INSTITUTO
UNIVERSITÁRIO
DE LISBOA

The EV-PV Co-Adoption Dilemma: How EU Policy limitations impacts Portugal's Efforts to Maximize its Joint PV and EV Potential

Gil Alexandre Pereira da Rocha

Master in International Management

Supervisor:
PhD, Florinda Maria Carreira Neto Matos, Assistant Professor, Iscte-IUL

PhD, José Evaldo Geraldo Costa, Invited Assistant Researcher, Iscte-IUL

October, 2025

BUSINESS
SCHOOL

Department of Marketing, Strategy and Operations

The EV-PV Co-Adoption Dilemma: How EU Policy limitations impacts Portugal's Efforts to Maximize its Joint PV and EV Potential

Gil Alexandre Pereira da Rocha

Master in International Management

Supervisor:
PhD, Florinda Maria Carreira Neto Matos, Assistant Professor, Iscte-IUL

PhD, José Evaldo Geraldo Costa, Invited Assistant Researcher, Iscte-IUL

October, 2025

Acknowledgement

My academic journey has been nothing short of a turbulent ride, with school transfers, degree changes, a pandemic, and so much more. All part of a path that culminated in this dissertation. Ten years after first enrolling in University, I can finally say that I feel pride. In myself. In my effort. In having so many believe in me.

Doing this research was never easy, and only I know the lengths of obstacles I went through to get it done. Not all battles can be won, but when we have the right people with us, it is always worthwhile to try and fight.

First and foremost, I want to thank both Professor Florinda and Professor Evaldo. Many things could've been different in the way we progressed, but despite all challenges, they had my full support when I most needed it. The insight they gave me allowed me not only to complete work that I can feel proud of, but it also crucially showed me just how much there is to learn about anything that goes around us.

Secondly, I want to thank my family. Recent years have not been easy, but we've all come together when any of us needed it, and that was the case here. After such a difficult and long period, I can only hope that the moments we have coming bring nothing but joy.

Finally, I just want to note that I am forever grateful to all who believed in me. I wouldn't be writing this if it weren't for your relentless efforts in making me see how far I can be pushed. At this point, I can finally say that indeed, you all were right.

A huge thank you to all who have been there for me, and a particularly warm hug to all of those who shaped me into becoming who I am today.

I will always be grateful.

Resumo

Nos últimos anos, a aceleração das iniciativas de descarbonização trouxe clareza sobre como a transição crítica para sistemas de energia descarbonizados é, não só vital para o nosso ambiente, mas também para apoiar o crescimento eficiente das economias. Em países como Portugal, as duas últimas décadas mostraram que as energias renováveis melhoram significativamente a nossa competitividade. No entanto, embora o potencial solar de Portugal comece a ser explorado em larga escala, será necessária uma mudança social mais ampla para nos afastarmos das fontes de energia fóssil. Os veículos elétricos (VEs), que já fazem parte do nosso dia-a-dia, precisam de se tornar parte integrante da forma como usamos – e armazenamos – energia solar, enquanto as políticas locais e da UE realçam a importância da coadoção destas tecnologias, sugerindo que a sua sinergia não está a ser promovida da forma mais eficiente.

Para esse efeito, esta dissertação visa analisar como as políticas da UE e portuguesas estão a promover a adoção integrada de VEs e energia solar fotovoltaica (PV), identificar as barreiras existentes e propor mecanismos alternativos que podem ser usados para as superar. A investigação foi realizada através de um método de design misto, combinando o mapeamento de 18 documentos de política publicados desde 2015, com a análise temática dos seus conteúdos e uma análise qualitativa de lacunas para identificar como o *benchmarking* comparativo pode ajudar a superar essas lacunas.

Os resultados da investigação indicam que a fragmentação de políticas é uma das principais barreiras à promoção da coadoção de VE-PV, dado que a maioria dos documentos de política analisados isola os domínios dos transportes e da energia, e apenas um dos 18 documentos analisados – a Diretiva Europeia de Desempenho dos Edifícios – contém mecanismos explícitos para promover a adoção conjunta dessas tecnologias

Palavras-chave: VE, PV, V2G, integração de políticas, governação multinível, Portugal, União Europeia, transição energética, Gestão Internacional

Códigos de Classificação JEL:

- Q48: Economia da Energia > Política Governamental
- O38: Desenvolvimento Económico, Inovação > Política Governamental
- F53: Economia Internacional > Acordos Internacionais e Política

Abstract

In recent years, the acceleration of decarbonization initiatives has brought clarity on just how critical transitioning to decarbonized energy systems is, not only for our environment but to support the efficient growth of economies. In countries like Portugal, the past two decades have shown that renewable energies greatly improve our competitiveness. However, as Portugal's solar energy potential begins to be tapped at a large scale, it is clear that wider societal change will be required to continue moving away from fossil-based energy sources. Electric vehicles (EVs), which are already part of our day-to-day, need to become an integral part of the way we use – and store – solar energy, but while local and EU policies note this importance, the co-adoption rate of these technologies suggests their synergy is not being promoted in the most efficient way.

To that effect, this dissertation aims to analyse how EU and Portuguese policies are promoting the integrated adoption of EVs and solar photovoltaic (PV), identify existing barriers, and propose alternative mechanisms that can be used to overcome them. Research was done using a mixed-methods design, combining the mapping of 18 policy documents published since 2015, with the thematic analysis of their contents and a qualitative gap analysis to identify how comparative benchmarking can help overcome those gaps.

Research findings indicate that policy fragmentation is one of the key barriers to the promotion of EV-PV co-adoption, as the majority of policies analysed isolate the transport and energy domains, and only one of the 18 documents analysed – the European Performance of Buildings Directive – contains explicit mechanisms to promote joint adoption of those technologies.

Keywords: EV, PV, V2G, policy integration, multi-level governance, Portugal, European Union, energy transition, International Management

JEL Classification Codes:

- Q48: Energy Economics > Government Policy
- O38: Economic Development, Innovation > Government Policy
- F53: International Economics > International Agreements and Policy

Table of Contents

Acknowledgement iv

Resumo vi

Abstract viii

List of Tables xiii

List of Figures xiii

List of Abbreviations xv

Chapter I: Introduction 1

1.1 Contextualization 1

1.2 Problem Statement 2

1.3 Problem Statement Justification and Research Objectives 4

1.4 Research Questions 5

1.5 Dissertation Structure 5

Chapter II: Literature Review 7

2.1 Theoretical Framework: State, Markets, and Policy Co-Adoption 7

2.2 The European Union's Policy Deficit and its Implications 9

2.2.1 Historical Precedent: The failure of the Lisbon Strategy and its impacts today 9

2.2.2 Diagnosing the roots of flawed governance in European Union policy 10

2.2.3 How fragmented policy is shapes Portugal's energy transition efforts 11

2.3 Modern Interventionist Models in Clean Energy and Mobility 12

2.3.1 The United States Model: 13

2.3.2 China's 21st century strategy 13

2.4 Portugal's National Policy Context 14

2.4.1 National Energy and Climate Plan (NECP 2030) 14

2.4.2 Roadmap for Carbon Neutrality 2050 (RNC 2050) 15

2.4.3 Portugal's Recovery and Resilience Plan (PRR) 15

2.4.4 Local Legislation 16
2.5 Identifying the Research Gap 16
Chapter III: Methodology 19
3.1 Research Design 19
3.2 Analytical Framework 20
3.2.1 Policy Integration 20
3.2.2 Multi-Level Governance 21
3.3 Data Collection and Sources 21
3.4 Policy Classification 22
3.5 Analytical Procedures 23
3.6 Validation and Comparative Perspective 24
3.7 Limitations 25
Chapter IV: Research Findings and Discussion 27
4.1 Analysis Findings on European Union and Portuguese policy supporting Electric Vehicle and Solar Photovoltaic adoption 27
4.2 Policy promoting the integration of Electric Vehicles and Solar Photovoltaic 31
4.2.1 European Union's Net Zero Industry Act (NZIA) 31
4.2.2 European Union's Alternative Fuels Infrastructure Regulation (AFIR) 32
4.2.3 Portugal's Roadmap for Carbon Neutrality 2050 (RNC2050) 33
4.2.4 Portugal's Recovery and Resilience Plan (PRR) 34
4.2.5 Energy Performance of Buildings Directive (EPBD) 35
4.3 Barriers to the Co-Adoption of Electric Vehicles and Solar Photovoltaic 35
4.3.1 Technical Barriers 36
4.3.2 Economic Barriers 37
4.3.3 Governance and Policy Barriers 38
4.4 Mechanisms that reinforce integration of technologies 39
4.4.1 Norway's National Charging Strategy 39
4.4.2 Germany's Electromobility Infrastructure in Buildings Act 40
4.4.3 Community-led PV-based microgrids 41

4.5 Discussion 42

Chapter V: Conclusions, Limitations, and Recommendations 43

5.1 Main Conclusions 43

5.1.1 Existing EV-PV Policies 43

5.1.2 Policy Gaps and Fragmentation 43

5.1.3 Future Policy Decisions 44

5.2 Contributions to International Management 45

5.2.1 Navigating Multi-Level Regulation 45

5.2.2 Identifying Market Opportunities 46

5.2.3 Supply Chain Management and Geopolitical Risks 46

5.3 Limitations 46

References 49

Appendix 55

List of Tables

Table 1. *Perspectives for the evolution of installed capacity for the production of electricity using solar PV in Portugal for the 2030 horizon ……. 3*

Table 2. *EU and Portuguese Policies covering EV and PV adoption ……. 25*

List of Figures

Figure 1. *Types of Policy related to EV and PV adoption found in the researched policies and their frequency percentages relative to the total of each region's analysed policies ……. 27*

List of Abbreviations

EU	European Union
ETS	Emissions Trading System
IRA	Inflation Reduction Act
PV	Solar Photovoltaic
RES	Renewable Energy Sources
NZIA	Net-Zero Industry Act
SEA	Single European Act
EIB	European Investment Bank
OMC	Open Method of Coordination
CSR	Country-Specific Recommendations
ECFR	European Council on Foreign Relations
IEA	International Energy Agency
AFIR	Alternative Fuels Infrastructure Regulation
V2G	Vehicle-to-Grid
ETS	EU Emissions Trading System
APA	Agência Portuguesa do Ambiente
R&D+I	Research and Development plus Investigation
NVE	Norwegian Water Resources and Energy Directorate
GEIG	Electromobility Infrastructure in Buildings Act
PI	Policy integration theory
MLG	Multi-level governance
AAE	Industry Fostering Areas
ACEA	European Automobile Manufacturers' Association
ACP	Automóvel Clube de Portugal
AT	Autoridade Tributária e Aduaneira
EBF	Estatuto dos Beneficios Fiscais
EC	European Commission
EPBD	Energy Performance of Buildings Directive
EPRS	European Parliamentary Research Service
EV	Electric Vehicle

LFP	Lithium Iron Phosphate
ICCT	International Council on Clean Transportation
LBC	Lei de Bases do Clima
NECP	National Energy and Climate Plan
PRR	Recovery and Resilience Plan
RED	Renewable Energy Directive
RNC	Roadmap for Carbon Neutrality
US	United States
EEC	European Economic Community
T&E	European Federation for Transport and Environment

Chapter I: Introduction

1.1 Contextualization

Since the turn of the century, the transition away from fossil fuels has spurred much of the change and innovation we've witnessed not only in Europe but in the world. Following its tradition in economic and climate leadership, the European Union (EU) has defined a strategy to assert itself as a global leader in economic and societal transformation, ensuring that it evolves into a resource-efficient, competitive economy that is just and prosperous for the next generations (European Commission [EC], 2019). This study focuses on how an EU member state like Portugal can leverage its national policies alongside the EU's broader policy frameworks to promote the co-adoption of electric vehicles (EVs) and solar photovoltaic (PV) systems to further integrate transport and renewable energy sources (RES) to accelerate the green transition.

While in the past decades the EU has established itself as a leader in clean technologies, with strong and innovative industries around wind turbines and low carbon fuels, competition from nations like China is seriously threatening the possibility for the EU to seize the green transition's economic opportunity in its whole (Draghi, 2024). In the 2024 report on the future of European Competitiveness, Draghi points to how EU policy that promises to favour innovation ends up adding new levels of bureaucratic and regulatory burdens that create challenges for member states. These complex mechanisms at the EU level translate to member states as challenges rather than opportunities, ultimately shaping the way countries like Portugal adopt, implement, and extract value from the resulting local legislation.

According to Kleimann et. al. (2023), current headline policies like the EU Emissions Trading System (ETS) should merely be a complementary policy, as they do not address key barriers, as excessive regulation. Aiming to achieve a share of at least 42.5% of energy from RES by 2023, the EU has to more than double its current installed capacity for solar PV (Draghi, 2024), a market where China is already producing over 75% of all required components (IEA, 2023). Policy gaps like these have come to shape the policy environment for member states like Portugal, which, in seeking to align EVs and PV policies for co-adoption, finds itself navigating a market of technologies dominated by China. Such an extensive EU dependence on imported

PV and solar panel components present an additional risk to the expansion of that technology, making it even more relevant to optimize EV-PV co-adoption policies in a way that an efficient deployment of the joint technologies is fully aligned with the broader energy and technology objectives.

Looking at Portugal's case, the National Energy and Climate Plan 2030 (NECP 2030), passed in 2019, highlights the country's natural potential for using PV to meet its targets, and goes as far as identifying that the increasing penetration of EVs motivates the increased electrification of its power grid. The plan further identifies that, with recent falls in costs for PV installation, promoting the dissemination of decentralized renewable energy production methods, like energy communities, is particularly relevant to complement the central power grid in its growing usage. Despite Portugal's pursuit of both EV and PV technologies, its local legislation, aligned with EU goals, lacks integrated mechanisms that can result in missed opportunities to fully exploit its PV potential by complementing its rollout with the growing adoption of EVs with Vehicle-to-Grid (V2G) capabilities.

These gaps signal a clear research opportunity: analysing how better integrated EU and Portuguese policies can promote the joint adoption of EVs and PV, contributing to the stabilization of an increasingly decarbonized power grid with better use of RES. The following sections will elaborate on the problem statement, research objectives, and research questions designed to address this challenge.

1.2 Problem Statement

With ambitious national goals set in its 2019 NECP, Portugal expected to experience a leap in EV adoption and expansions of its renewable energy infrastructure, but while a short-sighted analysis would suggest success in following that plan, we see that the EU policy set to support the set goals comes with gaps that cascade to national-level discrepancies. In November 2024, McKinsey's Industry & Energy Transition Index for Portugal reported that while 6th overall in the share of renewables in final energy consumption in 2022, and was still excessively dependent on energy imports.

Taking a closer look at the NECP, we can see that Portugal has set itself on a path where both the exploration of its solar PV potential and using electric mobility as a means to decarbonize are crucial for meeting its climate goals. From Table 1 shown below, we see that Portugal's PV capacity was set to reach 9.0 GW by 2030, with a broader goal of sourcing 20% of energy used for transportation from renewables, aimed at the strategic goal of reducing its

energy dependency to 65% by 2030.

Table 1 *– Perspectives for the evolution of installed capacity for the production of electricity using solar PV in Portugal for the 2030 horizon*

	2020	**2025**	**2030**
Solar Photovoltaic (PV)	**2.0 GW**	**6.6 GW**	**9.0 GW**
Of which is centralized	1.5 GW	5.8 GW	7.0 GW
Of which is decentralized	0.5 GW	0.8 GW	2.0 GW

Source: *NECP2030, Portuguese Government, 2019*

According to the NECP's targets and projections, from the 2020 baseline capacity of 2.0 GW, Portugal must add 7.0 GW of new PV capacity until 2030, with centralized generation expected to cover over 77% of total PV generation by that period. This represents very ambitious growth factors of 4.67 and 4.0 for centralized and decentralized PV, respectively, with centralized PV being expected to endure most of its growth in the first 5 years, and decentralized PV in the latter period covered by the NECP 2030. Despite this, and while the NECP recognizes the need to ensure grid stability and how the use of smart charging of EVs in bi-directional flows as a distributed energy storage solution can help manage the variability of renewables, the two technologies are treated in isolation.

Because they are regulated by the EU Emissions Trading System (EU ETS), policies targeting the decarbonization of electricity generation in Portugal focus primarily on areas that are not regulated at the EU level. NECP's policies for PV, and specifically on distributing PV to individual consumers and energy communities, focus on soft promotion of the technology and education on the benefits of distributed solar. This limitation increases the risk of misalignment between Portugal's specific needs – maximizing the potential of peak solar PV generation with decentralized energy storage solutions, for which V2G-equipped EVs can be used – and increases the risk of the decarbonization of power generation bringing instability to the electrical grid. Thus, while Portugal's NECP includes stated support for the adoption of both EV and PV technologies, separation suggests limited policy coherence between energy and transport sectors, which potentially constrains the synergies of the EV-PV co-adoption scenario, and the impact is visible in Table 1, where by 2025, we see decentralized PV is significantly behind when compared to centralized PV.

1.3 Problem Statement Justification and Research Objectives

Evaluating the effectiveness of EU policy requires an analysis of how it translates to national-level legislation. Using Portugal as our base for gauging the success of that process, we can evaluate how the EU's tradition of enacting complex plans with a wide scope and non-tailored governance mechanisms is impacting Portuguese initiatives, and benchmarking non-EU policy that might be considered good practice for combating the gaps in existing policy.

Whether we look at Portugal's Recovery and Resilience Plan (PRR) or the NECP, the disconnection between EVs and PV is clear. Influenced by EU policy, Portugal's policy comes to identify many of the actions it needs to fully explore its solar PV potential, but as we see in the previous section, it ends up promoting them in separate, non-integrated legislation. This policy gap not only impacts the efficient and sustainable adoption of decarbonized energy sources but also crucially poses risks to Portugal's long-term electrical grid stability. The NECP 2030 recognizes that energy storage solutions are critical to ensure the stability of the national electrical system, identifies the need to manage demand response with smart strategies for EV charging, but falls short by limiting associated policy to the creation of legal frameworks that allow for bi-directional EV charging in charging points located in its island territories. Not only is this not a direct incentive for joint adoption of EVs and PV, but it also fails to address the electrical stability issue in the mainland, where solar PV potential is highest.

Despite finding several studies covering the electric mobility and solar energy topics, only a few adopt analyses that bridge both technologies in an integrated way. This study will aim to address that gap by developing a structured database and combining both quantitative and qualitative approaches to assess the effectiveness of EU and Portuguese policies in promoting the co-adoption of EV-PV systems. This dissertation will then set out to identify and analyse Portuguese policies towards EV-PV co-adoption, and finding in those frameworks what would need to change at the EU-level to better foster member-states to fully exploit their unique capabilities to address the climate transition in the most efficient and impactful way.

From a theoretical standpoint, this study is informed by policy integration and multi-level governance theories. Policy integration theory highlights the need for coherence and coordination across multiple domains – in this case, transport and energy policy – while multi-level governance references the interaction between national-level decision making and EU-level policies. To analyse how EV and PV policies interact in the policy mix, this study adopts an integrative perspective focused on identifying gaps, opportunities for complementariness,

and governance mechanisms that can enhance the co-adoption of EV-PV systems in Portugal and in the EU.

1.4 Research Questions

This dissertation will be providing a diagnosis of the current situation, comparing it with alternatives from other geographies, and progressing to a set of recommendations to meet the objective of using existing alternative strategies to propose adaptations to EU policy, so that it becomes more effective in boosting the member state – level implementation of policies in the green energy space, focusing particularly on the mentioned push for EV-PV co-adoption in Portugal. The research questions are as follows:

RQ1: What policies currently exist in Portugal and at EU level that promote EV adoption, PV adoption, or their integration?

RQ2: To what extent do these policies jointly encourage EV-PV co-adoption, and what barriers remain?

RQ3: What instruments or governance mechanisms could strengthen integrated EV-PV policy in Portugal, drawing on EU and international experience?

To cover these research questions directly, this study combines qualitative and quantitative approaches. Initially, a set of EU and Portugal–level policies are compiled and classified according to their promotion of solar PV and EV adoption. Then, the compiled material's relevant policies are assessed for their integration levels, and governance mechanisms with the potential to improve EV-PV co-adoption are identified. The detailed methodological framework is presented in Chapter 3.

1.5 Dissertation Structure

This dissertation is structured with five main chapters. Chapter I presents and explains the main research topic, problem statement, objectives, and research questions. Chapter II investigates relevant literature, with a particular focus on policy integration theories, EU policy, and the national policy contexts for EV and PV adoption. Chapter III concerns with methodology, and thus encompasses the mixed-methods research design, data collection, and analytical framework used. Chapter IV presents the core research findings of this dissertation, including a mapping exercise with all collected policies, an analysis of barriers to EV-PV adoption, and

benchmarking of alternative mechanisms to overcome them. The final chapter, Chapter V, includes the conclusions derived from the findings, discusses possible limitations and contributions, and provides recommendations for strengthening integrated policy

Chapter II: Literature Review

2.1 Theoretical Framework: State, Markets and Policy Co-Adoption

To inform this study, the theoretical framework will be centred around policy integration and multi-level governance theories. According to Candel & Biesbroek (2016), Policy integration theory addresses the topic of cross-cutting policy problems that require a coherent and coordinated approach across different policy domains – in this case, transportation and energy policies – while multi-level governance highlights how authority and policy-making influence are shared across different levels of government, even using the EU as an example where member-states' national decision making power slips away from them due to this sharing of governing influence (Hooghe, Marks, 2002). Used in conjunction, these two frameworks provide the basis for the conceptual understanding of how different layers of governance in the EU's policymaking processes and instruments have shaped EV and PV policies in Portugal.

The nature of industrial policy is to effectively distort market forces in a way that its natural movements are counteracted to flow to otherwise uncompetitive players (Rodrik, 2004). According to Dani Rodrik (2004), industrial policy has traditionally been used as a government-led mechanism designed to address perceived gaps in a country's economy not in a strategic, collaborative way that effectively involves non-governmental institutions, but rather one that imposes measures like public ownership and state-planned subsidies in a purely Pigouvian manner. In the context of finding ways to optimize policy to support the green energy transition and related initiatives, the analysis needs to focus not only on the outcomes – particularly because doing so for ongoing projects would be impossible – but rather on the policy design process that was applied, if public and private sectors worked together in defining priorities, and how opportunities and constraints were balanced (Rodrik, 2004). For the specific issues faced by the EU, we need to frame the contrast between its traditional "Regulatory state" model, and the "Entrepreneurial state" that characterizes some of its global rivals.

A regulatory state, as defined by Giandomenico Majone (1997), has the principal objective of correcting undesirable market occurrences like monopolies, negative externalities or an insufficient provision of goods, using essentially fiscal and monetary policy to attempt the stabilization of the underlying macroeconomic causes to those occurrences by applying rules, the cost of which will ultimately be supported by private actors. Looking at the topic of EV-PV

integration, we can see that the current EU trend of setting targets and directives in isolation, while not being equally ambitious in promoting the creation of conditions to achieve those goals, leaves member-states with fragmented options to implement in local legislation (European Automobile Manufacturers' Association [ACEA], 2024). By separating policies – like the Renewable Energy Directive (RED) and the Alternative Fuels Infrastructure Regulation (AFIR) – the EU – as a regulatory state – sets the stage for member states – like Portugal – to separate policies influenced by each initiative, translating in member states' fragmented promotion of these technologies (ACEA, 2017). The way these responsibilities are separated provide a recent example of how EU policy lacks integration, given transport and renewable energy policies are designed independently from each other, and ultimately resulting in a fragmented adoption of PV and EV technology in Portugal.

On the other hand, an entrepreneurial state model is one that rather than operating reactively and mostly via regulatory policy, opts for a more proactive approach, assuming risks to boost private sector investments that make strategic sense for the countries' long-term goals (Mazzucato, 2011). This strategy of direct government support for agencies to experiment with technology to address long term national objectives aims to bring a country to a more competitive position in a set industry through "mission-oriented policies". Mariana Mazzucato (2011) states that, in an entrepreneurial state, broad challenges that require long-term commitments such as developing strategies for a greener economy – as is the case of fostering EV-PV co-adoption – require "mission-oriented policies" that have to be co-defined by the multiple stakeholders across multiple levels of society. In the US, this was seen in the Obama-era loans to companies like Tesla, which received $465 million from the government after a process where both the company and the Department of Energy agreed on the path towards electrification of the automotive sector (Mazzucato, 2018). In Portugal's case, entrepreneurial state policy like this could be translated as "mission-oriented policies" that would co-finance V2G deployment in decentralized PV adoption in energy communities, such as having that adoption promoted and supported by financial incentives aimed at reducing the financial barriers to entry for individuals (Portuguese Government, 2019a). This example illustrates where multi-level governance would be of great importance, with EU-level directives and national initiatives interacting in a coherent way could support the effective joint adoption of complementary technologies like EVs and PV.

The dichotomy posed between these two models of economic governance is central to the aim of this dissertation. Policy co-adoption, in the context of Portugal's desired push for EV-

-PV co-adoption, implies the design of legislation that maximize not only the adoption of the technologies, but that crucially regulate and stimulate the ideal development of the supporting markets and technologies. Sustainability-related transitions typically benefit from the evaluation of policy mixes involving governments, business and researchers (Kern, Rogge, Howlett, 2019), and to achieve a synergy at this level, policies for EV and PV adoption have to move from separate, regulation-based policies to integrated frameworks where the government will, together with the private sector, define how EVs and PVs should interact to achieve a decarbonized transportation reality in the most resource and capital efficient way.

2.2 The European Union's Policy Deficit and its Implications

Historically, the EU's approach to policy design has resulted in multiple implementation failures, generally characterized by gaps between the proposed requirements of policy and the real implementation by member states (Falkner et al., 2005). Looking at policy aimed towards core long-term climate and economic ambitions, as is the NZIA, it is evident that leaving gaps to implementation of fundamental policies is commonplace in the union (Bruegel, 2024).

The Lisbon Strategy, a flagship EU project of the 21st century, can be analysed as precedent for the policy deficits we still see in modern European policy.

2.2.1 Historical Precedent: The failure of the Lisbon Strategy and its impacts today

At the beginning of the 21st century, the EU Council launched its most ambitious attempt towards creating a future-proof, knowledge-based economy that would compete with the United States, providing better jobs and sustainable economic growth while pushing for increased social cohesion and environmental protection (Rodrigues, 2009).

Given the complexity of the program, political compromises were made to avoid binding commitments and allow every member state to maintain its national sovereignty, in the form of the Open Method of Coordination (OMC), which Rodrigues (2009) noted lacked meaningful enforcement tools. By the time final assessments were being completed towards the target date of 2010, it was clear that most EU countries had failed to achieve the Lisbon Strategies' goals, with the OMC proving to lead to an ineffective, fragmented implementation of what would've been foundational pillars to the EU's sustainable growth in the new technological age (Rodrigues, 2009).

This tendency to create well motivated but weak policy in the EU is still visible in its

contemporary policy and strategic programs. In 2023, the EU published the Net-Zero Industry Act (NZIA) as a set of policies focused on supporting the clean energy transition in the EU, aiming to cover 40% of net-zero manufacturing for the EU's annual deployment needs by 2030 (European Commission, 2023a). According Kleimann et. al. (2023), the fact that the EU's primary response to the U.S. IRA's aggressive measures, is NZIA's setting of ambitious targets – such as that of having the EU cover 40% of its own clean tech needs by 2030 – while providing no meaningful financial resources or tools, is yet another example of the ineffective initiatives that have recently characterized the EU.

This pattern of enacting policy that will "cost nothing and achieve nothing" is by now a symptom of the EU's wider issues in reaching consensus among its member states, just as has happened in 2022 when some EU countries pressured the commission to implement Gas price caps, but to keep the remaining member states satisfied that the price cap wouldn't be counterproductive, the commission preferred to design a price cap mechanism so complex it would rarely be activated, instead of reconciling both sides or even just taking a firm stance supporting only one of the paths forward (Bruegel, 2024). Such mechanisms are resulting today in the lack of effective measures to support the ambitious targets EU countries are setting, and using the example of Portugal's set goals to expand synergies in decarbonizing its power grid, the lack of policy instruments that support those specific initiatives greatly increase the risk of missing the opportunity of EV-PV synergies.

2.2.2 Diagnosing the roots of flawed governance in European Union policy

On the 2011 European Semester cycle, Zeitlin and Vanhercke (2018) write that excessive prescription of a unified, single supra-national policy for such core and strategic reforms did not leave enough space for national ownership of the implementation process. Further issues with this top-down approach to policy making arose when reviewing the 2020 goals for poverty rate reduction, with some member states pushing back on the targets, and the EU Commission acknowledging that early in the strategy implementation that programmed efforts were insufficient to achieve EU-wide goals (Zeitlin, Vanhercke, 2018).

In this process of reviewing member states' performance in reform programs, fiscal and social policies, the 2011 European Semester delivered Country-Specific Recommendations (CSRs) that included enforcement capabilities (Zeitlin, Vanhercke, 2018). But while the CSRs and their underlying enforcement mechanisms provide a powerful structure to, in theory, balance the non-binding nature of EU recommendations, Zeitlin and Vanhercke (2018) do note

that for these were integrated as a governance instrument, no real enforcement sanctions have been applied to occurrences of non-compliance in member states.

But while this failure to apply enforcement mechanisms may initially appear as a result of oversight, its consistency signals that the implementation gap might be a result of policy design itself. EU policy is designed to meet the compromises pushed by its member states, with agreements coming from negotiated settlements focused on specific national-level limitations rather than unified, coherent policies aimed at long-term objectives (Saurugger, Terpan, 2016). This state-centric approach has clearly translated to EU policy influencing the EV-PV adoption scenario, since there are multiple isolated frameworks where these are promoted, but not in a joint, unified way.

2.2.3 How fragmented policy is shapes Portugal's energy transition efforts

As we've seen in the problem statement, RES adoption in the Portuguese power grid and EV adoption are occurring at very different speeds.

When we look at current incentives for EV adoption in Portugal, we see in the NECP that policies are centred on direct incentives for acquisition, and indirect incentives like road tax exemptions. If we compare these with the frameworks included in the EU's Alternative Fuels Infrastructure Regulation (AFIR), we see that Portugal's incentives are aligned with the EU: using direct incentives for the purchase of alternative fuel vehicles, providing tax incentives to promote usage of those vehicles are policies originated in EU alternative fuels legislation (Portuguese Government, 2019a). Evidence of this narrow focus in policy design becomes more apparent when we look at the NECP's mentions of promoting integration of smart vehicle charging in smart, bi-directional energy networks, which again is a direct transposition of AFIR's measures to promote solutions to lower energy costs. At no point in either of these policies – at the Portugal level, or the EU proposals it bases itself on – do we see any mention of measures that offer the same level of direct incentivization of joint RES and alternative fuel vehicle adoption.

Focusing on PV incentives, we can see why EV adoption is moving faster than renewables' expansion in Portugal. Following the binding legislation enacted by the EU Commission in the Renewable Energy Directive (RED) of 2023, PV energy is considered critical for increasing the resilience of the energy system, there is no single direct incentive – like there is for EV adoption – for stimulating the expansion of PV. Instead, the RED, in its articles, opts to define simplified permit procedures and similar indirect policies for PV adoption, and goes as far as

stating that support schemes and financial instruments to that effect are to be particular of each member state (European Commission, 2023b). A result of this is that, in the NECP, Portugal promotes PV adoption with indirect policy like property tax incentives for introducing renewables in buildings (Portuguese Government, 2019a). This discrepancy in how EVs and PV are promoted once again shows how disconnected these two technologies are, despite apparent mentions of their benefits being mentioned in both local and EU legislation.

The lack of joint frameworks for EV-PV co-adoption can also be linked with the very way core packages like the European Green Deal are structured. By affecting RES and clean transport separately, this wide-ranging legislation was drafted by the EU Commission with siloed directives with minimal overlap (Kappe, Mikaelsson, Krustok, 2024), and thus with the transposition and interpretation of RED and AFIR frameworks in member states' local policies – like Portugal's NECP – EV and PV policies remain fragmented (SolarPower Europe, E-Mobility Europe, 2025).

2.3 Modern Interventionist Models in Clean Energy and Mobility

In recent years, the world has been going through major changes in the status of globalization, with geoeconomic competition being by now a well-established reality that has been pushing market-based economics in new ways (European Council on Foreign Relations [ECFR], 2012).

In the case of clean energy, the International Energy Agency (IEA) has reported in 2022 (IEA, 2022a) that due to the scale and ambition of the green energy transition, some energy importing regions, as is the case of the EU which from 2017 to 2022 imported over 84% of its installed solar PV modules, are particularly vulnerable to external shocks. Energy security in these cases can be greatly improved by direct local investment in these key goods, as diversifying green technology would improve resilience in the event of disruptions (IEA, 2022a). These conditions, as noted by Mariana Mazzucato (2021), make a mission-oriented, state-controlled approach ideal, signalling the need to move away from pure regulatory policy models in green energy topics. Still, following its trend to avoid effective imposition of universal goals to its member states, even in the particularly challenging times since 2020, the EU Commission moves forward with policy that is structurally weak and lacks the direct funding schemes its international counterparts support (Draghi, 2024). When placed side by side with the US IRA, the EU's strategy for green energy remains overly reliant on bureaucracy and EU's common methodology of repurposing funds tied to complex, ambitious targets rather than providing simpler, wider-range subsidies (Kleimann et. al., 2023).

To better understand the success and scale of recent interventionist models of policymaking, and aiming to extract potential alternative paths to policy that could help guide Portugal in expanding green technologies, we can look at the US's strategy on innovation and incentivization of new technologies, as well as China's focused long-term plans for geopolitical relevance and sustained growth.

2.3.1 The United States Model:

Contrasting with a key policy gap identified in Portugal's EU-based NECP, we can look at the U.S. Inflation Reduction Act (IRA) of 2022 (United States Congress, 2022). In fact, compared to the IRA, EU policies like NZIA present a less streamlined approach, that does not match the IRA's financial support and simplified approach to subsidization (Dekeyrel, Riekeles, Świeboda, 2025), with IRA policy examples such as:

- Combining different policy domains by including both PV and EVs in a single legislative package that identifies competitive gains in their adoption.
- Allowing for co-adoption with independent direct incentives to EVs and PV in one unified legislation package.
- Loosening the criteria for bi-directional charging by allowing V2G equipped EVs to be used as energy storage infrastructure, simplifying their eligibility for energy storage incentives.

Comparing these measures directly with the EU's response to the IRA – like the NZIA, that is transposed in its member states' legislation – we can see that not only is its policy a fragmented mix of measures that lack the level of funding found in the IRA, the EU maintains a gap in its ability to mitigate the additional load created by increasing EV charging with grid-stabilizing energy storage solutions – like V2G and bi-directional charging (European Federation for Transport and Environment [T&E], 2023).

2.3.2 China's 21st century strategy

Looking on other external challenges, the EU's fragmented policy design, specifically on initiatives affecting the green transition, may pose industrial challenges. China's interventionist policies allow the state to control industries that are key to the green tech supply chain (Draghi, 2024). Related to PV and EVs, this control can be seen in these examples:

- China has achieved a never-before-seen control over the solar PV supply chain, with over 80% of that technologies' manufacturing stages controlled by the country (IEA, 2022a).
- With near total vertical integration of the batteries and EV supply chains, China concentrates nearly 90% of global battery production (anodes and cathodes), virtually 100% of Lithium Iron Phosphate (LFP) battery production, and sees BYD as the global best-selling EV brand (IEA, 2024).

For Europe – and Portugal – the key takeaway is how critical China's dominance in EVs, batteries and the solar PV supply chain can be in the medium term. By separating policies for these technologies, the EU does not incentivize their local development equally. With member-states like Portugal wanting to maximize their RES potential, and without a coherent, coordinated EU strategy for the joint integration of EVs and PV, a critical dependence on China may be created (Draghi, 2024).

2.4 Portugal's National Policy Context

In alignment with the broader EU's passing of RES and climate neutrality legislation in recent years, Portugal has at a national level been implementing its own implementation of those policies.

2.4.1 National Energy and Climate Plan (NECP 2030)

As was covered in previous sections, the NECP documentation establishes concrete action towards energy and climate goals set for 2030. This plan includes specific measures for increasing renewables' share of total power production, including laws that promote self-consumption and the formation of energy communities, while also promoting EVs via direct incentives, or tax breaks for companies that electrify their fleets (Portuguese Government, 2019a).

Narrowing down our scope on the charging of EVs, the NECP 2030 specifies measures to promote private installation of EV charging points in residential buildings, and even mandates their installation in some commercial and public access locations, but on the topic of bi-directional charging, mentions only the possible advantages of the technology in the limited scope of the Portuguese island territories, due to their limited power grid, without creating any objective legal framework that promotes the technology. Even when considering that Portugal

explores smart integrations like V2G to address grid resilience and integration with renewables during peak PV generation periods, the lack of clear regulation limits scaling of these technologies (Anari Energy, 2024).

2.4.2 Roadmap for Carbon Neutrality 2050 (RNC 2050)

The Portuguese Roadmap for Carbon Neutrality 2050 (Portuguese Government, 2019b) was passed in 2019 with multiple references to policy and regulation towards promoting RES, EVs, electrification and energy infrastructure changes (Portuguese Government, 2019b).

This roadmap establishes that by 2050, Portugal must be consuming 80% of energy sourced from endogenous and RES, of which wind and PV represent two thirds of renewable power sources. For this, the RNC 2050 includes policy directives focused on decentralized solar PV expansion among private producers/consumers as a cost-effective way of achieving the plans' targets, and further aligns that with objectives for consumers and small producers of RES to represent over 20% of total power production by 2050.

As for EVs however, the RNC 2050 includes them in the overall electrification topic, and – like the NECP – aims to promote decarbonization of the transportation sector via direct and indirect incentives to private and public fleet renewal with EVs and other zero-emissions technologies. Unlike what can be said for the NECP 2030 however, the RNC 2050 is a long-term strategy that does not include specific promotion initiatives, with only the NECP 2030 implementation relaying to the relevance of promoting and supporting electric mobility, as well as the flexibility EVs offer for energy storage. (Agência Portuguesa do Ambiente [APA], 2024).

2.4.3 Portugal's Recovery and Resilience Plan (PRR)

In response to the Covid-19 pandemic, the EU created grants to support its member states in accelerating their economies with measures that included climate transition, decarbonization and energy efficiency through the Recovery and Resilience Facility (European Parliamentary Research Service (EPRS), 2025). Portugal implemented its recovery strategy through the PRR.

On the topic of energy, the PRR makes extensive references to Portugal's goals for climate neutrality by 2050, and aligns many policies and objectives with 2019's NECP 2030 (IEA, 2021a). Expanding on this policy alignment, the IEA (2021a) notes that the expansion of EV charging infrastructure, creation of energy communities and the development of smart, bi-directional charging systems are included in this updated Portuguese policy, expanding on detailed, specific initiatives to increase share of RES in its island. Despite this, besides mentioning the integration of batteries to maximize the advantages of RES in Madeira and the

Azores, there is like in the NECP – and overall EU policy on the green transition – no promotion of the co-adoption of EVs and PV.

2.4.4 Local Legislation

When looking at recent municipal-level legislation and policies, the green energy promotion is also common, particularly in the improvement of buildings and the expansion of EV adoption in Portuguese cities.

EVs are passively promoted in cities with indirect measures like Lisbon's EMEL "Dístico Verde" that makes any EV eligible for unlimited parking in any of the city's municipally managed limited parking areas through a fixed annual fee, and in other locations are typically allowed free parking during charging in any public charging location (Automóvel Clube de Portugal [ACP], 2024).

As for the integration of PV in residences and other buildings, the national Statute for Fiscal Benefits (EBF) – which can be adopted by municipal legislation – includes articles that stipulate property tax benefits for buildings that are improved with the integration of RES production equipment, but makes no specific mention of either PV or even, despite the integration of further tax benefits for improved energy efficiency in buildings, the integration of V2G equipped vehicles in homes or businesses is never mentioned (Portuguese Government, 2019c) – unlike what we've seen previously in the US IRA's policies.

2.5 Identifying the Research Gap

By covering the links between EU and Portugal's policy and benchmarking it with the alternative realities observed in other states with similar climate goals, the literature review confirms that a gap exists between current policy and Portugal's objectives of supporting its power grid decarbonization efforts with decentralized energy storage and production strategies (Amaral & Pedro, 2024).

To clearly diagnose the study object, RQ1 will be addressed by a policy mapping exercise aimed at displaying the main existing frameworks that support EVs and/or PVs, both at a local – Portugal – and EU level. This will highlight how these technologies are treated separately in these regions.

Moving to the actual policy gaps, RQ2's answer will be searched via highlighting the "vacuums" where co-adoption initiatives could be present in existing policies, and supporting

the identification of those gaps with the existence of more direct incentives to other technologies – or even to EVs and PVs in isolation – in those same policy frameworks.

Finally, to cover the recommendations' aspect presented by RQ3, a brief comparison will be made between Portugal's isolated approach to the EV-PV co-adoption and mechanisms existing in other countries' mechanisms, to identify directly transferrable policies that would mitigate the gaps previously identified in a way that is viable to address Portugal's energy security objectives.

Chapter III: Methodology

To better understand how this dissertation's study was conducted, the Methodology chapter outlines the methodological framework used to find answers to the research questions. Initially, the research design is detailed, explaining the use of multiple methods within a comparative case study approach. After this, the analytical framework and its underlying concepts and theories are presented. Data collection and policy classification procedures are detailed further along this chapter, which then is concluded by a presentation of the validation methods and possible limitations of the study.

3.1 Research Design

To analyse this study and answer the research questions, a mixed-methods research design (Creswell & Clark, 2018) was used, as to analyse both a qualitative and quantitative approach to address the research questions defined. Because the research questions proposed require more than one data source to find relevant answers, and since require a holistic approach to provide a more complete understanding of the topics, Creswell & Clarke's (2018) proposed combined use of quantitative and qualitative data allows for one method's strengths to mitigate the other's limitations. Since this study focuses on EU's policy implications at the member-state level in the EV-PV co-adoption topic for Portugal, the structuring as a comparative case study allows for the evaluation of the real-world implications of said policies.

The research was executed in distinct phases, and aligned to the core objectives of the dissertations and the defined research questions:

1. Policy mapping and collection: To know what policy documents should be reviewed, the initial phase of the research was comprised of a collection of recent (post 2015) policy documents from Portugal and the EU. These included active legislation, regulation and strategic plans authored either at the EU level, or by official Portuguese authorities. At this stage, collected documents were classified by their source (Portugal or EU), and on whether they contained relevant content to either PV, EV or the joint PV-EV topic.
2. Policy Classification and Analysis: Once listed and classified by source and topics, the collected policy documents were systematically analysed and classified to build a structured database, adapted to Table 2 (Chapter 4) and included in full in Appendix 1.

The classification parameters were guided by a thematic analysis of each policy to identify and categorize specific promotion mechanisms. The final classification criteria used are:

- Policy origin (EU or Portugal)
- Technologies promoted (EV, PV or their joint adoption)
- Included policy types (Direct incentives, indirect incentives, promotion of support infrastructure, economic policies, environmental policies and R&D+I promotion)

These classification parameters allow for quantitative analyses, as is the frequency graph in Figure 1 (Chapter 4) that help identify the existing gaps in policy types, and where (Portugal or EU) they are more common. This supports the qualitative analysis that is then used for determining the barriers that limit EV-PV co-adoption in Portugal.

3. Comparative benchmarking: The last stage of research consisted of finding basis for comparison of policy with cases that were not part of the initial assessment. By looking at specific examples from other countries and/or geographies, it is possible to analyse and compare those with EU and Portugal's examples, and benchmark them as possible alternatives to the barriers posed – and not overcome – by the collected list of Portuguese and EU policies.

3.2 Analytical Framework

3.2.1 Policy Integration

Policy integration theory (PI) seeks to analyse how distinct elements come together to define a single conception that is integrated policy (Candel & Biesbroek, 2016). To analyse these policies, Candel & Biesbroek (2016) propose that these documents are reviewed on four key dimensions: their understanding of the problem, the level of involvement across different policy domains, the coherence of policy goals and the consistency of policy instruments.

For the case of this dissertation, since the policy research covers the distinct policy domains of energy and transportation (PV and EVs), Candel & Biesbroek's (2016) approach is well suited. Furthermore, the four mechanisms proposed by this theory for evaluating policy integration provide a structured methodology for the cross-comparison of policies, allowing namely for the assessment of incoherence between policy goals and identification of inconsistent policy instruments across the analysed documents.

Ultimately, PI's definition provides a solid base to direct the analysis of policies collected

in the scope of this research, and the dimensions it uses to assess integration allow for a clear identification of policy gaps and other instances of policy fragmentation.

3.2.2 Multi-Level Governance

Multi-level governance (MLG) is defined by Hooghe & Marks (2002) as a theoretical framework for describing the ways central states allocate authority across levels of government. This theory originates from the observation of changes in formal authority from state-level towards increasingly dispersed institutions and goes as far as defining a specific type of governance model (Type I) for the EU's reality of governing in a stable system of limited jurisdictional levels from supranational institutions to subnational governments.

Focusing on the case of this dissertation, the very analysis of policy gaps between policies that are defined at different governance levels (Portugal and the EU) is sufficient to find alignment with MLG. This dissertation's analysis effectively looks at the relationship between policies at two levels (supranational – EU legislation – and subnational – Portuguese local implementation), and actively seeks to validate the existence of gaps among them.

As it provides the context for finding at which levels policy integration may fail, MLG, together with PI, ultimately allows this dissertation to affirm that the sharing of governing influence across multiple levels creates governance gaps that, when ineffectively managed, facilitate the occurrence of policy fragmentation.

3.3 Data Collection and Sources

To ensure the quality and relevance of the analysis, the data collection for this dissertation consisted only of a systematic gathering of content from high-quality sources, prioritizing mainly official documentation, specialized industry analysis and relevant academic theory. This Scoping review method (Pollock et. al. 2024) is justified as it allows for the systematic identification of contexts, sources and concepts relevant to the research. Pollock et. al. (2024) further argue that scoping reviews are ideal for exploring broad topics – as is the case of public policy and its implications – as it allows for the transparent review of heterogeneous evidence in a way that aligns with both future analysis and decision-making needs.

As such, the primary data set – used for the policy database – consists of official policy documents, all from governmental sources or governmental institutes. On the EU level, policies collected are the European Green Deal, Net-Zero Industry Act, Renewable Energy Directive,

Alternative Fuels Infrastructure Regulation, REPowerEU, Energy Performance of Buildings Directive and the Social Climate Fund. As for policies originated in Portugal, examples collected are the National Energy and Climate Plan 2030, the Roadmap for Carbon Neutrality 2050, the Portuguese Recovery and Resilience Plan, the *Estatuto dos Benefícios Fiscais*, *Recuperar Portugal*'s REPowerEU-related Chapter, *Fundo Ambiental* policy on green mobility, the Program for Support of Sustainable Buildings 2023, the city of Porto's pact for the climate, the city of Braga's municipal program for addressing energy poverty, and the *Lei de Bases do Clima*.

From these sources, quantitative data was reviewed to extract quantifiable variables derived from each document's systematic classification, which include quantifying the number of policies promoting EVs, PV or their co-adoption and the mapping the presence of policies containing each type of promotion mechanism, based on the policy classification process outlined in section 3.4.

To give context on the topic of this dissertation, and to allow for a better understanding of the reality where these policies fit, research also includes reports and analyses from reputed subject matter experts and specialized institutions. As such, and as is mostly found in Chapter 2, insights like strategic and quantitative data from the IEA, economic analysis from EU-based think tanks like Bruegel, and industry analysis reports from sources like McKinsey were combined in a systematic way. Other high-level reports, such as Mario Draghi's 2024 report on European Competitiveness were also key to frame the current context of EU policy around the green energy transition.

Finally, this dissertation's theoretical and analytic frameworks base themselves on varied sources of relevant academic material. Work from prominent academic authors like Mariana Mazzucato and Dani Rodrik, for example, are combined with peer-reviewed articles providing context and relevant examples that come together to validate the findings of this dissertation.

3.4 Policy Classification

To systematize the data collected, the selected policy documents were subjected to a classification using thematic analysis (Braun & Clarke, 2006) to break down each policy document and classify it according to a set of criteria. According to Braun & Clarke (2006) methodology enables the identification and organization of patterns in a dataset, and in our context that translates to the identification of recurring shared characteristics in policies

promoted. This resulted in the table in Appendix 1, which shows collected policies categorized by the following characteristics:

- Policy origin (EU or Portugal)
- Technologies promoted (EV, PV or their joint adoption)

The second layer of analysis and classification involved a more granular analysis of policy contents, as the intention was to identify what specific methods of promotion were present in each policy. This classification, which was used for the analysis in Fig. 1 (Chapter 4), considers the following categories:

- Direct incentives
- Indirect incentives
- Promotion of support infrastructure
- Economic policies
- Environmental policies
- R&D+I promotion

Using this two-layer approach to policy classification allowed for the creation of a more robust database, where patterns can be more easily identified, and that simplify the crossed-analysis between Portuguese and EU priorities.

3.5 Analytical Procedures

To ensure a comprehensive and systematic analysis of the policies collected, the data was viewed in sequential scopes directed towards the full exploration of the data provided by the table in Appendix 1, and aimed at exploring the topics raised by the three research questions.

As a starting point, the policies classified with the criteria detailed in section 3.4 were subject to a quantitative frequency analysis. The inclusion of this quantitative view produces count-based data sourced from the direct analysis done on the collected sources, rather than external data, and its extraction is detailed in section 3.3. This involved calculating the inclusion rate of the six policy types for both EU and Portuguese-originated policies, producing the data that underlines the graph in Fig. 1 (Chapter 4). With this, discrepancies in the strategic focus of thetwo policy groups, such as Portugal's relative de-prioritization of support infrastructure when compared with the EU, become clear.

After that, to address the specific requirements of RQ1 and RQ2, a qualitative gap analysis,

focused on the ‘co-adoption’ value of the ‘Technologies promoted’ category, was done on the policy database (Appendix 1). The main metric used for this was the presence, or absence, of clear and actionable promotion of mechanisms that support the EV-PV co-adoption. Doing this, it was possible to identify the overall lack of those mechanisms, which aligns with findings from the literary review, and that were systematized in groups of barriers to EV-PV co-adoption.

Finally, and to address RQ3, international examples were identified and subject to a process of comparative benchmarking analysis. This was done to allow for the identification of specific governance mechanisms and policy instruments, applied in policies not included in the collected list of EU and Portuguese policies, that could be adapted into EU and Portuguese policies to address the policy gaps previously identified.

3.6 Validation and Comparative Perspective

To ensure the analysis of the collected policies is accurate, the classification of policies in the database (section 3.4) was done by a multi-step thematic classification process. This consisted on cross-referencing the classified policy documents with their own stated policy objectives, promotion methods and legislation proposals, which ensures the classification exercise is not subjective and helps to minimize any pre-existing bias.

Following this initial step, the analysis was reinforced with a comparison exercise between the findings collected from reviewing the primary policy documentation with the secondary sources (listed in section 3.3). By comparing policy goals and mechanisms with reports from reputed sources and academic material, conclusions on policy gaps and their impact on the EV-PV co-adoption topic are better sustained and become more complete, which is critical for the exercise of seeking to mitigate said gaps.

Lastly, and focusing on the scenario where the issues found can be avoided or reduced using currently implemented alternatives, specific benchmarks from leading countries in the green transition (Norway) or that simply have enacted policy that differs from the patterns identified in the collected EU and Portuguese examples were collected and cross-analysed with the aim of tackling the EV-PV issue. Doing this allowed for the identification of specific and actionable policies that address topics that are currently left unmanaged by Portuguese policy, and because these alternatives are real policies with demonstrated results, it can be argued that the existing gaps should not be taken as given limitations on the overarching policies for promoting the green transition.

3.7 Limitations

Despite basing itself on quality data, classified and analysed through structured methods and supported in well-established theories and concepts, this dissertation's analysis of EV-PV co-adoption policy gaps still faces some limitations.

A primary limitation stands at the scope of the dataset. The sample of 18 Portuguese and EU policies only includes documents published after 2015, and is not exhaustive enough to ensure every regulation with impact to EV-PV co-adoption is included. As a result of this, it must be considered that the identified patterns of policy fragmentation may in reality be different, since less available, or more local policies may not have been considered in the analysis altogether. Still relating to the data collection method, the eligibility of sources was intentionally restricted to consider only publicly available policy documentation, academic articles and expert reports. This restricts this study's ability to explain the detail behind the decisions taken in defining policies and their mechanisms.

Besides this, there is a final limitation on the timeframe for policy collection. Because only policies passed after 2015 were considered, and given the delays between implementation and full policy results being visible, it is likely that some gaps – or policies – could have been considered ineffective before the full results of its implementation are visible. This means that some of the findings could be negated by the impacts of future implementations of the policies analysed, or even by future legislation that replaces them.

Chapter IV: Research Findings and Discussion

4.1 Analysis Findings on European Union and Portuguese policy supporting Electric Vehicle and Solar Photovoltaic adoption

The policy data collected to support the findings related to answering this dissertation's research questions amounts to a list of policies that cover the promotion of EV and PV technologies. These policies were analysed to find which ones promote each technology – EVs, PV, both or their joint adoption – and through which types of policy that promotion is done.

Table 2 *– EU and Portuguese Policies covering EV and PV adoption*

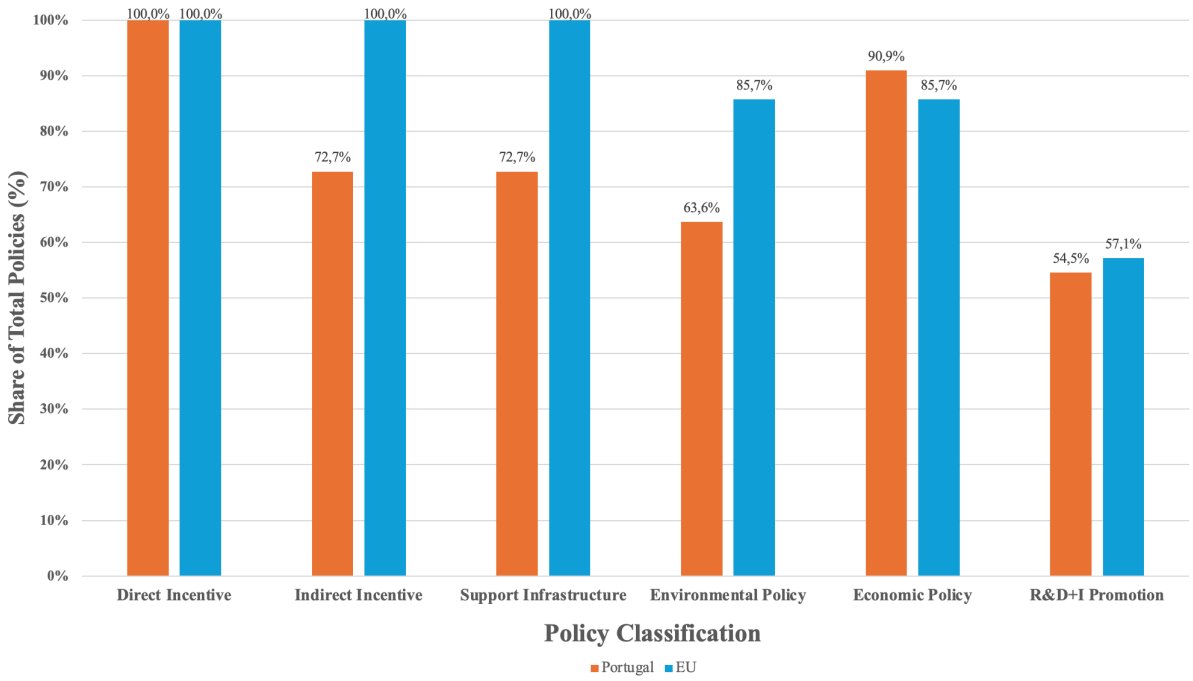
Policy	Policy Origin	Technologies Promoted	Co-adoption?	Reference
National Energy and Climate Plan (NECP 2030)	Portugal	PV and EV	No	Portuguese Government, 2019a
Roadmap for Carbon Neutrality 2050 (RNC 2050)	Portugal	PV and EV	No	Portuguese Government, 2019b
Recovery and Resilience Plan (PRR)	Portugal	PV and EV	No	Portuguese Government, 2021a
Estatuto dos Benefícios Fiscais (EBF)	Portugal	PV	No	Portuguese Government, 2019c
Recuperar Portugal – REPowerEU Chapter	Portugal	PV and EV	No	Portuguese Government, 2024a
Fundo Ambiental - Mobilidade Verde - Passageiros	Portugal	EV	No	Portuguese Government, 2025

Programa de Apoio a Edifícios mais Sustentáveis 2023	Portugal	PV	No	Portuguese Government, 2024b
DL nº15/2022 (Legal Framework for Self-Consumption)	Portugal	PV and EV	No	Portuguese Government, 2022
Lei de Bases do Clima (LBC) - Lei n.º 98/2021, 31/12	Portugal	PV and EV	No	Portuguese Government, 2021b
REPowerEU	EU	PV and EV	No	European Commission, 2022
European Green Deal	EU	EV	No	European Commission, 2019
Energy Performance of Buildings Directive (EPBD)	EU	PV and EV	Yes	European Commission, 2024b
Renewable Energy Directive	EU	PV and EV	No	European Commission, 2023d
Alternative Fuels Infrastructure Regulation (AFIR)	EU	PV	No	European Commission, 2023c
Net-Zero Industry Act (NZIA)	EU	PV and EV	No	European Commission, 2024a
Social Climate Fund	EU	PV and EV	No	European Commission, 2023e
Pacto do Porto para o Clima	Portugal	PV and EV	No	*Municipio do Porto*, 2025

Programa Municipal de Combate à Pobreza Energética	Portugal	PV	No	*Municipio de Braga*, 2023

Of these policies, we can see from Table 2 that 7 are EU originated, with the remaining 11 policies relating to Portuguese government – or municipal government – origin. The policies mentioned were then further analysed to understand the mechanisms through which PV and EVs were promoted, looking specifically for direct incentives, indirect incentives, promotion of support infrastructure, environmental policies, economic policies, and the promotion of Research and Development plus Investigation (R&D+I). Fig. 1 shows a representation of the cumulative share of these types of promotion mechanisms in both EU and Portuguese policies:

Figure 1 *– Types of Policy related to EV and PV adoption found in the researched policies and their frequency percentages relative to the total of each region's analysed policies. Elaborated by the author, using data compiled in Appendix 1*



In Fig. 1, we can see that while the types of policy considered are similarly preferred by both the EU and Portugal, their inclusion rates differ between the regions. Both Portugal and the EU show a clear preference for direct incentives, included in 100% of the analysed policies. Data also shows that the indirect incentives and support infrastructure promotion are present on

100% of EU-originated policies, but not for Portuguese ones – merely 72% of these include those types of incentives. Further discrepancies between the two regions' included policy types occur in the environmental policies – where the EU includes them in 85% of all analysed initiatives, versus only 63% for Portugal. Regarding economic policy and R&D+I promotion, the frequencies stand at 90% and 85% for the first, with the latter at 54% and 57% for Portugal and the EU, respectively, with the small variation indicating alignment in the focus both regions have in these types of policies. Looking at the overall inclusion rates of the policy types in both regions' initiatives, it is of note that the EU supports direct and indirect policies at the same level as it promotes support infrastructure, but Portugal emphasizes economic policy more strongly than indirect incentives or support infrastructure, as shown by the higher inclusion rate in Fig. 1. While this signals the country might be more focused on overcoming foundational shortcomings in its economy's ability to support parts of the green transition, the apparent de-prioritization of support infrastructure promotion might hint at short-term limitations in its capacity to scale key technologies like PV and EV, particularly in conjunction. Expanding on these limitations, Draghi (2024) mentions that clean and renewable technologies' adoption by EU member states is currently limited by multiple factors, like:

- Skill shortages: Particularly at the municipal level, 69% of EU municipalities report lack of knowledge related to environmental and climate assessments, key to accelerate the permitting process.
- Regulatory barriers: Uncertain permitting processes that create large variations in adoption speed across member-states (i.e. PV installations can be approved in 1 year in one country, but take up to 4 years in another).
- Limited financing: 43% of small EU companies in the clean tech sector indicate lack of financing options as an obstacle to their growth, reflecting the EU's gap in manufacturing financing grants vs the US (i.e. the IRA is five to ten times more generous in financing for clean tech manufacturing than the EU).

These constraints act as bottlenecks that influence each member state differently, and looking at Portugal's policy discrepancies versus the EU, it becomes clear that with limited financial capacity the country has to choose what to prioritize. Further detail on the types of policy included in each of the analysed initiatives is included in Appendix 1, found in the appendix.

For the purpose of this dissertation, it is relevant to find the ways through which existing

policy promotes EVs and PV adoption. By classifying the selected policies by the type of technologies promoted – PV, EV, both or their joint adoption – as well as the ways through which that promotion occurs, the focus of each of the research questions proposed can be narrowed down into a more focused dataset. Having established the comparative landscape of policy mechanisms, we now turn to the specific research questions.

4.2 Policy promoting the integration of Electric Vehicles and Solar Photovoltaic

RQ#1 "What policies currently exist in Portugal and at the EU level that promote EV adoption, PV adoption, or their integration?".

On Table 2, we can immediately state that from a wide range of policies promoting PV and EV technologies, only one of 18 contains explicit and actionable provisions supporting the integrated adoption of both technologies: the EU's Energy Performance of Buildings Directive (EPBD). By the classification parameters used for categorizing the policies covered in this dissertation, the EPBD includes all policy types, except R&D+I promotion. This suggests that while the EPBD is comprehensive in its approach to integration, it may rely on other instruments to support innovation and technological development.

Furthermore, Table 2 reveals that only 4 of the 18 policies analysed don't include some form of EV promotion, while PV promotion is more evenly distributed. To better understand the unique positioning of the EPBD, this section will examine two key policies from both the EU and Portugal. The aim is to identify the specific mechanisms that enable the EPBD to support joint adoption, and to assess whether similar integration strategies are present in other initiatives.

4.2.1 European Union's Net Zero Industry Act (NZIA)

The NZIA is a EU policy designed to scale up clean technologies and enhance sustainability in the EU's transition to a net-zero economy. Its primary goal is to make the EU sustainable in the net-zero space, and sets policy for PV manufacturing and for supporting EVs and smart EV charging technology.

On PV promotion, the NZIA includes initiatives like Article 28, which aims to award financial compensation – direct incentives – towards individuals or companies that improve

their homes and/or buildings with net-zero devices that reinforce their energy resilience and sustainability. This measure also lays down criteria for additional financial compensation to eligible citizens living in energy poverty – thereby being an example of economic policy. The NZIA also includes initiatives for expanding the deployment of rooftop solar PV, like Recital 79. Here, the document mentions how national programs should direct their support funds towards local initiatives that focus on rooftop solar PV, calling for direct incentives towards this goal.

Moving to EVs, being mostly an industrial policy document, the NZIA directs most of its EV-related efforts to economic policy, such as streamlining permits for electric charging and propulsion factories (outlined in Chapter II). This reflects an effort to reduce administrative barriers and accelerate industrial deployment of EV-related infrastructure. The NZIA also promotes R&D+I through measures like Article 33, which promotes the creation of specific "net-zero regulatory sandboxes" to foster innovation in electric charging and propulsion technologies. On the EV-PV topic that concerns this dissertation, the NZIA's most pertinent contribution to EV-PV integration is a limited reference to the need for substantial transformation in the EU's power distribution infrastructure. For this, one of the proposed areas of focus of the document is the integration of EV's with smart charging equipment, as a means of managing the power grid from the demand side. Despite this mention, the NZIA does not specify how this can be promoted in any way, nor does it link smart EV charging with PV. So, despite its broad scope, the NZIA does not provide concrete mechanisms for the integrated deployment of EVs and PV systems.

4.2.2 European Union's Alternative Fuels Infrastructure Regulation (AFIR)

The AFIR establishes mandatory EU targets for deployment of specific alternative fuels. It aims to ensure dense and reliable networks for public EV charging, connected to a renewable-backed power grid.

The policy includes various articles that are mainly concerned with the way zero-emission transport fleets are powered, with a great focus on ensuring renewables' penetration in EV charging infrastructure is increasingly present in EU member-states. Examples of this are articles on the assessment of national-level renewable integration, such as Article 15. This includes the mandate for member-states to assess the deployment and operation of EV charging points in a rolling basis, and calls for appropriate measures – such as local regulation – to be

put in place as to ensure operators contribute to the flexibilization of the increasingly renewable-backed energy system. Article 15 also contains a reference to bi-directional charging, as it considers these as equipment that facilitate the integration of EVs in the energy system. It does not, however, make any specific mention of concrete policies that promote the co-adoption of EVs and any RES, nor is that pursued anywhere else in the AFIR.

4.2.3 Portugal's Roadmap for Carbon Neutrality 2050 (RNC2050)

The RNC2050 is Portugal's roadmap to reach carbon neutrality by 2050. The shift for 100% renewable electricity production, with particular emphasis on solar PV, is complemented by plans for a near total shift to zero emission vehicles. This policy document also highlights a vision for the countries' electricity production becoming increasingly decentralized, including a goal for families and small electricity producers to become responsible for over 20% of total power generation through decentralized PV in energy cooperatives.

Continuing on the PV topic, the RNC2050 includes mostly infrastructure policy, such as expanding interconnections with the EU power grid and implementing batteries as storage solutions to manage the challenges posed by the variability of RES like solar PV, as well as examples of economic policy, as is the case of the development of new regulatory models to allow for new energy market agents like energy communities to take an increasing share of the power generation market.

In parallel, the roadmap outlines a comprehensive strategy for transport electrification. On EVs, the RNC2050 defines the electrification of transport as a key driver of the country's decarbonization efforts. As such, it contains varied incentives, such as direct support schemes for the purchase of EVs, and measures for promoting decarbonization through the renewal of state fleets using zero-emission vehicles.

While the RNC2050 does not mention the joint adoption of EVs and PV – these are covered in different sections of the documentation, one in "Mobility and Transport", and the latter in the "Electro-producer sector" – it does suggest that PV, expected to supply 70% of the country's electricity by 2050, will indirectly support the decarbonization of other electrified sectors, like transport. Although the RNC2050 treats PV and EVs as separate pillars of decarbonization, the implicit reliance on PV as the backbone of the future grid suggests and indirect contribution to transport electrification. However, o explicit mechanisms for their joint development are provided.

4.2.4 Portugal's Recovery and Resilience Plan (PRR)

The PRR is Portugal's national plan aimed at stimulating the economy around resilience, the climate transition and digital transformation. It includes promotion of PV and renewables, as well as EVs and charging infrastructure.

On solar PV, the PRR includes multiple direct incentive policies to promote the adoption of the technology, such as its Component 13 energy efficiency in buildings policy that allocates budget for the state to improve its infrastructure – like schools or other state-owned buildings – in ways that not only make them more energy efficient, but crucially that allow them to be more self-sufficient in their power needs – a possibility given by installing solar PV. Component 13 also allocates funds towards programs for citizens to apply for renewing their homes with technologies that both mitigate the energy poverty issue that plagues the country, but also that, just like what is promoted for state-owned buildings, allows for self-sufficiency through auto consumption from renewables owned either individually, or by localized energy communities. Another key initiative of the PRR specifically linked to PV is included in its Component 7: this section of the policy documentation includes measures to implement a new model of AAE (Industry Fostering Areas) that, to be considered, must include RES production and storage systems for auto consumption – specifically mentioning PV – and EV charging points located within the AAE.

Moving to EVs, the PRR also includes multiple instances where the technology is promoted, such as Component 7 including objectives for the expansion of the public EV charting network. While this particular objective does not include PRR financial support, the policy mandates that wherever the market is unable to ensure the availability of EV charging in line with the PRR's objectives due to low population density, the government will support the necessary investment in a way that mitigates the issue. Also, in a similar way to Component 13's policies to improve state-owned buildings, Component 15 includes policies to renew public transit fleets with 145 electric buses, making this more affordable through a support program for the acquisition of these vehicles.

As for the case of promoting the co-adoption of EVs and PV, just like the three examples of policies covered before the PRR, there is no direct mention of any policy that explicitly links the two in a way they complement each other and actively support the stabilization of the countries' power grid. The closest the PRR comes to do this is in the above-mentioned Component 7, when mentioning the AAE's mandatory inclusion of RES like PV for self-consumption, together with mandatory installation of EV charge points. There is however no

requirement for these charge points to be bi-directional-capable, nor is there any mention made to how EVs can store PV-generated power in surplus periods.

4.2.5 Energy Performance of Buildings Directive (EPBF)

As stated in the beginning of this section, the EU's Energy Performance of Buildings Directive (EPBD) is the only policy covered by our analysis that includes an explicit link between PV and EVs. Despite being primarily focused on the topic of standardizing EU's zero-emission buildings and related goals for the 2050 horizon, the EPBD not only mandates that new buildings are PV-ready, but it also requires bi-directional EV charging infrastructure to be fitted to those same buildings.

Looking at the EPBF's Article 10, we see the EU is mandating that all its member-states ensure new buildings are designed to optimize their solar generation potential, and further demands that PV equipment installation in these buildings is done by a simplified permit-granting procedure. Moving to Article 14, the EPBF focuses on infrastructure for sustainable mobility, mandating member-states to not only ensure pre-cabling of EV chargers is included in buildings, but also that the installed recharging points must be capable of smart and bi-directional charging using non-discriminatory protocols – i.e. interoperable across vehicles.

Unlike other policies analysed, the EPBD operationalizes the co-adoption of EVs and PVs through mandatory building standards, making it a unique and actionable framework for integrated development. Due to the way he EPBF links these initiatives, and how they are focused on maximizing the solar potential of buildings, it is the only policy document we can attest that favourably and effectively promotes the co-adoption of EV and PV technologies.

4.3 Barriers to the Co-Adoption of Electric Vehicles and Solar Photovoltaic

RQ#2: "To what extent do these policies jointly encourage EV-PV co-adoption, and what barriers remain?".

The overall scarcity of integrated EV-PV policies identified under RQ#2 indicates toward the existence of systemic issues in governance and market alignment, which are further explored in the upcoming categories of barriers. As previously discussed, only one of these policies addresses EV and PV co-adoption, the rarity of this joint promotion of these technologies implies that core barriers for consumers to adopt them together are not resolved. To expand on this – and to bring clarity to the barriers that have a direct impact on the penetration of the co-

adoption of EVs and PV – we will list the main barriers that may impact consumers' willingness to – or capacity to – adopt both technologies simultaneously.

While Norway's load-based tariff directly addresses grid instability (a barrier identified further under RQ#2), Portugal lacks equivalent demand-side mechanisms, which indicates a missed opportunity for behavioural incentives. This contrast exemplifies just how policy design differences can either mitigate or exacerbate barriers to co-adoption across EU member states.

4.3.1 Technical Barriers

The synergy between PV and EVs requires that both interact with each other in a direct way, as part of the wider electrical power grid, but as is recognized in the NECP 2030, in countries like Portugal, an uncoordinated scale-up of RES and EVs poses serious risks to the stability of the country's electric grid.

One key way through which EVs can interact with PV to participate in the electricity distribution grid is via V2G, an active control protocol that allows an EV to discharge its battery back into the power grid when connected to a bi-directional charging point (IEA, 2022b). V2G is repeatedly mentioned in both Portuguese and EU policy as a key technical enabler of this synergy, as this technology theoretically allows for the direct usage of PV-sourced electricity to charge EVs, while in turn allowing for EVs to act as batteries that feed the power grid during periods where cheap and abundant PV energy is not available. The IEA's 2022 report on the Grid Integration of Electric Vehicles considers V2G integration as feasible when in power grids that rely on high levels of variable energy generation from RES, as it will in those cases actively assist in maximizing the consumption of RES-generated power – and thus maximize their decarbonization potential. Since Portugal aims, as per the RNC2050, to achieve 100% renewable energy production by 2050, V2G is considered ideal for its conditions.

However, for it to work, V2G-capable vehicles must be connected to smart, bi-directional chargers that make the link between the demands of the power grid. Because this requires common, and interoperable communication protocols are adopted by all stakeholders in the process – such as EV makers, charging equipment manufacturers, and even power grid operators – and, as seen from the policies analysed in this study, only the EPBD pursues the deployment of these standardized systems. Because this push for standardization is not widespread, and since the EPBD sets targets for the post-2030 horizon, the lack of effective policy enablers to the deployment of V2G act as barriers that limit the success – and scalability – of V2G in Portugal and the wider EU.

Furthermore, since V2G relies on continuously cycling (i.e., charging and discharging) EV batteries, this too poses a barrier to its expansion. Lithium-ion batteries used in EVs are sensitive to rate of charge/discharge, depth of charge/discharge, and are rated for a limited amount of charge/discharge cycles in their service life (IEA, 2022b). Because V2G implies a more frequent usage of the batteries, and since Lithium-ion battery degradation occurs at faster rates whenever batteries remain at too high or too low states of charge, the IEA proposes that the issue of V2G's technical limitations in energy storage is addressed through the passing of regulations that expand battery warranties to account for V2G usage.

4.3.2 Economic Barriers

While it promotes a vision of reduced energy costs, the adoption of PV and EVs still presents as a large capital investment that consumers may not be able to undertake (IEA, 2021b). When we add V2G to the discussion, the increased complexity of which chargers have bi-directional compatibility, ensuring the electrical installation supports them, and selecting an EV capable of V2G only adds cost and complexity that disincentivizes its adoption (EVBoosters, 2023).

A reality that clashes with is the access to existing subsidies. Not only are subsidies to consumers mostly limited to EV promotion, as seen in the literature review, but the adoption of these has historically been following a trend that caters to households with higher incomes, with some markets with top rates of EV adoption seeing those households having incomes over 60% higher than the ones that don't acquire EV's. (Bauer, Hsu, Lutsey, 2021). The gaps in adoption of these technologies also relate to behavioural deterrents like range anxiety: as per the International Council on Clean Transportation's (ICCT) 2021 paper on the economic implications in EV adoption reports, lower income households typically own fewer vehicles, and EV's range capabilities – which can be impacted by V2G usage as seen in the technical barriers - remain untrusted by a relevant part of the population (IEA, 2021b), their adoption is ultimately impacted.

Ultimately, EV-PV co-adoption is economically restricted by existing EV-specific economic hurdles. High up-front costs, and policies that fail to reach the larger share of population in the lower economic strata restrict the adoption of EVs, and when combined with the complexity and added cost of adding V2G equipment, such as bi-directional chargers, an even larger portion of the public becomes economically isolated from this key part of the green energy transition.

4.3.3 Governance and Policy Barriers

Another key barrier to EV-PV co-adoption in Portugal and the EU are the frameworks that are and have been used to promote the green transition. Referring once more to Table 2, the fragmentation of policies is clear: not all policies cover both PV and EVs, key incentive types and policy categories are not included in many policies, and despite multiple mentions of smart and bi-directional charging infrastructure, only one, non-mobility-focused policy – the EPBD – contains explicit provisions towards the co-adoption of EVs and PV.

With standard-setting EU policies like AFIR and RED – both covering energy – are designed in completely isolated silos, the fragmentation ultimately cascades down to state-level policy, like Portugal's NECP 2030. While this Portuguese policy is an example that identifies the potential of bi-directional charging, the legal framework it creates is limited in scope, as it only mentions V2G for island territories, and never connects that potential with direct policy to promote its implementation. Combine that with the excessive regulation that Draghi (2024) reports around the rollout of these technologies, and the delays together with lack of clear support for investment configure a decisive barrier to their implementation.

The lack of coherence in policy passed at the EU level, and the fragmented approach to not only policy and target definition, but also regarding the way through which individual municipalities are tasked with implementing complex policy, reflects the EU's difficulty in being aligned and pushing for common goals through central policy. The weak governance mechanisms in place allow for the same goals to be pursued in distinct, unrelated policies, disperse funding mechanisms, and ultimately fail to address the needs of EU member-states like Portugal, where the dependence on fragmented union funding policies forces an inconsistent green transition.

Looking at all these barriers, and linking them with the policy analysis made for this dissertation, it becomes clear that the identification of only 1 in 18 policies that promotes the joint adoption of EVs and PV is a symptom of the state of EU's policy-making. Long identified barriers to green technologies remain unaddressed, and an overall policy-vacuum on these is visible around the EV-PV co-adoption issue. Fragmented regulation is not only a barrier, but rather a key enabler of barriers that aren't overcome by countries like Portugal, ultimately limiting the success potential of its 2050 carbon neutrality goals.

4.4 Mechanisms that reinforce integration of technologies

RQ#3: "What instruments or governance mechanisms could strengthen integrated EV-PV policy in Portugal, drawing on EU and international experience?".

Given that current EU and Portuguese policies are not supporting the integration of technologies effectively, it becomes relevant to explore mechanisms that could help cover existing gaps, and ultimately strengthen Portugal's integration of EV and PV. In this section we will look at a set of specific incentives promoted in other countries that have proven successful in that area, and highlight what actionable takeaways Portugal and the EU could implement in their upcoming policy roadmaps.

4.4.1 Norway's National Charging Strategy

Long seen as a successful early adopter for EV and renewables adoption, Norway currently has the world's largest EV fleet per capita, and is actively seeking to maximize its power grid's potential using government incentives (Norwegian Government, 2023).

Looking to further cement its lead in the EV and RES areas, Norway's National Charging Strategy (2023) identifies the power grid as critical to support the growing demand that follows its EV adoption curve, and explicitly acknowledges the difficulties of aligning grid capacity with all locations that may experience increased demand. To that end, policies in Norway's National Charging Strategy (2023) include two main goals: managing demand, and accelerating the rollout of new power grid connections and improvements.

- Managing Demand: Since the power grid would have issues in supporting simultaneous charging of *all* EVs, Norway is implementing a load-balancing capacity-based tariff to all customers connected to its power grid. This tariff includes a fixed component, plus variable energy and capacity charges. With the variable charges, consumers are incentivized to spread out their energy use throughout the day, ultimately balancing their demand on the power grid, and avoiding the need to upgrade or expand existing grid infrastructure.
- Accelerated permits: Whenever a customer – as an individual or as a company – requests a grid connection, a critical step of the process is the obtaining of licenses with the Norwegian Water Resources and Energy Directorate (NVE). This process typically experiences delays rooted in capacity bottlenecks, so the country's goal with this policy is to expand the capacity of NVE teams dedicated to handling these requests, while

simultaneously making the licensing for these specific charging projects more simplified and digitalized.

Given that Portugal's own policies, like the NECP 2030, identify the increased adoption of EVs and RES as a potential cause for grid instability, Norway's load-balancing power tariff is a clear example of how that issue can be minimized, as it directly and clearly incentivized consumers to change their power usage habits by making it cheaper to make a mindful use of electricity that's more spread out towards the day. Furthermore, since excessive regulation is a recognized motivator of the delays that the EU overall faces and that limit its innovation potential (Draghi, 2024), Norway's example of strategic simplification of permitting for key power grid related projects is another example of what can be prioritized in future EU revisions to existing, or outright creation of new policies, as it directly addresses technical, economical, behavioural and governance barriers previously identified.

4.4.2 Germany's Electromobility Infrastructure in Buildings Act

With the aim of accelerating electromobility, the German Government passed in 2021 a set of policies mandating specific electric infrastructure characteristics to be included in new buildings and building refurbishment projects, called the Electromobility Infrastructure in Buildings Act (GEIG).

In effect since 2021, the GEIG mandates that buildings are ready for EV charging infrastructure to be installed, with minimum requirements for charging points according to the building's planned parking capacity, and also includes provisions to ensure that the charging infrastructure installed is smart-charging capable. This latter requirement effectively sets the stage for a push for ensuring grid stability despite increased load from the higher number of EVs charging in German buildings. By mandating the installation of smart charging infrastructure, the GEIG also enables the promotion of green energy use for cost savings in EV charging, by allowing end-users to charge their EVs at off-peak hours where RES production is most plentiful.

While many of these policies are included in the EV-PV promoting EPBD, it must be once more noted that Portugal as of yet has no policies that transpose mandates for buildings to be bi-directional smart EV charging capable. The GEIG then serves as a clear benchmark on how Portugal must step up its legislation to be more assertive, and move beyond just mentioning

the benefits of bi-directional charging, to actively promoting it. By legally requiring this technology is installed in buildings, some of the barriers – like the economic aspect of bi-directional chargers costing more than simple chargers – are pushed away from the EV-PV purchase decision, as it becomes a standard in the very buildings people live in.

4.4.3 Community-led PV-based microgrids

With the increased availability and lower costs of PV equipment, in some cases it becomes relevant to create decentralized energy networks dedicated to supplying electricity to specific and localized groups of people (Wang, et. al., 2025). These community-led projects are gaining popularity worldwide, but given the particular barriers present in Africa, we'll look at an example of how PV microgrids are changing the paradigm.

In Kenya, PV microgrids are being installed across communities that are either off-grid, marginalized, or otherwise receive some form of unreliable connection to the country's power grid (Ihirwe, et. al., 2021). From a total of roughly 63 PV microgrids operating in Kenya in 2017, Ihirwe, et. al. (2021) notes that, helped by decentralized and non-restrictive governance, 34 of them were managed by communal organizations or other private developers, and are addressing the issues to access to power in the communities they serve.

For the Portuguese case, a key takeaway can be extracted to address the previously identified governance barriers: with more permissive policy and governance mechanisms, local communities can more easily adopt some solutions, like PV, in ways that benefit them directly rather than becoming part of a wider issue directly. The decentralization of PV in energy communities also delivers load management and grid balancing benefits, but does so locally, rather than injecting additional power from an intermittent source in a national grid that already struggles with stabilizing the integrated RES.

As such, despite the apparent lack of solutions included in the policies in Table 2, these Norwegian, German and Kenyan examples prove that EU and Portuguese policy can still be improved towards the specific barriers identified in the EV-PV co-adoption scenario. While the Kenyan example serves more as a proof-of-concept rather than specific governance or policy, the Norwegian National Charging Strategy and Germany's GEIG show what is being done locally in the specific European scenario, but is neither translating into community policy, nor to countries like Portugal.

4.5 Discussion

The analysis presented above returns key findings that confirm that EV-PV co-adoption policies are limited by the fragmentation of EU policy design, and that national-level governance in Portugal does not overcome this limitation. This validates arguments in Candel & Biesbroek's (2016) policy integration theory note that cross-sectoral coherence is essential to overcome these gaps, as fragmentation is impeding the adoption of these technologies, while Hooghe and Marks's (2002) multi-level governance theories are also validated, as the dispersion of policy implementation authority down to the municipal level also limits the implementation of EV-PV co-adoption.

A deeper dive on the alignment of these policies between Portugal and the EU also shows that the limited references of EV-PV co-adoption in policies validates critiques by Draghi (2024), who highlights how the EUs complex governance structures difficult fast progress in key policies like those related to the green transition. Countries like Norway and the US have implemented more direct approaches to these incentives, and as Mariana Mazzucato (2011) notes, the more entrepreneurial approach of the US towards policy proves to be more effective at stimulating technological integration.

Portugal's absence of EV-PV co-adoption policies is thus not unexpected when compared with the overall EU's wider scope of public policies for green energy, making its challenges systemic rather than isolated. This again reflects EU's tendencies towards passing regulatory policy, rather than development-focused proposals (Majone, 1997). To address this EV-PV co-adoption gap, Portugal would likely benefit from stronger coordination with other EU and European Economic Community (EEC) countries, like Germany and Norway, to ensure its own policy instruments reflect Portugal's needs and are more effective in driving the economy and the public to overcome existing barriers to EV-PV co-adoption.

Chapter V: Conclusions, Limitations and Recommendations

5.1 Main Conclusions

From the beginning of this investigation, the main goal was set as analysing how EU and Portuguese policies regarding the co-adoption of EVs and PV were being implemented, identify gaps between them and propose mechanisms to ensure a better alignment across multi-level policies, mainly around topics concerned with the green energy transition. The conclusions of this research are shown here as answers to the research questions defined in Chapter 1.

5.1.1 Existing EV-PV Policies

As detailed in Chapter 4, the investigation done resulted in a list of 18 relevant Portuguese and EU policies, with 11 being of Portuguese origin and the remaining 7 from the EU. After mapping and classifying them in Table 2, the analysis returned that within a large set of policies that promote EVs and PV separately, the promotion of their co-adoption was rare.

Covering RQ#1's main concern, only one policy – the EPBD – out of the 18 was found to contain explicit provisions that promote the co-adoption of PV and EVs, as it mandates buildings to include bi-directional charging infrastructure and PV readiness simultaneously.

Expanding on that, and because other policies, like the PRR, do mention the benefits of synergies between PV and EVs, a conclusion we can come to is that significant policy fragmentation and siloed promotion of technologies ultimately leads to this inconsistency in regulation. More evidence pointing to this is the fact that a great share of the policies analysed do in fact contain provisions for both EVs and PV, but since those are in separate chapters the policies for each technology promote them individually rather than in an integrated way.

5.1.2 Policy Gaps and Fragmentation

Since we know from RQ#1's answer that only one policy meets the criteria we defined, it can be affirmed for RQ#2 that current policies do not effectively encourage EV-PV co-adoption.

As such, and as can be seen in the more detailed discussion in section 4.3, a number of barriers – technical, economical, and of governance and policy – remain limiting this joint adoption of two key components for the decarbonization of transport and power generation.

On technical barriers, the lack of policy that mandates V2G standardization, combined with

automakers not being required to clearly ensure the long-term capacity of vehicles to handle those loads ultimately lead to consumers not only not being incentivized to include V2G in their decision process in choosing an EV, but also creates lack of trust that the EV can safely handle the continuous cycling of the battery for maximizing the PV generation potential.

Regarding the economic barriers, because incentives – especially for individual consumers – are skewed towards EVs, and that combined with the lack of cross-disciplinarity of said policies among areas of operation leads to EV subsidies not covering the additional costs of bi-directional charging infrastructure, their joint adoption is limited. In fact, by not actively promoting the synergies between EVs and PV, the analysed policies are indirectly shifting adoption of both technologies towards higher-income families, rather than the ones that could see a larger impact of subsidies in their budgets.

Finally, on governance and policy barriers, the already covered aspect of siloed policy that separates transport policy from energy policy, results in frameworks that do not link the promotion of EVs with PV. The analysis shows that this sort of fragmentation in policy can be seen as staring in EU-level policies like the AFIR or RED, and that their proposals cascade to local policies, like the NECP 2030, with all the same separation between energy and transport.

5.1.3 Future Policy Decisions

Since the policies analysed – which include EU policies – show largely non-existing policies to promote EV-PV co-adoption, to answer RQ3 it was necessary to include other examples that are not Portuguese or EU sourced. From section 4.4, it is possible to identify examples from Norway, Germany and Kenya that contribute with some form of alternative mechanism that promotes the decentralization of power grids and links its benefits directly to end users.

Norway provides a benchmark on how demand-side tariffs, implemented in alignment with the grid's capacity and peak renewable generation periods, provides a direct economic incentive for consumers to shift balance their electricity usage along the day, rather than concentrating demand in certain periods. Doing this, the country's electrical grid, which relies heavily on RES – just like Portugal aims to by 2050 – can better support demand. Furthermore, since Norway has a very high EV adoption rate, and given that EVs are a main energy use for households, the demand-side tariffs that penalise heavy electric consumption in peak demand hours effectively contributes to the alignment of EV charging with RES power generation, and removes a significant economic barrier by creating a direct incentive to the use of bi-directional charging as a means for load-balancing using idle EV's connected to the grid for energy storage.

In Germany, infrastructure mandates like the GEIG – which precedes the EU's EPBD, the only policy we found to promote EV-PV co-adoption in the EU – demonstrate how even at the national-level, mandates for smart charging infrastructure can be implemented in a unified way. By legislating the mandatory installation of bi-directional capable charging infrastructure, as well as minimum numbers of EV charging spots according to building size, and the mandatory installation of PV infrastructure, German policy is working towards removing key technical barriers by ensuring every new or refurbished building has a standardized set of EV-PV infrastructure elements that remove barriers to the co-adoption of those technologies.

Lastly, Kenya has been exploring the decentralization of its power grid by allowing for bottom-up adoption of PV by cooperative energy communities in areas with limited access to stable electricity from the national grid. This example serves as a proof of concept of how non-restrictive policy can also be beneficial to adoption of these technologies, as it demonstrates that the energy market can evolve organically to adopt ideal RES solutions in organized local communities.

5.2 Contributions to International Management

Policy, and in particular that which concerns long-term geopolitical strategies, has a core role in defining the path that businesses and the industry will follow in the coming years. Due to its intersection of so many critical fields, policy that covers the energy transition is of massive relevance to international management as crossing multi-level policy across competing countries with their individual opportunities, advantages and needs requires massive efforts of coordination and planning to avoid missed opportunities or undesired impacts. This dissertation ultimately offers four key topics of concern for international management, which can greatly support them to facilitate coordination and avoid possible negative outcomes.

5.2.1 Navigating Multi-Level Regulation

In the research conducted, multi-level governance challenges in EU policy were found to be not only causes for ineffective EV-PV promotion, but overall as a key motivator of fragmented promotion of technologies with clear joint benefits.

International management can address the critical needs of merging EU's member-states' goals and priorities with the union's long-term objectives, as current policy tends to avoid catering to each country's national-level constraints. If local regulation and macroeconomic variables are considered in policymaking, the long-term impact of policy implementation can

be better optimized to deliver maximum added-value to EU-wide industries.

5.2.2 Identifying Market Opportunities

The ineffective, or outright absent promotion of EV-PV co-adoption is a critical policy gap, but beyond that, creates gaps in the market that could be served to exploit the lack of clear government subsidies.

In markets where local policy does not effectively promote EV-PV co-adoption, as is the case for Portugal, international management can study the market potential for innovative financing models for PV and V2G installation, for example as packages tied to EV purchases that already benefit from government subsidies. This would effectively minimize the impact of lacking state promotion of these technologies and accelerate the economic benefits of increased activity and transactions in that sector.

5.2.3 Supply Chain Management and Geopolitical Risks

EU's current technological dependency on foreign regions like China is a key area of concern in the overall efforts to decarbonize the economy. Because such a great share of required components and equipment are being sourced from outside the EU, the implications for local industry can be critical in the long-term.

To address these risks, International Management can be tasked with exploring new synergies across EU member-states, as to find more efficient ways to complement local industries by optimizing cost structures and centralizing innovation on key areas where resources would allow for the faster scaling of those industries. By acting as the link between competing EU industries, international management can further develop partnerships to ensure job retention in key industrial centres by finding ways to make EU manufacturing more competitive, and where needed, take proactive measures in lobbying authorities both locally and at the EU-level to ensure those needs are effectively prioritized by governments.

5.3 Limitations

This study acknowledges some limitations that are essentially centred on the method for data collection, and which may inadvertently skew the conclusions.

The dataset collected consists only of policy documentation from Portugal and the EU, published after 2015. While the resulting 18 policies are representative of the overall EV-PV

policy scenario, the limitations imposed can make the analysis less exhaustive and thus influence the conclusions of the study.

By collecting data available in public documentation, expert reports and academic literature, the study knowingly avoided the inclusion of primary qualitative methods like interviews with policymakers or other key experts in the areas concerned with the EV-PV topic. While this was done to avoid skewing the researcher's analysis, the inclusion of those primary qualitative methods could have provided alternative insights as to why the policy fragmentation is present.

Finally, while the analysis done shows gaps across policies and, critically, in the lack of connection between EV and PV promoting policies, the fact that the analysed measures are so recent – newer than 2015 – can result in cases where the full implications and results of policies are not yet visible. The gaps identified in this study must then be seen as current gaps, as they might be resolved in the future.

References

ACEA (2017). *EU market for electric cars highly fragmented, new data shows as Commission finalises CO2 proposal*. Accessed on October 24, 2025. https://www.acea.auto/press-release/eu-market-for-electric-cars-highly-fragmented-new-data-shows-as-commission-finalises-co2-proposal/

ACEA (2024). *Europe's EV conundrum: More chargers, sustained market support, smarter policies*. Accessed on October 23, 2025. https://www.acea.auto/message-dg/europes-ev-conundrum-more-chargers-sustained-market-support-smarter-policies/

Agência Portuguesa do Ambiente (2024). *1ST BIENNIAL TRANSPARENCY REPORT 2024 Portugal SUBMITTED TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE.* Accessed on October 24, 2025. https://unfccc.int/sites/default/files/resource/BTR_PT_20241230.pdf

Amaral, T. C., Pedro, M. O. (2024). *Distributed energy resources in Portugal: Challenges, opportunities, and the way forward*. Accessed on October 24, 2025. https://www.ibanet.org/distributed-energy-resources-portugal

Anari Energy (2024). *Portugal Powers Ahead: Europe's New EV Charging Hotspot—A Deep Dive into Policy, Market, and Strategic Levers*. Retrieved October 24, 2025: https://www.anariev.com/portugal-powers-ahead-europe-ev-charging-hotspot/

Automóvel Clube de Portugal (2024). *Regras de estacionamento de carros elétricos*. Retrieved October 24, 2025, from https://www.acp.pt/article.aspx?menuid=2600

Bauer, G., Hsu, C.,Lutsey, C. (2021). *When might lower-income drivers benefit from electric vehicles? Quantifying the economic equity implications of electric vehicle adoption*. | International Council on Clean Transportation. Accessed on October 27, 2025. https://theicct.org/wp-content/uploads/2021/06/EV-equity-feb2021.pdf

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Bruegel (2024) *The Net-Zero Industry Act puts EU credibility at risk*. Retrieved October 28, 2025 from https://www.bruegel.org/first-glance/net-zero-industry-act-puts-eu-credibility-risk

Candel, J. J. L., & Biesbroek, R. (2016). Toward a processual understanding of policy integration. *Policy Sciences*, *49*(3), 211–231. https://doi.org/10.1007/s11077-016-9248-y

Creswell, J. W., & Clark, V. L. P. (2018). Designing and Conducting Mixed Methods Research (3rd ed.). Thousand Oaks, CA: SAGE Publishing.

Dekeyrel, S., Riekeles, G., & Świeboda, P. (2025). *Building Economic Security into Europe's Clean Energy Agenda: Eight Recommendations for Europe's Net-Zero Course Correction*. Accessed on October 24, 2025. https://www.epc.eu/publication/Building-Economic-Security-into-Europes-Clean-Energy-Agenda-Eight-Re-61dac8/

Draghi, M. (2024). *The future of European competitiveness: Part A: A competitiveness strategy for Europe*. European Commission. Retrieved October 28, 2025 from https://commission.europa.eu/document/download/97e481fd-2dc3-412d-be4c-f152a8232961_en

European Commission. (2019). *The European Green Deal*. Retrieved October 28, 2025 from https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF

European Commission (2024a). *Regulation (EU) 2024/1735 of the European Parliament and of the Council of 13 June 2024 on establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem and amending Regulation (EU) 2018/1724.* https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401735

European Commission (2023a). *The Net-Zero Industry Act.* Retrieved October 28, 2025 from https://single-market-economy.ec.europa.eu/industry/sustainability/net-zero-industry-act_en

European Commission (2023b). *DIRECTIVE (EU) 2023/2413 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652. Renewable Energy Directive (RED III).* Accessed on October 28, 2025 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302413

European Commission. (2022). *REPowerEU*. Accessed on October 28, 2025 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52022DC0230

European Commission (2021). *Fit for 55 legislation*. Retrieved October 28, 2025 from https://ec.europa.eu/commission/presscorner/api/files/document/print/en/ip_23_4754/IP_23_4754_EN.pdf

European Commission (2023c). *Alternative Fuels Infrastructure Regulation*. Retrieved October 28, 2025 from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1804

European Commission (2023d). *Renewable Energy Directive.* Retrieved October 28, 2025 from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302413

European Commission (2024b). *Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings.* Accessed on October 28, 2025 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401275

European Commission (2023e). Social Climate Fund. Accessed on October 28, 2025 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0955

European Federation for Transport and Environment. (2023). *How the EU can get its Net Zero Industrial Act right*. Accessed on October 28, 2025 https://www.transportenvironment.org/articles/how-the-eu-can-get-its-net-zero-industrial-act-right

European Parliamentary Research Service (2025). *Portugal's National Recovery and Resilience Plan*. Retrieved October 9, 2025 from https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/729408/EPRS_BRI(2022)729408_EN.pdf

EVBoosters Editorial Board (2023). *Advantages and Challenges of V2G Implementation*. Retrieved October 27, 2025, from https://evboosters.com/ev-charging-news/advantages-and-challenges-of-v2g-implementation/

Falkner, G., Treib, O., Hartlapp, M., & Leiber, S. (2005). *Complying with Europe: EU Harmonisation and Soft Law in the Member States*. Cambridge University Press. https://books.google.pt/books?id=H95O2VanF1YC

German Government (2021). *GEIG in Kraft! Gebäude-Elektromobilitätsinfrastruktur-Gesetz*. Retrieved October 28, 2025, from https://geig-online.de/

Hooghe, L., & Marks, G. (2002). *Types of Multi-Level Governance* (SSRN Scholarly Paper No. 302786). Social Science Research Network. https://doi.org/10.2139/ssrn.302786

IEA. (2022a). *Special Report on Solar PV Global Supply Chains*. https://doi.org/10.1787/9e8b0121-en

IEA (2025). *Inflation Reduction Act of 2022* Retrieved September 18, 2025, from https://www.iea.org/policies/16156-inflation-reduction-act-of-2022

IEA (2023). *The State of Clean Technology Manufacturing: An Energy Technology Perspectives Special Briefing – November 2023 Update*. Retrieved October 7, 2025, from https://iea.blob.core.windows.net/assets/710264f6-0cb8-4f5c-8c95-4ae2ea64998a/TheStateofCleanTechnologyManufacturing_November2023Update.pdf

IEA (2024). *Global EV Outlook 2024*. Retrieved October 8, 2025 from https://www.iea.org/reports/global-ev-outlook-2024

IEA (2021a). *Portugal 2021 Energy Policy Review*. https://doi.org/10.1787/3b485e25-en

IEA (2022b). *Grid Integration of Electric Vehicles—A manual for policy makers*. Accessed on October 27, 2025. https://iea.blob.core.windows.net/assets/21fe1dcb-c7ca-4e32-91d4-928715c9d14b/GridIntegrationofElectricVehicles.pdf

IEA (2021b). *The Cost of Capital in Clean Energy Transitions – Analysis*. Accessed on October 27, 2025. https://www.iea.org/articles/the-cost-of-capital-in-clean-energy-transitions

Ihirwe, J. P., Li, Z., Sun, K., Bimenyimana, S., Wang, C., Asemota, G. N. O., Nduwamungu, A., & Mesa, C. K. (2021). Solar PV Minigrid Technology: Peak Shaving Analysis in the East African Community Countries. *International Journal of Photoenergy*, *2021*. https://doi.org/10.1155/2021/5580264

Kappe, K., Mikaelsson, M.A., & Krustok, I. (2024). *The EU Green Deal in turbulent times: insights from the EU Green Policy Tracker from Sweden and Estonia. Stockholm Environment Institute*. Accessed on October 24, 2025. https://doi.org/10.51414/sei2025.017

Kern, F., Rogge, K., Howlett, M. (2019). *Policy Mixes for Sustainability Transitions: New Approaches and Insights through Bridging Innovation and Policy Studies*. https://doi.org/10.1016/j.respol.2019.103832.

Kleimann, D., N. Poitiers, A. Sapir, S. Tagliapietra, N. Véron, R. Veugelers and J. Zettelmeyer (2023) *How Europe should answer the US Inflation Reduction Act*. Retrieved October 28, 2025 from https://www.bruegel.org/system/files/2023-02/PB%2004%202023_0.pdf

Lequesne, C. (2016). The Eurozone crisis and European integration: 'New intergovernmentalism' as a valid theory. In Saurugger, S., Terpan, F., *Crisis and institutional change in regional integration* (pp. 55–73). Routledge. https://doi.org/10.4324/9781315667959

Majone, G. (1997). From the Positive to the Regulatory State: Causes and Consequences of Changes in the Mode of Governance. *Journal of Public Policy*, *17*(2), 139–167. http://www.jstor.org/stable/4007608

Mazzucato, M. (2011). *The Entrepreneurial State*. Retrieved October 28, 2025 from https://www.researchgate.net/publication/263242587_The_Entrepreneurial_State

Mazzucato, M. (2018). *Mission-Oriented Innovation Policies: Challenges and Opportunities. Industrial and Corporate Change*. https://doi.org/10.1093/icc/dty034.

McKinsey & Company (2024). *The Industry & Energy Transition Index: Portugal*. Retrieved October 7, 2025 from https://www.mckinsey.com/~/media/mckinsey/industries/electric%20power%20and%20natural%20gas/our

%20insights/the%20industry%20energy%20transition%20index%20portugal/the-industry-and-energy-transition-index-portugal.pdf

Municipio de Braga (2023). *Programa Municipal de Combate à Pobreza Energética*. Accessed on October 20, 2025 https://diariodarepublica.pt/dr/detalhe/regulamento/1258-2023-224684051

Municipio do Porto (2025). *Plano Municipal de Ação Climática do Porto 2030.* Accessed on October 20, 2025. https://ambiente.cm-porto.pt/files/uploads/cms/PMAC%20Porto_%20vers%C3%A3o%20para%20discuss%C3%A3o%20p%C3%BAblica.pdf

Norwegian Ministry of Transport (2023). *National charging strategy*. Accessed on October 27, 2025. https://www.regjeringen.no/en/documents/national-charging-strategy/id2950371/

Pollock, D., Evans, C., Menghao Jia, R., Alexander, L., Pieper, D., Brandão De Moraes, É., Peters, M. D. J., Tricco, A. C., Khalil, H., Godfrey, C. M., Saran, A., Campbell, F., & Munn, Z. (2024). "How-to": Scoping review? *Journal of Clinical Epidemiology*, *176*, 111572. https://doi.org/10.1016/j.jclinepi.2024.111572

Portuguese Government (2019a). *National Energy and Climate Plan 2030.* Retrieved October 7, 2025 from https://energy.ec.europa.eu/system/files/2020-06/pt_final_necp_main_en_0.pdf

Portuguese Government (2019b). *Roteiro para a Neutralidade Carbónica 2050*. Retrieved October 8, 2025. https://unfccc.int/sites/default/files/resource/RNC2050_PT-22-09-2019.pdf

Portuguese Government (2021a). *PRR – Recuperar Portugal, Construindo o Futuro*. Accessed on October 8, 2025. https://recuperarportugal.gov.pt/wp-content/uploads/2021/10/PRR.pdf

Portuguese Government (2019c). *Estatuto dos Benefícios Fiscais.* Retrieved October 9, 2025. https://www.cm-odemira.pt/uploads/document/file/13386/estatuto_dos_beneficios_fiscais__ebf_2019_.pdf

Portguguese Government (2024a). *Recuperar Portugal: REPowerEU.* Accessed on October 28, 2025. https://recuperarportugal.gov.pt/wp-content/uploads/2024/06/21_Componente-REPower.pdf

Portuguese Government (2025). *Fundo Ambiental - Mobilidade Verde — Passageiros.* Accessed on October 19, 2025 https://www.fundoambiental.pt/apoios-2025/mitigacao-as-alteracoes-climaticas/introducao-no-consumo-de-veiculos-de-emissoes-nulas-no-ano-de-2025-mobilidade-verde-passageiros.aspx

Portuguese Government (2024b). *Fundo Ambiental - Programa de Apoio a Edifícios mais sustentáveis.* Accessed on October 19, 2025. https://www.fundoambiental.pt/paes-2023/documentacao/orientacoes-gerais-pdf.aspx

Portuguese Government (2022). *Decreto-Lei n.º 15/2022, de 14 de janeiro.* Accessed on October 19, 2025. https://diariodarepublica.pt/dr/detalhe/decreto-lei/15-2022-177634016

Portuguese Government (2021b). *Lei de bases do clima: Lei n.º 98/2021.* Accessed on October 20, 2025. https://diariodarepublica.pt/dr/detalhe/lei/98-2021-176907481

Rodrigues, M. J. (Ed.). (2009). *Europe, globalization, and the Lisbon Agenda*. Edward Elgar. https://www.europeansources.info/record/europe-globalization-and-the-lisbon-agenda/

Rodrik, D. (2004). INDUSTRIAL POLICY FOR THE TWENTY-FIRST CENTURY. Retrieved October 28, 2025 from https://drodrik.scholar.harvard.edu/files/dani-rodrik/files/industrial-policy-twenty-first-century.pdf

Saurugger, S., Terpan, F. (2016). *Crisis and institutional change in regional integration*. Routledge, Taylor & Francis Group. https://doi.org/10.4324/9781315667959

SolarPower Europe, E-Mobility Europe (2025). *From sun to wheels: Synergies in solar-powered e-mobility—SolarPower Europe*. Accessed on October 24, 2025. https://www.solarpowereurope.org/advocacy/position-papers/from-sun-to-wheels-synergies-in-solar-powered-e-mobility-1

Torreblanca, J. I., Prislan, N. (2012). *The ominous rise of geoeconomics*. ECFR. https://ecfr.eu/article/commentary_the_ominous_rise_of_geoeconomics/

United States Congress (2022). *Inflation Reduction Act of 2022.* Retrieved October 28, 2025 from https://www.congress.gov/bill/117th-congress/house-bill/5376/text

Wang, S., Li, Y., Cui, Y. *et al.* (2025) *Integrating renewable energy into building energy systems: a systematic review of strategies, barriers, and policy interfaces*. https://doi.org/10.1007/s43621-025-01966-4

Zeitlin, J., Vanhercke, B. (2018) *Socializing the European Semester: EU social and economic policy co-ordination in crisis and beyond*. Journal of European Public Policy. https://doi.org/10.1080/13501763.2017.1363269

Appendix

Appendix 1: *EU and Portuguese Policies covering EV and PV adoption, with policies categorized by type*

Policy	Policy Origin	Technologies Promoted	Co-adoption?	Types of Policy Included	Source	Reference
National Energy and Climate Plan (NECP 2030)	Portugal	PV and EV	No	Direct Incentive, Indirect Incentive, Support Infrastructure, Economic Policy, R&D+I Promotion	Portuguese Government, 2019a	https://energy.ec.europa.eu/system/files/2020-06/pt_final_necp_main_en_0.pdf
Roadmap for Carbon Neutrality 2050 (RNC 2050)	Portugal	PV and EV	No	Direct Incentive, Indirect Incentive, Support Infrastructure, Environmental Policy, Economic Policy, R&D+I Promotion	Portuguese Government, 2019b	https://unfccc.int/sites/default/files/resource/RNC2050_PT-22-09-2019.pdf
Recovery and Resilience Plan (PRR)	Portugal	PV and EV	No	Direct Incentive, Indirect Incentive, Support Infrastructure, Environmental Policy, Economic Policy, R&D+I Promotion	Portuguese Government, 2021a	https://recuperarportugal.gov.pt/wp-content/uploads/2021/10/PRR.pdf
Estatuto dos Benefícios Fiscais (EBF)	Portugal	PV	No	Direct Incentive, Indirect Incentive, Environmental Policy, Economic Policy, R&D+I Promotion	Portuguese Government, 2019c	https://www.cm-odemira.pt/uploads/document/file/13386/estatuto_dos_beneficios_fiscais__ebf_2019_.pdf
Recuperar Portugal – REPowerEU Chapter	Portugal	PV and EV	No	Direct Incentive, Indirect Incentive, Support Infrastructure, Economic Policy, R&D+I Promotion	Portuguese Government, 2024a	https://recuperarportugal.gov.pt/wp-content/uploads/2024/06/21_Componente-REPower.pdf
Fundo Ambiental - Mobilidade Verde - Passageiros	Portugal	EV	No	Direct Incentive, Support Infrastructure, Environmental Policy, Economic Policy	Portuguese Government, 2025	https://www.fundoambiental.pt/apoios-2025/mitigacao-as-alteracoes-climaticas/introducao-no-consumo-de-veiculos-de-emissoes-nulas-no-ano-de-2025-mobilidade-verde-passageiros.aspx
Programa de Apoio a Edifícios mais Sustentáveis 2023	Portugal	PV	No	Direct Incentive, Economic Policy	Portuguese Government, 2024b	https://www.fundoambiental.pt/paes-2023/documentacao/orientacoes-gerais-pdf.aspx

DL nº15/2022 (Legal Framework for Self-Consumption)	Portugal	PV and EV	No	Direct Incentive, Indirect Incentive, Support Infrastructure, Environmental Policy, Economic Policy	Portuguese Government, 2022	https://diariodarepublica.pt/dr/detalhe/decreto-lei/15-2022-177634016
Lei de Bases do Clima (LBC) - Lei n.º 98/2021, 31/12	Portugal	PV and EV	No	Direct Incentive, Indirect Incentive, Support Infrastructure, Environmental Policy, Economic Policy	Portuguese Government, 2021b	https://diariodarepublica.pt/dr/detalhe/lei/98-2021-176907481
REPowerEU	EU	PV and EV	No	Direct Incentive, Indirect Incentive, Support Infrastructure, Environmental Policy, Economic Policy, R&D+I Promotion	European Commission, 2022	https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52022DC0230
European Green Deal	EU	EV	No	Direct Incentive, Indirect Incentive, Support Infrastructure, Environmental Policy, Economic Policy, R&D+I Promotion	European Commission, 2019	https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF
Energy Performance of Buildings Directive (EPBD)	EU	PV and EV	Yes	Direct Incentive, Indirect Incentive, Support Infrastructure, Environmental Policy, Economic Policy	European Commission, 2024b	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401275
Renewable Energy Directive	EU	PV and EV	No	Direct Incentive, Indirect Incentive, Support Infrastructure, Environmental Policy, Economic Policy	European Commission, 2023d	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302413
Alternative Fuels Infrastructure Regulation (AFIR)	EU	PV	No	Direct Incentive, Indirect Incentive, Support Infrastructure, Environmental Policy, R&D+I Promotion	European Commission, 2023c	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1804
Net-Zero Industry Act (NZIA)	EU	PV and EV	No	Direct Incentive, Indirect Incentive, Support Infrastructure, Environmental Policy, Economic Policy, R&D+I Promotion	European Commission, 2024a	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401735
Social Climate Fund	EU	PV and EV	No	Direct Incentive, Indirect Incentive, Support Infrastructure, Economic Policy	European Commission, 2023e	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0955
Pacto do Porto para o Clima	Portugal	PV and EV	No	Direct Incentive, Indirect Incentive, Support Infrastructure, Environmental Policy, Economic Policy, R&D+I Promotion	*Municipio do Porto*, 2025	https://ambiente.cm-porto.pt/files/uploads/cms/PMAC%20Porto_%20vers%C3%A3o%20para%20discuss%C3%A3o%20p%C3%BAblica.pdf

Programa Municipal de Combate à Pobreza Energética	Portugal	PV	No	Direct Incentive, Economic Policy	*Municipio de Braga*, 2023	https://diariodarepublica.pt/dr/detalhe/regulamento/1258-2023-224684051