centralised structure of government institutions who are responsible for overseeing the development of energy transition projects limits the participation of citizens and the civil society in the decision-making process. Several participants who were interviewed further supported this finding. As the policy advisor noted (EI3), *"There is consultation, but not co-creation. Local voices seldom shift major decisions."* (Interviewee 3).

5.2.2. Distributive Justice

Policy documents stress the role of energy transition in Greece and other EU Member States in delivering jobs, infrastructure and other benefits. This aligns with the principle of distributional justice as presented by Jenkins et al. (2016) and Pellegrini-Masini et al. (2020) who emphasise the need for equal access to energy services and distribution of those services respectively. Directive (EU) 2024/1788 of the European Parliament emphases that every state should enact policies and procedures to protect vulnerable consumers by ensuring that they are not disconnected from energy services. However, the participants in the study indeed acknowledged that energy transition projects have failed to distribute the benefits equally to all members of society. More specifically, it was demonstrated that vulnerable groups, including "elderly women", "single mothers", those living with "disabilities" and "indigenous" groups were burdened disproportionately. One of the participants, for instance, observed her the installation of energy plants creates noise pollution, and the activities of the plants harms the environment. Another participant also mentioned that some of these companies would freely set up their plants in any region by exploiting the existing legislative framework. Energy cooperatives, SMEs and marginalised groups encounter regulatory barriers, lack of information and minimal support. In practice, as both policy review and interviews confirm, the "winners" of the hydrogen transition are those with pre-existing power, connections and expertise. During the interview, the Interviewee 5 commented:

> "Community projects talk a lot about sharing, but most benefits are captured by established actors."

Another key element of distributional justice is premised on the argument that the conditions that lead to the realisation of an end goal should also benefit the stakeholders (Sovacool & Dworkin, 2015). A publication of the World Bank estimates that the energy transition will lead to a loss of up-to 10,600 jobs, directly and indirectly. Whereas arguments by the EU centre on the fact that the existing workforce will be retrained, there is no evidence that the demand for jobs in the development of hydrogen production will supplement the supply of jobs. Also, evidence was reported in this study that local governments and the EU have failed to invest in retraining the existing workforce in the lignite area.

5.2.3. Recognition Justice

Recognition justice — ensuring that historically disadvantaged groups have a voice and stake in the transition—features prominently in EU and national rhetoric. However, this study finds little evidence of effective, sustained outreach or inclusion. Instead, evidence from this study based on the participants' perspectives indicates that the governments in Colombia and Chile do not involve the indigenous people when making investment decisions in their areas. The indigenous groups are not sufficiently informed about the intended benefits of the energy transition, and evidence suggests that the hydrogen produced in the plants that have prompted land relocation will be sold to other wealthier nations, such as Germany. Essentially, interviewees report that the needs of these groups are recognised *"mostly in name only."* The social impact of green hydrogen is *"talked about but not measured or tracked in any systematic way"* (Interviewee 8).

5.2.4. Implications for Legitimacy and Sustainability

The persistent gaps identified across all three justice dimensions undermine both the legitimacy and long-term sustainability of the hydrogen transition in Western Macedonia. Where communities perceive decision-making as opaque, benefits as inaccessible, and their identities as invisible, trust in the process erodes. This risks fueling resistance, limiting local buy-in, and ultimately stalling or reversing progress toward decarbonisation goals.

5.3. Findings in relation to academic literature

This research's findings closely align with trends documented in both Greek and wider European literature. Energy justice studies have regularly shown that procedural fairness, distributive equality, and acknowledgement of impacted stakeholders are often only partially noticed in the real world (Dillman & Heinonen, 2022; Jenkins et al., 2016). Policy analysis by Zervas (2020) observes that, despite explicit references to social justice, actual implementation of participatory mechanisms remains weak. The Ministry of Environment and Energy (2022) and the Master Plan for Western Macedonia (2021) each highlight stakeholder engagement, but, as noted in the European Court of Auditors (2024) review, these processes often amount to "tick-box" exercises, where local voices *"are seldom integrated into project design"*.

A recent case study in the UK urges the direction from a narrow *'just transition'* frame toward a *'trust transition'* (Terry-Doyle et al., 2025). The authors introduced the term *informational justice* as a fourth pillar that underpins the rest of the tenets. *Informational justice* refers to the provision of trusted, accessible, and tailored information. By conducting twelve interviews with community-energy practitioners, the authors stated that community-energy organisations often act as "trusted intermediates", able to reach marginalised groups, alleviate energy poverty through consultative support and build linking social capital between residents and authorities (Terry-Doyle et al., 2025). It can lead to practical pathways to more meaningful participation. Our study of Western Macedonia found that stakeholder engagement is often more symbolic than real. This is also accurate in other post-coal regions like Poland and Germany, where the central government and industry still have too much power over transition pathways (Brauers & Oei, 2020; Hermwille et al., 2023). Greece faces procedural issues, with foreign critics claiming policy frameworks often establish nominal consultation processes without genuine power-sharing. (Chapman et al., 2019; Emodi et al., 2021).

Distributive concerns are similarly echoed in both academic and NGO reports. The Green Tank (2021) analysis of hydrogen policy highlights how funding and resource flows "continue to favour established actors over genuine community initiatives" (p. 14). In practice, as EI5 noted, "SMEs and local energy communities are overwhelmed by administrative barriers." Skapoula (2024) and World Bank (2020) underscore that vague benefit-sharing and lack of local capacity can undermine both economic inclusion and social trust. Across case studies beyond Greece, for instance, the fact that established actors tend to get the most monetary benefits while marginalised groups have challenges gaining them has been seen not only in Western Macedonia but also in Spain's coal transitions and the growth of the hydrogen sector in the Asia-Pacific region (Aditiya & Aziz, 2021; García-García et al., 2024; Gordon et al., 2024).

Recognition gaps are repeatedly flagged in reports from Initialising Towards Energy Balance Zero(INZEB) (2021), and Master Plan for Western Macedonia (2021), which note the "limited operationalisation of gender, youth, and poverty criteria in project planning and funding allocation" (Master Plan for Western Macedonia, 2021). Gouveia et al. (2023) and EmpowerMED Consortium (2023) add that "energy vulnerable groups" often remain invisible in hydrogen transition debates, despite policy commitments. The third pillar seems to be a persistent challenge globally. This phenomenon is similar to what global studies have found about the rhetorical but not substantive inclusion of vulnerable groups in energy planning (Dudka et al., 2023; EmpowerMED Consortium, 2023; Lindner, 2022). The results of this study highlight the necessity from the literature to go beyond tokenistic references and make recognition a part of the system, for example by using allocations, increasing capacity, and working together to construct policy tools (Proka et al., 2018; Skapoula, 2024).

While Western Macedonia's transition is ambitious in scale, its persistent justice gaps reflect experiences in other EU lignite regions, as seen in World Bank (2020), The Green Tank (2021), and Kitsikopoulos and Vrettos (2023). Still, some innovative models—such as cooperative energy hubs, as described in ENA Institute for Alternative Policies (2024) and Initialising Towards Energy Balance Zero(INZEB) (2021)—offer glimpses of what more effective justice operationalisation could look like. At the same time, from the UK case study findings, it is indicated that building trusted, community-centred organisations and practices can convert formal commitments into lived fairness (Terry-Doyle et al., 2025). This approach could align with emerging energy-hub models referenced for the Western Macedonian case.

5.4. Findings in relation to policy and stakeholder engagement

The documentary evidence, triangulated with interviews, reveals that legacy governance structures and limited resourcing for participatory practices often undermine procedural justice. The European Court of Auditors (2024) finds that, across several EU member states, “central ministries retain most decision-making authority,” with “regional and local forums acting in an advisory, not a directive, capacity”. Interviews in this study reinforce this pattern, with community leaders noting that “consultations are rarely accompanied by feedback loops or real opportunities to change outcomes” (EI2).

At the distributive level, both project documentation, Master Plan for Western Macedonia (2021) and The Green Tank (2021) and fieldwork point to the dominance of large corporate consortia in winning hydrogen projects, and to the regulatory and administrative hurdles facing energy cooperatives and smaller actors. “A lot of money is coming in, but it’s not reaching the people who need it most,” as one hydrogen expert put it (EI 1). The Green Tank (2021) and Espitalier-Noël et al. (2025) — show that while projected job creation is high, there is no guarantee that these jobs will be local or sustainable, and little tracking of their distribution.

Recognition remains the most abstractly addressed justice pillar. While the Master Plan for Western Macedonia and the NECP discuss “inclusive transition” and list vulnerable groups as stakeholders, few concrete mechanisms exist to ensure their participation or benefit. For instance, the Gouveia et al. (2023) survey documents the continued prevalence of energy poverty, but this issue is rarely prioritised in hydrogen transition planning. As the EI8 commented: “There’s a lot of talk about leaving no one behind, but no real structures for engagement or support for those groups”.

5.4.1. Discussions of Stakeholder Engagement Patterns

The interviews and policy analysis jointly indicate that effective stakeholder engagement is typically piecemeal and often reliant on motivated individuals or pilot initiatives rather than systematic institutional practice. For example, Skapoula (2024) describes how some energy communities have built participatory cultures, but these remain the exception in a system still geared mainly toward large-scale, top-down development.

Reports from the Master Plan’s public consultation phase (Master Plan for Western Macedonia, 2021; Zervas, 2020) note that feedback was collected from municipalities and civil society, but integration into final project priorities was limited. EmpowerMED Consortium (2023) and Kitsikopoulos and Vrettos (2023) similarly document the frustration of marginalised groups at being invited to participate, only to see their contributions marginalised or ignored.

5.4.2. Discussions in the context of Policy Mechanisms

The Green Tank (2019) and European Court of Auditors (2024) stress that justice objectives can only be realised if backed by “explicit eligibility criteria, transparent reporting, and strong accountability mechanisms.” The current reliance on voluntary or ad hoc practices is insufficient. Initialising Towards Energy Balance Zero(INZEB) (2021) and EmpowerMED Consortium (2023) recommend the institutionalisation of gender and youth quotas, support for local hiring, and community benefit agreements as ways to move from rhetoric to action. World Bank (2020) suggests that, to build local capacity and trust, transition policies must also include “investment in education, social services, and technical assistance tailored to vulnerable groups.”

6

Conclusions

This study explored the justice dimensions of the green hydrogen transition in Western Macedonia, a region emblematic of Greece's broader energy transformation ambitions and post-lignite future. The main problem addressed was the gap between ambitious national and European policy frameworks for hydrogen and the practical realisation of justice based on procedural, distributional and recognition dimensions. The objective was to systematically analyse how these justice dimensions manifest in Western Macedonia's hydrogen initiatives and to identify pathways for a more inclusive, equitable transition.

6.1. Research questions

The current thesis was guided by the following main research question:

What are the energy justice concerns within the green hydrogen transition in Western Macedonia?

To assess the critical question, I systematically analysed the justice concerns of Western Macedonia's transition to green hydrogen by combining content analysis and setting semi-structured interviews. The focus was on assessing whether and how the tenets of justice are operationalised in both policy and practice and identifying where gaps persist. The findings demonstrate that, despite the prominence of justice rhetoric in high-level policy, actual implementation in the region remains highly uneven. Procedural fairness is impeded by centralised and symbolic participation processes; distributive mechanisms tend to reinforce existing inequalities; and recognition of diverse local identities and needs is often more rhetorical than substantive.

Another key objective of the study was to define energy justice and how its tenets have been addressed in the context of Western Macedonia's transition. Energy justice was identified as a framework by which decisions can be made about energy transition and policy, its development and distribution. This framework helps determine the participants in decision-making processes, beneficiaries and the needs that are prioritised or neglected. In Western Macedonia, the relevance of energy justice concerns is intensified by the region's legacy of lignite dependency, which has left many communities vulnerable to exclusion, unemployment and "energy transition fatigue." The rapid pace of the hydrogen transition, alongside ongoing socio-economic vulnerabilities and technological uncertainties makes it critical to ensure a just approach. Both the literature research and interviewees' insights emphasised that, without explicit attention to energy justice, hydrogen projects may simply replicate the extractive patterns of the past and deepen regional disparities.

I also evaluated the relevant policies on the green hydrogen transition and the concerns that were raised. The analysis of documents from the European, national and regional perspective revealed an ambitious set of legal and financial frameworks for hydrogen— most notably the EU Hydrogen Strategy, Greece's National Energy and Climate Plan (NECP) and the Western Macedonia Just Transition Plan. While these documents formally foreground justice and inclusion, a closer examination reveals

that operational mechanisms for ensuring fair participation and benefit-sharing are limited in scope and effectiveness. For instance, requirements for participatory consultation are present but often lack binding force; distributive policy tools, such as Just Transition Mechanism funds, tend to flow toward established or better-resourced actors; and efforts to recognise the specific vulnerabilities of groups such as former lignite workers, women, the elderly and youth are not fully developed in practical policy implementation.

Finally, I examined the relevant stakeholders participating in the green hydrogen transition, including their energy justice concerns. Based on stakeholder mapping before and after setting the interviews, a spectrum of actors involved in the transition were identified, including ministries, regional authorities, industry representatives, municipal officials, energy community members and NGOs. Several interviews with these stakeholders, coming mainly from the academia and community-based environments, surfaced a range of energy justice concerns. These included the persistence of top-down planning approaches, limited channels for meaningful local input, barriers faced by genuine energy communities, insufficient targeted reskilling opportunities for displaced workers and ongoing distrust linked to previous experiences of “symbolic” consultation. Energy Community and NGOs members highlighted their worries regarding the dominance of large corporate players and the limited material benefits reaching to the residents.

6.2. Research limitations

While I provide a timely examination of the justice dimensions shaping Greece’s hydrogen transition through the Western Macedonia’s case study, I would like to acknowledge a few limitations. First, the interviewees’ sample, though carefully selected to span key stakeholder categories—such as policy advisors, academic experts, energy community members, and local residents—remained relatively limited in size. As a result, the perspectives of certain marginalised or less formally organised communities may not be fully represented in the analysis. On the other hand, there was a high interest for the research, at first, from key-role actors from the industry and the Greek electricity grid system who are directly involved with the projects. However, they never approached me at last. Thus, it seemed harder to approach them than I expected. This limitation highlights the importance of further work with a broader, more demographically diverse participant base to validate and extend these findings.

Additionally, the content analysis focused on the most current and relevant policy and regulatory documents available at the time of research. However, the policy landscape in Greece compared to the European Union remains highly dynamic, with frequent updates and legislative changes, but the Greek context stays inactive and restricted to the technological development. For instance, recent or forthcoming amendments to Just Transition Mechanism funding allocations, or adjustments to Greek energy community laws (Zervas, 2020), may shift the institutional context and affect the generalisability of some conclusions. Consequently, some very recent policy shifts may not be fully captured in this study.

A further methodological consideration concerns the potential for researcher and coding bias. As with all qualitative studies, the interpretation of interviews and policy texts is shaped by the researcher’s framework, prior assumptions, and thematic coding approach. While the systematic use of *Atlas.ti* software supports transparency and consistency in coding, it cannot entirely eliminate the possibility of subjective emphasis or oversight. Different research teams, or alternative analytical approaches, could potentially yield somewhat different thematic priorities or interpretations.

Finally, although Western Macedonia is widely recognised as emblematic of Greece’s broader energy transition challenge due to its status as the country’s primary lignite region and the intensity of its transformation its unique institutional culture and local dynamics may limit the direct transferability of these findings to other Greek or European regions. Comparative studies will be necessary to test the broader relevance of these insights in more diverse or contrasting contexts.

6.3. Recommendations for future research

The complexity and rapid evolution of green hydrogen implementations, both in Greece and across Europe, generate several promising avenues for future research. One important direction is the implementation of longitudinal studies that track the evolution of justice practices in green hydrogen and post-lignite transitions over multiple years. Such continuous studies could contribute to assess whether

proposed policy recommendations—such as binding consultation mechanisms or earmarked funding for marginalised groups—are actually enacted in practice and what tangible effects they have on justice outcomes (ENA Institute for Alternative Policies, 2024; Gordon et al., 2024; Lindner, 2022). A discreet assessment can clarify which models and practices most effectively advance energy justice and community resilience in the context of a just hydrogen transition. (Dworkin, 2012; European Court of Auditors, 2024).

Additionally, comparative research is needed to apply the justice framework developed here to other regions undergoing similar transitions, such as Megalopolis in Peloponnese, Greece, the second biggest lignite production network in Greece, or post-coal areas elsewhere in the European Union. We can make our energy systems more equitable and stronger by learning from other countries that are going through similar changes, such the coal mining areas of Poland, Germany, and Greece (Brauers & Oei, 2020; Carmona-Martínez et al., 2024). These studies could identify both common patterns and region-specific challenges, and explore how green hydrogen policies interact with other renewable energy sectors like wind and solar.

Quantitative survey approaches can also significantly contribute to what we learn from qualitative research. Surveys may regularly investigate the level of trust, fairness, and satisfaction people in the community have with participatory processes at various stages of the hydrogen transition. This initiative can show big patterns and ideas that can be missed if you only look at policy analysis or elite interviews.

The experiences of groups that are typically left out of mainstream energy transitions are a very relevant subject for further investigation. More in-depth research on women, young people, former lignite workers, and energy-poor households will help to understand their needs better, the barriers to participation, and potential solutions to include them more fully and share the benefits. Finally, it will be very important to systematically evaluate the various policy interventions and pilot projects that Greece and the EU are trying out, such as cooperative energy hubs, local benefit-sharing agreements, and improved social impact assessment methods. A tactful evaluation can enhance to determine which ideas and approaches work best to promote energy justice and community resilience within the context of a fair hydrogen transition.

6.4. Research implications

The findings of the thesis yield several important implications for theory, policy, and practice regarding just energy transitions in Western Macedonia. Theoretically, the research confirms the strength and flexibility of the energy justice framework as a diagnostic tool for analysing both achievements and persistent limitations in large-scale decarbonisation. Applying the energy justice lenses to both policy documents and the interviews enabled a nuanced understanding of Greece's hydrogen transition, revealing its layered complexities and specific local dynamics. For instance, the continued dominance of centralised governance and the particular vulnerabilities of former lignite communities illustrate the necessity for intersectional and context-sensitive approaches to justice analysis (Kitsikopoulos & Vrettos, 2023).

Moreover, the research demonstrates that general or aspirational commitments to justice in policy must be complemented by detailed, institutionalised mechanisms in order to have a substantive effect. As highlighted in both the literature and empirical findings (Vrontisi et al., 2024; Ziouzios et al., 2021), bridging the gap between rhetoric and practice depends on embedding clear procedures for participatory budgeting, binding feedback mechanisms, and dedicated funding pathways for energy cooperatives and marginalised actors. Policies ought to move beyond principles to include operational details that ensure accountability and inclusion at every stage of project design and implementation. From both a policy and practical perspective, the evidence highlights the value of co-designing hydrogen projects with the communities themselves. Successful pilots in energy communities (Marinakis et al., 2020; Mazza et al., 2024) reveal that when local input shapes project planning and execution, outcomes are more legitimate, sustainable, and resilient. Furthermore, it is essential to earmark transition funds specifically for local retraining and for supporting cooperative or community-based energy initiatives. Consistent with recommendations by The Green Tank (2021) and World Bank (2020), such targeted resource allocation is particularly necessary for groups most at risk of exclusion—namely, former lignite

workers, as well as young and elderly people.

The findings also point to the critical need for institutionalising recognition mechanisms to guarantee inclusion. Practical interventions such as quotas for vulnerable groups, reserved project shares, direct outreach, and systematic social impact monitoring should become standard practice in policy design. Establishing independent, adaptive governance structures at the regional level is likewise vital for effective monitoring and for the capacity to adjust policies in response to observed justice gaps.

6.5. Reflection

Working on the process and findings of this research, it seems that the persistent gap between the rhetoric and the lived reality of energy justice in the green hydrogen transition of Western Macedonia exists. Greece's policy frameworks do not align closely with European and international expectations to a bigger extend. Also, the experience on the ground is still marked by uneven participation, unequal distribution of benefits, and the ongoing exclusion of vulnerable groups. As the energy community leader (EI2) poignantly remarked, *"The transition is happening, but not for everyone. It's up to us to keep pushing for a seat at the table."*

Firstly, a few actionable insights regarding the institutionalising co-design and accountability should be a priority. A proper project planning should move beyond dividing consultation toward genuine co-creation, including binding feedback mechanisms and transparent records of decision-making. The creation of independent regional bodies to monitor and enforce justice outcomes, as recommended in the European Court of Auditors (2024) and Master Plan for Western Macedonia (2021) is a critical step forward.

From the financial perspective, targeted funding and capacity-building must be embedded in policy. Portions of the Just Transition Mechanism, Recovery and Resilience Facility, and other funds should be dedicated to local retraining, the creation of cooperative hubs, and direct support for excluded groups.

Thirdly, recognition and inclusion mechanisms is necessary to be operationalised. This means introducing quotas, targeted outreach, and tailored support for marginalised populations across the hydrogen projects, coupled with annual public reporting on progress and outcomes.

On a personal and academic level, this thesis journey—especially the integration of document analysis with semi-structured interviews—has powerfully reaffirmed that energy transitions are not merely technical or economic processes, but deeply social and political ones. The justice framework, though sometimes abstract, provides an essential lens for illuminating whose interests are being served and whose are at risk of being left behind. The importance of listening to a diversity of voices cannot be overstated: meaningful progress on decarbonisation will only be possible if justice is treated not merely as an aspiration but as a concrete practice embedded in every stage of the transition.

References

Aditiya, H., & Aziz, M. (2021). Prospect of hydrogen energy in asia-pacific: A perspective review on techno-socio-economy nexus. *International Journal of Hydrogen Energy*, *46*(71), 35027–35056. https://doi.org/https://doi.org/10.1016/j.ijhydene.2021.08.070

Alamoush, A. S. (2024). Harboring change: Exploring the multifaceted and complex determinants of decarbonizing ports. *Energy Research & Social Science*, *118*, 103751. https://doi.org/https://doi.org/10.1016/j.erss.2024.103751

Battulga, S., & Dhakal, S. (2024). Stakeholders' perceptions of sustainable energy transition of ulaanbaatar city, mongolia. *Renewable and Sustainable Energy Reviews*, *189*, 114020. https://doi.org/10.1016/j.rser.2023.114020

Bloomberg. (2025). Bloomberg coal countdown - greece [[Online; accessed 24-February-2025]]. https://bloombergcoalcountdown.com/countries/GR

Boemi, S. N., Samarentzi, M., & Dimoudi, A. (2020). Research of energy behaviour and energy poverty of households in northern greece. *IOP Conference Series: Earth and Environmental Science*, *410*(1), 012083. https://doi.org/10.1088/1755-1315/410/1/012083

Brauers, H., & Oei, P.-Y. (2020). The political economy of coal in poland: Drivers and barriers for a shift away from fossil fuels. *Energy Policy*, *144*, 111621. https://doi.org/https://doi.org/10.1016/j.enpol.2020.111621

Burke, M. J., & Stephens, J. C. (2018). Political power and renewable energy futures: A critical review [Energy and the Future]. *Energy Research & Social Science*, *35*, 78–93. https://doi.org/https://doi.org/10.1016/j.erss.2017.10.018

Caglayan, D. G., Heinrichs, H. U., Robinius, M., & Stolten, D. (2021). Robust design of a future 100% renewable european energy supply system with hydrogen infrastructure. *International Journal of Hydrogen Energy*, *46*(57), 29376–29390. https://doi.org/https://doi.org/10.1016/j.ijhydene.2020.12.197

Carley, S., & Konisky, D. M. (2020). The justice and equity implications of the clean energy transition. *Nature Energy*, *5*(8), 569–577. https://doi.org/10.1038/s41560-020-0641-6

Carmona-Martínez, A. A., Rontogianni, A., Zeneli, M., Grammelis, P., Birgi, O., Janssen, R., Di Costanzo, B., Vis, M., Davidis, B., Reumerman, P., & et al. (2024). Charting the course: Navigating decarbonisation pathways in greece, germany, the netherlands, and spain's industrial sectors. *Sustainability*, *16*(14), 6176. https://doi.org/10.3390/su16146176

Centre for Renewable Energy Sources and Saving (CRES). (2022, July). Blueprint on the region of western macedonia's energy transition. https://tracer-h2020.eu/wp-content/uploads/2022/09/TRACER-D6.5-Blueprint_EL53-WMR_final.pdf

Chapman, A., Itaoka, K., Hirose, K., Davidson, F. T., Nagasawa, K., Lloyd, A. C., Webber, M. E., Kurban, Z., Managi, S., Tamaki, T., Lewis, M. C., Hebner, R. E., & Fujii, Y. (2019). A review of four case studies assessing the potential for hydrogen penetration of the future energy system. *International Journal of Hydrogen Energy*, *44*(13), 6371–6382. https://doi.org/https://doi.org/10.1016/j.ijhydene.2019.01.168

Christiaensen, L., & Ferré, C. (2020). Just coal transition in western macedonia, greece: Insights from the labor market. https://openknowledge.worldbank.org/handle/10986/34737

Claar, S. (2022). Green colonialism in the european green deal: Continuities of dependency and the relationship of forces between europe and africa. *Culture, Practice & Europeanization*. https://api.semanticscholar.org/CorpusID:255036833

Creswell, J. w. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches*. SAGE Publications, Inc.

Dembi, V. (2022). Ensuring energy justice in transition to green hydrogen. *SSRN Electronic Journal*. https://doi.org/https://doi.org/10.2139/ssrn.4015169

Dillman, K., & Heinonen, J. (2022). A ”just” hydrogen economy: A normative energy justice assessment of the hydrogen economy. *Renewable and Sustainable Energy Reviews*, *167*, 112648. https://doi.org/https://doi.org/10.1016/j.rser.2022.112648

Dudka, A., Moratal, N., & Bauwens, T. (2023). A typology of community-based energy citizenship: An analysis of the ownership structure and institutional logics of 164 energy communities in france. *Energy Policy*, *178*, 113588. https://doi.org/https://doi.org/10.1016/j.enpol.2023.113588

Durakovic, G., del Granado, P. C., & Tomasgard, A. (2023). Are green and blue hydrogen competitive or complementary? insights from a decarbonized european power system analysis. *Energy*, *282*, 128282. https://doi.org/https://doi.org/10.1016/j.energy.2023.128282

Dworkin, S. L. (2012). Sample size policy for qualitative studies using in-depth interviews. *Archives of Sexual Behavior*, *41*(6), 1319–1320. https://doi.org/10.1007/s10508-012-0016-6

Emodi, N. V., Lovell, H., Levitt, C., & Franklin, E. (2021). A systematic literature review of societal acceptance and stakeholders' perception of hydrogen technologies. *International Journal of Hydrogen Energy*, *46*(60), 30669–30697. https://doi.org/https://doi.org/10.1016/j.ijhydene.2021.06.212

EmpowerMED Consortium. (2023). Gender and energy poverty: Facts and arguments [Accessed: 2025-06-23]. https://www.empowermed.eu/wp-content/uploads/2023/08/EmpowerMED-Gender-and-energy-poverty-Factsheet-July2023-FINAL-1.pdf

ENA Institute for Alternative Policies. (2024). ENA Energy Communities: Policies, practices and recommendations. In Greek ENA Ενεργειακές Κοινότητες: Αναλύσεις, προτάσεις και καλές πρακτικές [Accessed: 2025-06-23]. https://enainstitute.org/wp-content/uploads/2024/03/%CE%95%CE%9D%CE%91_%CE%95%CE%BD%CE%B5%CF%81%CE%B3%CE%B5%CE%B9%CE%B1%CE%BA%CE%AD%CF%82-K%CE%BF%CE%B9%CE%BD%CF%8C%CF%84%CE%B7%CF%84%CE%B5%CF%82.pdf

Energy Press Greece. (2024, September). European and national regulatory framework for hydrogen: Gaps in environmental permitting and land uses. https://energypress.gr/news/eyropaiko-kai-ethniko-kanonistiko-plaisio-gia-ydrogono-ta-kena-stin-periballontiki-adeiodotisi

Espitalier-Noël, M., Muron, M., Pawelec, G., Santos, S., Staudenmayer, O., Fonseca, J., & Fraille, D. (2025). https://hydrogeneurope.eu/wp-content/uploads/2024/11/Clean_Hydrogen_Monitor_11-2024_V2_DIGITAL_draft3-1.pdf

European Climate, Infrastructure and Environment Executive Agency. (2023). The transition towards a greener future of western macedonia is the first project supported by the european union's public sector loan facility [[Online; accessed 24-February-2025]]. https://trek.gr/energy-policy-infrastructures-in-the-region-of-western-macedonia/

European Commission. (2020). A hydrogen strategy for a climate-neutral europe. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0301

European Commission. (2021a). *Just development transition programme (jtdp)* (tech. rep.) (Accessed: 2025-06-23). European Commission. sfc2021-JTDP_EN.pdf

European Commission. (2021b). *Territorial just transition plan – western macedonia* (tech. rep.) (Accessed: 2025-06-23). European Commission. sfc2021-TJTP%20WESTERN%20MACEDONIA_EN.pdf

European Commission. (2022, May). Communication from the commission to the european parliament, the european council, the council, the european economic and social committee and the committee of the regions repowereu plan (com/2022/230 final). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483

European Commission. (2025). The just transition mechanism: Making sure no one is left behind [[Online; accessed 24-February-2025]]. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en#introduction

European Council. (2024). Fit for 55 - consilium. https://www.consilium.europa.eu/en/policies/fit-for-55/

European Court of Auditors. (2024). *The eu's industrial policy on renewable hydrogen: Legal framework has been mostly adopted – time for a reality check* (tech. rep.). European Court of Auditors.

Figgou, L., & Pavlopoulos, V. (2015). Social psychology: Research methods. In J. D. Wright (Ed.), *International encyclopedia of the social & behavioral sciences (second edition)* (Second Edition, pp. 544–552). Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-08-097086-8.24028-2

Flath, A., & Quittkat, C. (2025). Mapping the hydrogen power players: An analysis of lobbying on eu hydrogen policy-making.

García-García, P., Carpintero, Ó., & Buendía, L. (2024). Just transitions to renewables in mining areas: Local system dynamics. *Renewable and Sustainable Energy Reviews*, *189*. https://doi.org/10.1016/j.rser.2023.113934

Geier, J. (2021, April). Report on a european strategy for hydrogen: A9-0116/2021: European parliament. https://www.europarl.europa.eu/doceo/document/A-9-2021-0116_EN.html

Gordon, J. A., Balta-Ozkan, N., Haq, A., & Nabavi, S. A. (2024). Coupling green hydrogen production to community benefits: A pathway to social acceptance? *Energy Research & Social Science*, *110*, 103437. https://doi.org/https://doi.org/10.1016/j.erss.2024.103437

Gouveia, J. P., Bessa, S., Palma, P., Mahoney, K., & Sequeira, M. (2023). Energy poverty national indicators: Uncovering new possibilities for expanded knowledge. https://energy-poverty.ec.europa.eu/system/files/2024-05/EPAH2023_2nd%20Indicators%20Report_Final_0_0.pdf

Grossoehme, D. H. (2014). Overview of qualitative research. *Journal of Health Care Chaplaincy*, *20*(3), 109–122. https://doi.org/10.1080/08854726.2014.925660

Hanto, J., Herpich, P., Loffler, K., Hainsch, K., Moskalenko, N., & Schmidt, S. (2024). Assessing the implications of hydrogen blending on the european energy system towards 2050. *Advances in Applied Energy*, *13*, 100161. https://doi.org/https://doi.org/10.1016/j.adapen.2023.100161

Heffron, R. J., & Sokołowski, M. M. (2024). Resolving energy policy failure: Introducing energy justice as the solution to achieve a just transition. *Energy Policy*, *187*, 114042. https://doi.org/https://doi.org/10.1016/j.enpol.2024.114042

Hermwille, L., Schulze-Steinen, M., Brandemann, V., Roelfes, M., Vrontisi, Z., Kesküla, E., Anger-Kraavi, A., Trembaczowski, Ł., Mandrysz, W., Muster, R., & Zygmunt-Ziemianek, A. (2023). Of hopeful narratives and historical injustices – an analysis of just transition narratives in european coal regions. *Energy Research & Social Science*, *104*, 103263. https://doi.org/https://doi.org/10.1016/j.erss.2023.103263

Höfer, T., & Madlener, R. (2020). A participatory stakeholder process for evaluating sustainable energy transition scenarios. *Energy Policy*, *139*(100), S0301421520300355. https://doi.org/10.1016/j.enpol.2020.111277

Independent Power Tranmission Operator (IPTO). (2024). https://www.admie.gr/en/kentro-typoy/press-releases/2023-record-year-clean-energy-greece

Initialising Towards Energy Balance Zero(INZEB). (2021). Energy poverty in greece 2.0 [Accessed: 2025-06-23]. http://inzeb.org/wp-content/uploads/2021/05/ENERGY-POVERTY-IN-GREECE-2.0_EN.pdf

Institute for European Energy and Climate Policy (IEECP). (2023). Just transition brief: Greece [Accessed: 2025-06-23]. https://ieecp.org/wp-content/uploads/2023/07/JUSTEM-Just-Transition-BRIEF_GREECE.pdf

International Energy Agency. (2023, April). Greece 2023 – analysis- outlook. https://www.iea.org/reports/greece-2023

International Energy Agency (IEA). (2024, October). Global hydrogen review 2024 – analysis - iea. https://www.iea.org/reports/global-hydrogen-review-2024

International Trade Administration. (2024, May). Greece renewable energy projects 2024. https://www.trade.gov/market-intelligence/greece-renewable-energy-projects-2024

Jenkins, K., McCauley, D., Heffron, R., Stephan, H., & Rehner, R. (2016). Energy justice: A conceptual review. *Energy Research & Social Science*, *11*, 174–182. https://doi.org/https://doi.org/10.1016/j.erss.2015.10.004

Johnston, R., & Revest, M. (2025, February). https://www.e3g.org/wp-content/uploads/E3G-202502_EU-H2-Briefing.pdf

Kafetzis, A., Bampaou, M., Kardaras, G., & Panopoulos, K. (2023). Decarbonization of former lignite regions with renewable hydrogen: The western macedonia case. *Energies*, *16*(20). https://doi.org/10.3390/en16207029

Kaldellis, J. K. (2025). Long-term analysis of hydropower's pivotal role in sustainable future of greece. *Energies*, *18*(9). https://doi.org/10.3390/en18092214

Kaldellis, J. K., Boulogiorgou, D., Kondili, E. M., & Triantafyllou, A. G. (2023). Green transition and electricity sector decarbonization: The case of west macedonia. *Energies*, *16*(16). https://doi.org/10.3390/en16165970

Kalt, T., Simon, J., Tunn, J., & Hennig, J. (2023). Between green extractivism and energy justice: Competing strategies in south africa's hydrogen transition in the context of climate crisis. *Review of African Political Economy*, *50*(177–178). https://doi.org/10.1080/03056244.2023.2260206

Karamaneas, A., Koasidis, K., Frilingou, N., Xexakis, G., Nikas, A., & Doukas, H. (2023). A stakeholder-informed modelling study of greece's energy transition amidst an energy crisis: The role of natural gas and climate ambition. *Renewable and Sustainable Energy Transition*, *3*, 100049. https://doi.org/https://doi.org/10.1016/j.rset.2023.100049

Katsaprakakis, D. A., Proka, A., Zafirakis, D., Damasiotis, M., Kotsampopoulos, P., Hatziargyriou, N., Dakanali, E., Arnaoutakis, G., & Xevgenos, D. (2022). Greek islands' energy transition: From lighthouse projects to the emergence of energy communities. *Energies*, *15*(16). https://doi.org/10.3390/en15165996

Kavadias, K., Apostolou, D., & Kaldellis, J. (2018). Modelling and optimisation of a hydrogen-based energy storage system in an autonomous electrical network [Transformative Innovations for a Sustainable Future - Part III]. *Applied Energy*, *227*, 574–586. https://doi.org/https://doi.org/10.1016/j.apenergy.2017.08.050

Kerneïs, K., & Jacques Delors Institute (JDI). (2024). Sun4all policy brief: Fleshing out energy community legislation in eu member states for a fair energy transition. https://knowledge4energy.eu/resource?t=Sun4All+Policy+brief%3A+Fleshing+out+energy+community+legislation+in+EU+Member+States+for+a+fair+energy+transition

Ketikidis, C., Triantafillidis, A., Stogiannis, P., Amarantos, P., Kontodimos, I., & Grammelis, P. (2023). Clean energy technologies in western macedonia: Opportunities for jobs and growth within the coal phase-out era. *Engineering Proceedings*, *56*(1). https://doi.org/10.3390/ASEC2023-15404

Kitsikopoulos, D., & Vrettos, C. (2023). The social impact of energy communities in greece (K. Metaxa, Ed.). https://gr.boell.org/sites/default/files/2023-05/social-impact-of-ec-in-greece_en_final_0.pdf

Kostis Moussouroulis. (2020). Just transition development plan [[Online; accessed 24-February-2025]]. https://www.sdam.gr/sites/default/files/consultation/Current_situation_and_prospects_for_areas_in_energy_transition_in_Greece_EN.pdf

Kourougianni, F., Arsalis, A., Olympios, A. V., Yiasoumas, G., Konstantinou, C., Papanastasiou, P., & Georghiou, G. E. (2024). A comprehensive review of green hydrogen energy systems. *Renewable Energy*, *231*, 120911. https://doi.org/https://doi.org/10.1016/j.renene.2024.120911

Koutsandreas, D., Trachanas, G. P., Pappis, I., Nikas, A., Doukas, H., & Psarras, J. (2023). A multi-criteria modeling approach for evaluating power generation scenarios under uncertainty: The case of green hydrogen in greece. *Energy Strategy Reviews*, *50*, 101233. https://doi.org/https://doi.org/10.1016/j.esr.2023.101233

Kruczek, M., Markowska, M., Servou, A., Roumpos, C., Mertiri, E., Ernst, P., Darmosz, J., & Kempka, T. (2025). Navigating socio-technical challenges in energy efficiency: Case studies on hybrid pumped-hydropower storage in poland and greece. *Energies*, *18*(3). https://doi.org/10.3390/en18030599

Lagioia, G., Spinelli, M. P., & Amicarelli, V. (2023). Blue and green hydrogen energy to meet european union decarbonisation objectives. an overview of perspectives and the current state of affairs. *International Journal of Hydrogen Energy*, *48*(4), 1304–1322. https://doi.org/https://doi.org/10.1016/j.ijhydene.2022.10.044

Lampropoulos, A., Varvoutis, G., Athanasiou, C., & Marnellos, G. E. (2025). Assessing the electricity potential from agricultural residues in western macedonia, greece. *Renewable and Sustainable Energy Reviews*, *214*, 115530. https://doi.org/https://doi.org/10.1016/j.rser.2025.115530

Lindner, R. (2022). Green hydrogen partnerships with the global south. advancing an energy justice perspective on "tomorrow's oil". *Sustainable Development*, *31*(2), 1038–1053. https://doi.org/10.1002/sd.2439

Lindsey, R., & Dahlman, L. (2025, May). Climate change: Global temperature in 2024. https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature

Lowitzsch, J. (2019). *Energy transition: Financing consumer co-ownership in renewables*. Palgrave Macmillan.

Luka Dimitrov for ICIS. (2021). Greek hydrogen projects move closer to eu funding [[Online; accessed 24-February-2025]]. https://www.icis.com/explore/resources/news/2021/09/07/10682510/greek-hydrogen-projects-move-closer-to-eu-funding/

Maestre, V., Ortiz, A., & Ortiz, I. (2021). Challenges and prospects of renewable hydrogen-based strategies for full decarbonization of stationary power applications. *Renewable and Sustainable Energy Reviews*, *152*, 111628. https://doi.org/https://doi.org/10.1016/j.rser.2021.111628

Mahmudi, S. (2022). The drivers and obstacles of green energy transition in republic of north macedonia. *International Journal of Academic Research in Business and Social Sciences*, *12*. https://doi.org/10.6007/IJARBSS/v12-i8/14517

Manolopoulos, D., Kitsopoulos, K., Kaldellis, J. K., & Bitzenis, A. (2016). The evolution of renewable energy sources in the electricity sector of greece. *International Journal of Hydrogen Energy*, *41*(29), 12659–12671. https://doi.org/https://doi.org/10.1016/j.ijhydene.2016.02.115

Mantzaris, Nikos. (2021). Delignitisation and just transition: Causes, threats and challenges [[Online; accessed 24-February-2025]]. https://gr.boell.org/en/2021/01/25/apolignitopoiisi-kai-dikaii-metabasi-aities-apeiles-kai-prokliseis

Marinakis, V., Flamos, A., Stamtsis, G., Georgizas, I., Maniatis, Y., & Doukas, H. (2020). The efforts towards and challenges of greece's post-lignite era: The case of megalopolis. *Sustainability*, *12*(24). https://doi.org/10.3390/su122410575

Master Plan for Western Macedonia. (2021). Master plan for the just development transition of western macedonia.

Mata Pérez, M. d. l. E., Scholten, D., & Smith Stegen, K. (2019). The multi-speed energy transition in europe: Opportunities and challenges for eu energy security. *Energy Strategy Reviews*, *26*, 100415. https://doi.org/https://doi.org/10.1016/j.esr.2019.100415

Mazza, A., Forte, A., Bompard, E., Cavina, G., Angelini, A., & Melani, M. (2024). Assessment of the role of green hydrogen as the commodity enabling a new green dialogue among the mediterranean shores. *Energy Conversion and Management: X*, *23*, 100614. https://doi.org/https://doi.org/10.1016/j.ecmx.2024.100614

Ministry of Environment and Energy. (2022). National climate law 4936/2022 on the transition to climate neutrality and adaptation to climate change. https://climate-laws.org/document/national-climate-law-4936-2022-on-the-transition-to-climate-neutrality-and-adaptation-to-climate-change_2ff3

Muller, F., Tunn, J., & Kalt, T. (2022). Hydrogen justice. *Environmental Research Letters*, *17*(11), 115006. https://doi.org/10.1088/1748-9326/ac991a

Mundaca, L., Busch, H., & Schwer, S. (2018). 'successful' low-carbon energy transitions at the community level? an energy justice perspective. *Applied Energy*, *218*(100), 292–303.

Nanaki, E. A., Kiartzis, S., & Xydis, G. (2024). Is greece ready for a hydrogen energy transition?-quantifying relative costs in hard to abate industries. *Energies*, *17*(7). https://doi.org/10.3390/en17071722

Nikas, A., Frilingou, N., Heussaff, C., Fragkos, P., Mittal, S., Sampedro, J., Giarola, S., Sasse, J.-P., Rinaldi, L., Doukas, H., Gambhir, A., Giannousakis, A., Golinucci, N., Koasidis, K., Rocco, M. V., Trutnevyte, E., Xexakis, G., Zachmann, G., Zisarou, E., … Van de Ven, D.-J. (2024). Three different directions in which the european union could replace russian natural gas. *Energy*, *290*, 130254. https://doi.org/https://doi.org/10.1016/j.energy.2024.130254

Noble, H., & Smith, J. (2015). Issues of validity and reliability in qualitative research. *Evidence Based Nursing*, *18*(2), 34–35. https://doi.org/10.1136/eb-2015-102054

Noussan, M., Raimondi, P. P., Scita, R., & Hafner, M. (2021). The role of green and blue hydrogen in the energy transition - a technological and geopolitical perspective. *Sustainability*, *13*(1). https://doi.org/10.3390/su13010298

O'Connor, J. (2024, June). Overview of renewable energy spatial planning and designation of acceleration areas in selected eu member states. https://caneurope.org/spatial-planning-for-renewables/

Panchenko, V., Daus, Y., Kovalev, A., Yudaev, I., & Litti, Y. (2023). Prospects for the production of green hydrogen: Review of countries with high potential. *International Journal of Hydrogen Energy*, *48*(12), 4551–4571. https://doi.org/https://doi.org/10.1016/j.ijhydene.2022.10.084

Papada, L., & Kaliampakos, D. (2016). Measuring energy poverty in greece. *Energy Policy*, *94*, 157–165. https://doi.org/https://doi.org/10.1016/j.enpol.2016.04.004

Papadis, E., & Tsatsaronis, G. (2020). Challenges in the decarbonization of the energy sector. *Energy*, *205*, 118025. https://doi.org/https://doi.org/10.1016/j.energy.2020.118025

Pathak, V., Jena, B., & Kalra, S. (2013). Qualitative research. *Perspectives in Clinical Research*, *4*(3), 192. https://doi.org/10.4103/2229-3485.115389

Patonia, A. (2025). Green hydrogen and its unspoken challenges for energy justice. *Applied Energy*, *377*, 124674. https://doi.org/10.1016/j.apenergy.2024.124674

Pavloudakis, F., Karlopoulos, E., & Roumpos, C. (2023). Just transition governance to avoid socio-economic impacts of lignite phase-out: The case of western macedonia, greece. *The Extractive Industries and Society*, *14*, 101248. https://doi.org/https://doi.org/10.1016/j.exis.2023.101248

Pellegrini-Masini, G., Pirni, A., Maran, S., & KlГ¶ckner, C. A. (2020). Delivering a timely and just energy transition: Which policy research priorities? *Environmental Policy and Governance*, *30*(6), 293–305. https://doi.org/https://doi.org/10.1002/eet.1892

Proka, A., Hisschemöller, M., & Loorbach, D. A. (2018). Transition without conflict? renewable energy initiatives in the dutch energy transition. *Sustainability*, *10*, 1721.

Quitzow, R., & Zabanova, Y. (2024). *The geopolitics of hydrogen. volume 1, european strategies in global perspective*. Springer. https://link.springer.com/book/10.1007/978-3-031-59515-8

Regulatory Authority for Energy, Waste and Wate. (2023, August). https://www.raaey.gr/energeia/en/electricity/storage/

Ryghaug, M., Skjølsvold, T. M., & Heidenreich, S. (2018). Creating energy citizenship through material participation. *Social Studies of Science*, *48*(2), 283–303. https://doi.org/10.1177/0306312718770286

Sekaran, U., & Bougie, R. (2016). *Research methods for business: A skill building approach*. Wiley. https://books.google.nl/books?id=Ko6bCgAAQBAJ

Skapoula, A. (2024). *Ενεργειακή μετάβαση και κοινωνική υπεραξία των ενεργειακών κοινοτήτων στην ελλάδα [energy transition and the social value of energy communities in greece]* (tech. rep.). Παρατηρητήριο Βιώσιμης Ανάπτυξης ΕΝΑ.

Smith, C., Bucke, C., & van der Horst, D. (2023). Green hydrogen powering sustainable festivals: Public perceptions of generators, production and ownership. *International Journal of Hydrogen Energy*, *48*(23), 8370–8385. https://doi.org/https://doi.org/10.1016/j.ijhydene.2022.11.171

Sovacool, B. K., & Dworkin, M. H. (2015). Energy justice: Conceptual insights and practical applications. *Applied Energy*, *142*, 435–444. https://doi.org/https://doi.org/10.1016/j.apenergy.2015.01.002

Szemző, H., & Gerőházi, É. (2024, January). Energy poverty at building level & policy recommendations. https://comact-project.eu/wp-content/uploads/2021/05/ComAct-D1.1_Overview-report-on-the-energy-poverty-concept_Final-version_UPDATED-1.pdf

ten Brink, P. (2025, May). https://eeb.org/wp-content/uploads/2025/05/EEB-Annual-Report-2024.pdf

Terry-Doyle, F., Palmer, J., & Nolden, C. (2025). From the 'just transition' to the 'trust transition': Rethinking justice in community energy projects. *Local Environment*, *0*(0), 1–20. https://doi.org/10.1080/13549839.2025.2540118

The Green Tank. (2019). The economics of greek lignite plants: End of an era [[Online; accessed 24-February-2025]]. https://thegreentank.gr/wp-content/uploads/2019/09/The-economics-of-Greek-lignite-plants_EN_LR.pdf

The Green Tank. (2021). Review: Energy communities in the lignite regions of greece [[Online; accessed 24-February-2025]]. https://thegreentank.gr/en/2021/11/22/brief-encom-en/

Todorović, I. (2023, May). Hellenic hydrogen to install electrolyzer of up to 100 mw in greece's coal region. https://balkangreenenergynews.com/hellenic-hydrogen-to-install-electrolyzer-of-up-to-100-mw-in-greeces-coal-region/

Tranoulidis, A., Sotiropoulou, R.-E. P., Bithas, K., & Tagaris, E. (2022). Decarbonization and transition to the post-lignite era: Analysis for a sustainable transition in the region of western macedonia. *Sustainability*, *14*(16). https://doi.org/10.3390/su141610173

TREK development. (2025). Energy policy & infrastructures in the region of western macedonia [[Online; accessed 24-February-2025]]. https://trek.gr/energy-policy-infrastructures-in-the-region-of-western-macedonia/

Tunn, J., Kalt, T., Müller, F., Simon, J., Hennig, J., Ituen, I., & Glatzer, N. (2024). Green hydrogen transitions deepen socioecological risks and extractivist patterns: Evidence from 28 prospective exporting countries in the global south. *Energy Research and Social Science*, *117*, 103731. https://doi.org/10.1016/j.erss.2024.103731

van Bommel, N., & Höffken, J. I. (2021). Energy justice within, between and beyond european community energy initiatives: A review. *Energy Research & Social Science*, *79*, 102157. https://doi.org/https://doi.org/10.1016/j.erss.2021.102157

van Uffelen, N. (2022). Revisiting recognition in energy justice. *Energy Research & Social Science*, *92*, 102764. https://doi.org/https://doi.org/10.1016/j.erss.2022.102764

Virens, A. (2024). Green hydrogen futures: Tensions of energy and justice within sociotechnical imaginaries. *Energy Research and Social Science*, *114*, 103587. https://doi.org/10.1016/j.erss.2024.103587

Vrontisi, Z., Charalampidis, I., Fragkiadakis, K., & Florou, A. (2024). Towards a just transition: Identifying eu regions at a socioeconomic risk of the low-carbon transition. *Energy and Climate Change*, *5*, 100129. https://doi.org/https://doi.org/10.1016/j.egycc.2024.100129

World Bank. (2020). *Just coal transition in western macedonia, greece: Insights from the labor market* (tech. rep.).

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, *35*(5), 2683–2691. https://doi.org/https://doi.org/10.1016/j.enpol.2006.12.001

Zervas, E. (2020). *Παρατηρήσεις για το εθνικό σχέδιο για την ενέργεια και το κλίμα [comments on the national energy and climate plan]* (tech. rep.). ΙΜΕ ΓΣΕΒΕΕ.

Zervas, E., Vatikiotis, L., & Gareiou, Z. (2021). Proposals for an environmental and social just transition for the post-lignite era in western macedonia, greece. *IOP Conference Series: Earth and Environmental Science*, *899*, 012049.

Ziouzios, D., Karlopoulos, E., Fragkos, P., & Vrontisi, Z. (2021). Challenges and opportunities of coal phase-out in western macedonia. *Climate*, *9*(7). https://doi.org/10.3390/cli9070115

Zografidou, E., Petridis, K., Arabatzis, G., & Dey, P. K. (2016). Optimal design of the renewable energy map of greece using weighted goal-programming and data envelopment analysis. *Computers & Operations Research*, *66*, 313–326. https://doi.org/https://doi.org/10.1016/j.cor.2015.03.012

A

Interview Questionnaire

Table A.1: Interview Questionnaire

Number	Question for Greek participants	Question for non-Greek participants
Intro Q1	Please introduce yourself and describe your role in the energy transition in Western Macedonia.	Please introduce yourself and describe your role or perspective in the hydrogen/energy sector internationally.
Q1	What is the role of your energy community or organization in the hydrogen transition of Western Macedonia?	In your opinion, what are the key justice issues observed in international hydrogen projects or transitions?
Q2	What are the main barriers faced by energy communities or local actors to participate meaningfully in hydrogen projects?	What barriers to participation or inclusion have you seen in other countries' hydrogen transitions?
Q3	Which social groups in Greece might be excluded from hydrogen transition benefits? What could be done to enhance their visibility?	Which social groups are most at risk of exclusion in hydrogen transitions, and how has their inclusion been successfully addressed in previous projects?
Q4	How can a fair distribution of the economic and social benefits of hydrogen projects be ensured? Are there examples?	How can the benefits and burdens of hydrogen projects be distributed fairly among different stakeholders?
Q5	What technical or institutional recommendations could strengthen the hydrogen–energy justice link in the country?	Are there specific strategies or frameworks you would recommend for hydrogen policy development in Greece, particularly for Western Macedonia?
Q6	What do you consider the most critical justice issue in Western Macedonia's hydrogen transition?	What do you see as the most pressing justice challenge in hydrogen transitions internationally, and specifically for the Western Macedonian case?

For each interview process, I was looking at the background and expertise of each participant. Greek participants, including local stakeholders and practitioners, were asked questions focused on their lived experiences, perceptions of justice, and specific challenges encountered in the Greek hydrogen transition. For the non-Greek interviewees—typically international experts or comparative researchers—were engaged with questions drawing on their broader perspective, with a focus on lessons learned and justice mechanisms from other contexts.

B

List of Experts and Interviewees

Table B.1: Background information on experts and interviewees and connection with the case study

Name	Background	Involvement in the case study
Expert 1	Hydrogen Engineer Expert	-
Expert 2	Energy community co-founder	Cooperator with local energy communities
Expert 3	Policy advisor	ex-resident and Part of the research
Expert 4	University professor	ex-resident and Part of the research
Expert 5	Process Engineer	-
Expert 6	Local government	resident
Expert 7	Academic research (PhD candidate)	-
Expert 8	Energy Engineer Expert	Part of the research and resident
Expert 9	Energy Poverty expert	Cooperator with local energy communities

C

Empirical Analysis using Atlas.ti software

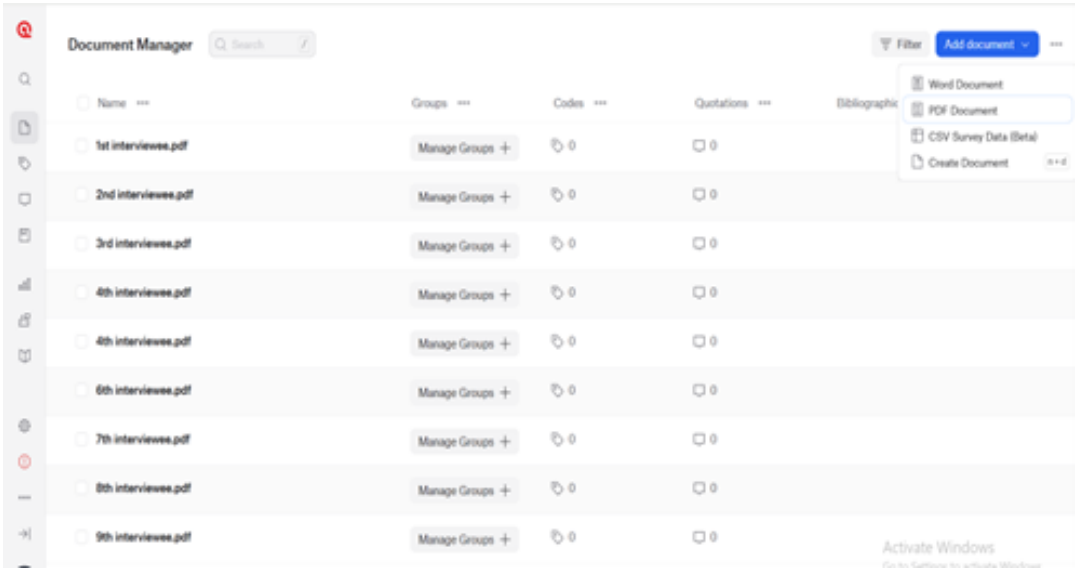

Figure C.1: Documents' manager environment. Here I uploaded the interviews transcripts to code them

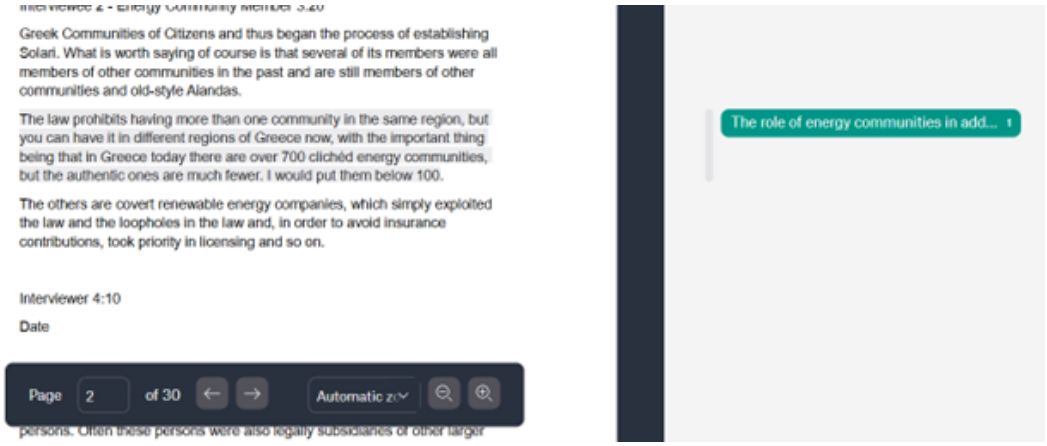

Figure C.2: Quotations' manager environment. In this stages, I attempted to collected quotes from the transcripts to refer them through the project.

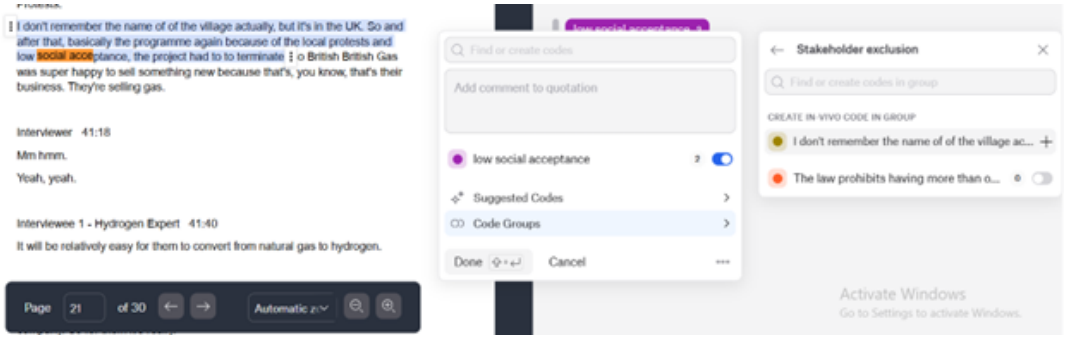

Figure C.3: Code manager environment. Through this stage, I formulated groups from the implemented codes for a more convenient way of organising and summarised the theme sections.