

A comparative analysis of the renewable electricity transition in the UK and the Netherlands through their solar and wind power generation policies

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Candidate Number: **259834**

SPRU – Science Policy Research Unit

Business School

University of Sussex

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Abstract

This dissertation investigates the divergent trajectories of the United Kingdom (UK) and the Netherlands in transitioning their electricity generation sectors towards renewables by exploring policies promoting the deployment of solar and wind energy. Also, it combines qualitative analysis of policies and review of related literature to draw insightful comparisons using Multi-level Perspective.

The findings reveal that the UK initially embraced a neoliberal approach, shifting from the Renewable Obligation (RO) scheme to subsidies and auctions (CfD), resulting in substantial progress in renewable electricity, particularly offshore wind. Conversely, the Netherlands revised its policies from demand to supply-based, implementing various feed-in tariffs but faced challenges due to policy inconsistencies and prolonged negotiations linked with its corporatist approach. Yet it has still managed to gain momentum in recent years notably through small-scale investors.

In conclusion, this study underscores the critical role of transparent, effective, and predictable policy design in driving sustainable electricity transitions and attracting renewable investments. It emphasizes that ambitious renewable targets must align with a tailored regulatory framework, mindful of each nation's unique contextual conditions and institutional traditions. The research offers valuable lessons for future renewable energy transitions and decarbonisation efforts.

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List of Abbreviations

ACM	Authority of Consumers and Markets
CfD	Contract for Differences
CO ₂	Carbon dioxide
CPF	Carbon Price Floor
DECC	Department of Energy and Climate Change
DTe	Office of Energy Regulation
DTI	Department of Trade and Industry
EMR	Electricity Market Reform
EPS	Emissions Performance Standard
ETS	Emission Trading System
EU	European Union
EV	Electric Vehicle
FiP	Feed in Premium
FiT	Feed in Tariff
GHG	Greenhouse Gas
Gt	Gigaton
GW	Gigawatt
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
IKIA	Integral Knowledge and Innovation Agenda
IPCC	Intergovernmental Panel on Climate Change
Kw	Kilowatt
kWh	Kilowatt-hour
LCIS	Low Carbon Industrial Strategy
MEP	Milieukwaliteit van de Elektriciteitsproductie (Environmental Quality of Power Production)
MLP	Multi-Level Perspective
MW	Megawatt

MWh	Megawatt-hour
NAEI	National Atmospheric Emissions Inventory
NREAP	National Renewable Energy Action Plan
NGO	Non-Governmental Organisations
OECD	Organisation for Economic Co-operation and Development
OFGEM	Office of Gas and Electricity Markets
PV	Photovoltaic
R&D	Research and Development
RO	Renewables Obligation
ROC	Renewables Obligation Certificate
SDE	Stimulerend Duurzame Energie (Feed-in Premium Programme)
SEG	Smart Export Guarantee
SER	Sociaal-Economische Raad (Social and Economic Council)
TM	Transition Management
TSO	Transmission System Operator
TWh	Terawatt-hour
UK	United Kingdom
UN	United Nations

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1. Introduction

1.1 Background and Significance of Research

According to the most recent report released by the *IPCC*, while the severity of climate change-related consequences is escalating, reducing the carbon intensity of economies has become an essential issue on the agenda of countries worldwide (2023). Under these circumstances, most countries declared the Paris Agreement in 2015 as a critical threshold in international efforts to tackle the adverse impacts of climate change. They agreed to effectively limit the average temperature rise globally and achieve the specified targets (UN, 2015).

A significant share of *Greenhouse Gas (GHG)* emissions comes from electricity generation and other energy-related sectors. In 2021, while electricity made up one-fifth of final energy consumption, the sector was an essential contributor to CO₂ emissions, due to the combustion of fossil fuels (IEA, 2022a). Beyond their polluting nature, fossils still play an important role in supplying the energy needs of most countries, while questions regarding energy security are also further raised due to their varying resource availability and the fact that they are likely to run out in the not-too-distant future (Martins, Felgueiras, Smitkova, & Caetano, 2019). To brief, it is imperative that governments shift their reliance from fossil fuels to sustainable and renewable sources for electricity generation to not only effectively combat climate change but also improve energy security. Notably, wind turbines and solar photovoltaic systems are among the most promising technologies available, and their expanding deployment is transforming electricity systems in many social, technical, and economic aspects (Markard, 2018).

Inspired by above reasons and other varying motivations, many countries are adopting a series of policies to increase the deployment of renewable energy sources and transform their energy and electricity systems in a sustainable direction, in their own contexts (Gan, Eskeland, & Kolshus, 2007). This transition process embodies the unique experiences of each country, depending on individual dynamics (Bayraktar, 2020). Whether successful or not, the lessons learnt from these experiences may offer valuable insights for policymakers and researchers, thereby contributing to ongoing or future energy transitions.

Both Netherlands and United Kingdom, are characterised by industrialised economies with energy-intensive sectors (Oxford Reference, n.d; Sendich, 2014). Notably, their efforts to reshape their electricity generation sectors and policy frameworks for renewables are noteworthy.

Leading the way with ambitious emission reduction targets, the UK plans to fully decarbonise its electricity system by 2035 to ensure the country's transition to a cleaner and sustainable energy future and reinforce energy security within the scope of its net-zero strategy and for this purpose, they relied on various renewable and low-carbon technologies. (UK Government, 2021). The UK, known for its historical reliance on coal-based power, has embarked on a transformative journey since the late 20th century, and its commitment to reducing carbon emissions led to a shift in focus from coal to a diversified energy mix and a sweeping policy revision over time (Banga, Rosendahl, & Böhringer, 2022). Renewable energy installations increased rapidly in the following years, and eventually, 43% of total electricity came from them in 2020 (BEIS, 2021).

The Netherlands, which has a particular interest in the climate issue due to its low-lying geography (Kwadijk, et al., 2010), has progressed in its own energy transition path. The past of the Netherlands reflects an attachment to natural gas stretching back over many decades (Sovacool, 2016). However, the country has taken several actions to diversify its energy resources and promote renewables, recognising the necessity of achieving a clean electricity system over time (IEA, 2020). This recognition culminated in the Energy Agreement in 2013, which not only set out ambitious targets for carbon reduction but also underlined a collaborative endeavour and policy framework that foster an enabling environment for adopting renewable technologies (Government of Netherlands, 2013).

While the overarching goal of transitioning to renewables unites the general trajectories of these two countries, it is vital to explore the differences in their energy governance approaches, the policy instruments they implemented, and the dynamics at play within their socio-technical systems.

1.2 Research Objective and Research Question

This dissertation aims to compare the transition of the power systems of the UK and the Netherlands by putting policies for renewable generation from solar and wind at the centre.

To achieve this goal, the study will employ the Multi-level Perspective, gain insights into the factors that shape the transition to sustainable systems of respective electricity sectors, assess the effectiveness of related policies and eventually provide an answer to the following main research question:

- Why have the UK and the Netherlands followed different trajectories in the transition of their electricity generation sectors to renewables, using which strategies and policies?

The sub-questions that support the main research question are:

- In which ways do the energy governance approaches of the UK and the Netherlands differ in terms of their focus, objectives and strategies, and how do they influence shaping renewable electricity policies?
- From a multi-level perspective, what are the policy instruments adopted by the UK and the Netherlands to support the wind and solar PV niche between 2000 and 2020, and what fundamental dynamics were at work at the landscape and regime levels influencing their effectiveness?
- How has the evolution of electricity generation systems in the UK and the Netherlands developed, and in what ways are the transition processes and policy outcomes similar or different?

These questions point to complex answers that also depend on many factors that play a role in the energy transition of these countries and require a holistic systems perspective. Broader dynamics in system transformation should also be analysed for more balanced evaluation (Verbong & Geels, 2007). This study will address these dynamics as well.

The dissertation is structured as follows: Chapter 2 presents a literature review on renewable electricity transition with related policies and governance approaches. Chapter 3 contains the analytical framework and data-related methods on which the study is based. Chapter 4 evaluates the transformation of electricity generation and policies for renewables at landscape regime and niche levels for the UK case, while chapter 5 carries out a similar analysis for the Netherlands. Chapter 6 discusses the findings and interpretations and sets the stage for the conclusion in Chapter 7.

2. Literature Review

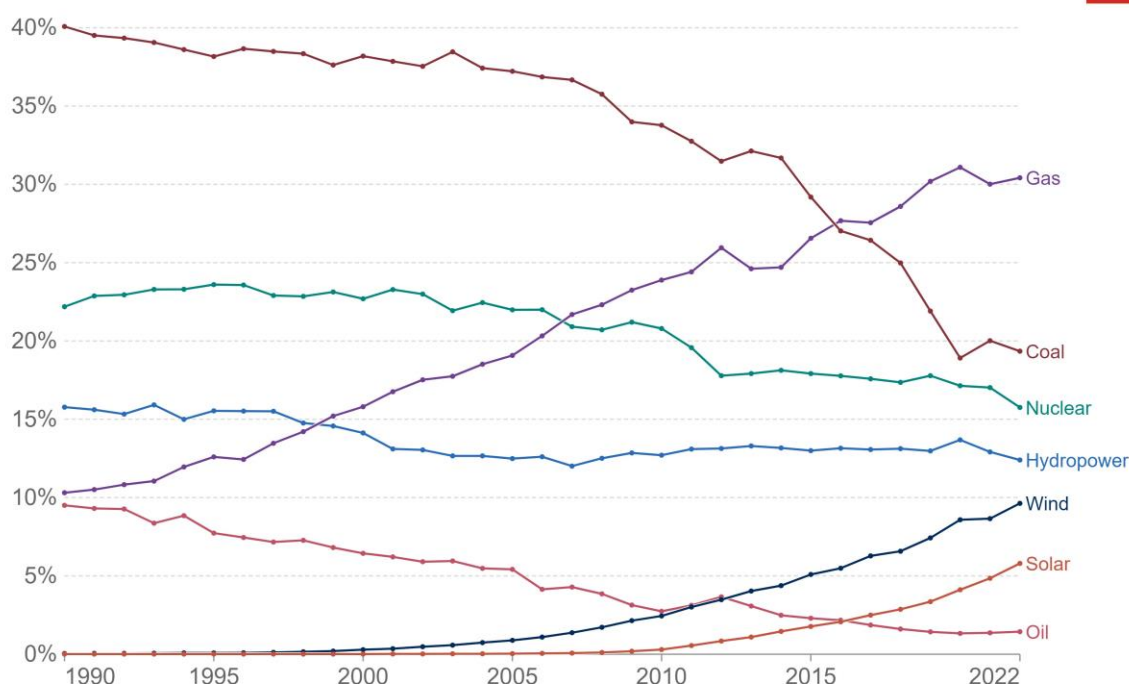
To delve deeper into how and why renewable policies transform electricity systems in a sustainable direction, this chapter reviews the relevant literature and identifies the key concepts involved. In this context, this chapter first presents the literature on renewable electricity transitions in general. Then, the scope of liberalised electricity markets and policies for the renewable transition of the sector will be examined in the literature, and the insights gained will be reflected. Third, the chapter will focus on the governance of transitions, including overarching government strategies and the role of institutions.

2.1 Renewable Electricity Transition

Although there are various sources of electricity production, countries use different sources at different rates by considering them under their own economic and geographical conditions (Burke, 2010). For several reasons, power plants based on fossil fuels like oil and coal still account for the primary source of electricity generation in many countries (Papadis & Tsatsaronis, 2020; Solarin, Bello, & Bekun, 2021). However, these fuel types are far from sustainable owing to their finite and highly polluting nature (Holechek, Valdez, Geli, & Sawalhah, 2022). In addition, the rising levels of global CO₂ emissions in recent decades have made it crucial to increase the share of clean renewable sources in the electricity sector by shifting away from conventional hydrocarbon sources (Heinberg & Fridley, 2016). Under these conditions, the gradual expansion of renewable energy technologies points to a new trajectory for the power generation sectors. This is clearly seen in Figure 1, which shows the percentage distribution of resources used for electricity generation in OECD countries over the last three decades (Our World in Data, n.d.a).

Share of electricity production by source, OECD (EI)

Our World
in Data



Source: Ember's Yearly Electricity Data; Ember's European Electricity Review; Energy Institute Statistical Review of World Energy
OurWorldInData.org/energy • CC BY

Figure 1. Electricity generation share (%) by source in OECD countries between 1990 and 2022 (Our World in Data, n.d.a)

According to this figure, coal stood out as the most used resource in 1990. However, while the share of coal halved to 20%, natural gas increased steadily and reached around 30% by 2022. In 1990, the shares of nuclear and hydroelectricity, the second and third most utilised sources, decreased slightly since then. Furthermore, coal, oil and nuclear energy have been ceding their share in the mix in favour of renewable wind and solar, the deployment of which has been moderately growing since the 2000s (Our World in Data, n.d.a).

Another important factor that played a role in this shift was the development of renewable energy technologies. The prices of wind turbines and solar PV technologies witnessed a sharp decline on a global scale while their efficiencies and load capacities were improving simultaneously (IRENA, 2022a).

These resources, harnessed from nature's abundance, have been characterised in the literature as *intermittent renewables* due to their variability and sensitivity to weather conditions, and it is also often highlighted that their integration into the grid brings several challenges (Sandhu & Thakur, 2014; Stram, 2016). In their works, Bhandari et al. (2015) and Martinot (2016)

evaluated the electricity produced from wind and sun in terms of its continuity, reliability, and effects on the stability of the network. Das, et al. (2020), also examines the operational challenges for the grid in the transition to a new system involving large-scale renewable energy sources through the Indian power system. Hence, innovative technologies, flexibility solutions (e.g. grid-side innovations, storage technologies) and further strategies gain greater importance in parallel with the growing embrace of intermittent renewables (Wang, Wang, & Ton, 2012; Lamnatou, Chemisana, & Cristofari, 2022).

Moreover, developments such as heat pumps and the spillover of electric vehicles (EV) in the heating and transportation sectors are expected to strengthen the electrification trend and increase the demand for electricity from renewables in future scenarios (IRENA, 2020).

2.1.1 Liberalised Electricity Markets

The renewable electricity transition policies of the countries cannot be considered separately from their electricity market designs. Therefore, the specific dynamics around respective electricity market designs in which these policies are implemented should be regarded. Although there is much research on this subject in the literature, this section emphasises the necessary points for this study.

Liu, Wang, and Cardinal(2022) state that: “Electricity market serves as an effective mechanism linking generators, transmission enterprises, consumers, regulatory bodies, and government policy together” (p. 1). According to the same authors, since the 1980s, policies based on liberalisation and competitiveness have started to be adopted in the electricity markets, primarily in various industrialised countries (2022). The primary objective of this process, defined as reform, is to replace the vertically integrated state-owned structure with private enterprises and investment in the sector, thereby increasing economic efficiency (Holburn & Spiller, 2002; Ventosa, Baíllo, Ramos, & Rivier, 2005). Another essential goal points out as the commodification of electricity by adjusting the interconnection and flow capacities and facilitating exchange in the free market (Liu, Wang, & Cardinal, 2022). However, the factors shaping this path and the development of electricity market mechanisms differ depending on the specific context of each country (Joskow, 2008).

Before 1990, electricity markets in the EU were administered by a single authority, as in every country (IEA, 2016). Similarly, the *Central Electricity Generation Board* was responsible for power generation and transmission in the UK as a state monopoly whereas existence of old and low-efficient power plants had required the acceleration of energy-related investments. In this

context, the idea of liberalisation based on private sector-driven investments was focused on (Rotaru, 2013). *The White Paper* issued by the government in 1988 drew a road map for privatisation actions. According to this, the goal was to reshape the electricity generation structure by considering both consumers and distribution companies, and to eliminate monopolies in the sector (Heddenhausen, 2007). With the enactment of *the Electricity Act* in the following year, the reform process in the electricity market in the UK accelerated (Meyer, 2003). Afterwards, with the changes arising from EU legislation, the market continued to develop within the framework of principles such as competition, transparency, grid access and security (House of Commons, 2017). Today, the UK power generation market is one in which there are many generating companies holding licences (Ofgem, 2023), and the six largest supplier companies (*big six*) have around 70% of installed capacity (Statista, 2023). Customers can freely pick up the suppliers and services they will receive related to electricity, and despite various criticisms, the UK is often pointed out as a good example of a liberalised market that has taken the earliest steps (Rotaru, 2013).

On the other hand, the Dutch electricity market underwent a gradual reform process within the framework of its internal dynamics and reached a market outlook that completed its liberalisation in 2004 (Pomp & Shestalova, 2007). Reijnders (2002) also contributed to this literature by analysing the liberalisation of green electricity based on various renewable resources in 2001, which is part of this process. Kooshknow and Davis (2018) characterise the development of the market in the following period, emphasising three critical changes: “the unbundling of activities, market liberalisation, and regulation of natural monopolies” (p. 593). Also according to the same researchers, there is a transmission system operator (TSO) owned by the state for grid operations, yet the rest of the activities in the sector are competitive. While many companies already involved in electricity generation and supply, consumers also free to pick up their provider (2018), as in the case of the UK.

2.1.2 Policy For Renewables in Liberalised Systems

While the energy and climate policies pursued by many countries today aim to decarbonise the energy sector, the transition of electricity generation to renewables is a milestone (Yu, Fang, Xiao, & Pan, 2023). The report by the IEA, elaborating on *the Sustainable Development Scenario* based on the Paris Agreement goals, forecasts a more than eight-fold increase in electricity generation from solar and wind by 2040 compared to 2018 levels (2019). Therefore, increased utilisation of these sources leads to changes in the market architecture due to their

generation and ownership features, as well as their cost structures and various externalities (May & Neuhoﬀ, 2021).

The literature on renewables in liberalised markets reveals the complex relationship between renewable energy policies, energy transition, market liberalisation and environmental objectives.

Nicolli and Vona examine how the deregulation of energy markets in OECD nations is linked to their policies for renewables. Their research suggests that the influence of deregulation on renewable energy policies is closely tied to how well the liberalization process is structured and its eventual results. In countries such as Denmark and the Netherlands, where there are fewer obstacles for new actors in the energy sector and rooted public ownership traditions, the authors contend that liberalization has a favourable impact on policies for renewables. This is particularly evident in these countries because they have open grid access for a variety of market participants, as opposed to favouring specific incumbents, and they actively support decentralized electricity generation (2019).

Adoption of renewable energy in such markets offers significant benefits but also some challenges. Many studies have highlighted the various benefits of renewable power generation, such as reduced greenhouse gas emissions and energy supply diversification (Markard & Truffer, 2006; Zahedi, 2011; Silva, Laranjeira, & Soares, 2021). However, these technologies are also known by their costly installation and efficiency related concerns (Ciarreta, Gutiérrez-Hita, & Nasirov, 2011). Therefore, the significance of support mechanisms (e.g., grants, subsidies, green certificates) and effective policy designs to promote the diffusion of renewable energy sources by reducing costs is emphasised in the literature (Newbery, 2018; Polzin, Egli, Steffen, & Schmidt, 2019; Qadir, Al-Motairi, Tahir, & Al-Fagih, 2021).

Furthermore, Geels, Sovacool, Schwanen and Sorrell underline that policies to move away from a high carbon intensity regime are at least as crucial as regulations to facilitate renewable energy innovations, and they note the risk that such removal policies may face political resistance. The authors suggest emission regulatory policies and carbon taxes as examples of such measures (2017).

In the past, economic evaluations of coal, natural gas and nuclear power plants ignored negative externalities such as carbon emissions and radioactive waste, and this meant that renewable energy technologies could not compete with such conventional power plants (May & Neuhoﬀ, 2021). “From a theoretical viewpoint, the efficient solution for establishing competition

between the two types of generation technology is through a tax or environmental tax to penalize polluting technologies and to subsidize those that generate clean energy” (Ciarreta, Gutiérrez-Hita, & Nasirov, 2011, p. 2518).

Menges also touches upon some quota and certificate models as market-based instruments to support renewables and claims that these policies are focused on quantity rather than price. Also, he takes environmental quality as a common good and justifies policy measures by market failure, emphasising the governments’ responsibility in this regard (2003). Other instruments commonly seen in liberalised markets, such as feed-in tariffs (FiT), feed-in premiums (FiP) and power purchase agreements, are financial schemes that promise payment guarantees to producers against market prices. (Blazquez, Fuentes-Bracamontes, Bollino, & Nezamuddin, 2018). To summarise, it is clear from the literature that all these regulatory policies and financial incentives aim to support generation from renewables and level the playing ground against the externalities of fossil fuel-based electricity generation, that traditionally enjoys economies of scale and established market positions which Owen (2006) discusses in his study. The following table gives an overview of these policies.

Regulatory Policies	Administratively set pricing instruments (FIT-FIP)
	Competitively set pricing instruments (Auctions)
	Quotas and certificates (e.g., RPS, RPO, renewable electricity certificates)
	Net metering/billing
Financial and Fiscal Incentives	Investment grants/Subsidies
	Tax incentives
	Loans

Table 1. Policies for Renewables in Power Sector (adapted to this study from IRENA, IEA and REN21 (2018))

Higher carbon prices, cheaper financing costs and local acceptance reinforce renewable resources competitiveness, whilst raising questions about investments in fossil fuel-fired power plants, their operating costs and long-term sustainability over time (May & Neuhoff, 2021). However, even though the process has moved in favour of renewables, the following paragraph illustrates that the impact of growing renewables on electricity markets raises some concerns about financial viability.

Blazquez, Fuentes-Bracamontes, Bollino, and Nezamuddin argue that the substantial deployment of renewables results in lower wholesale electricity prices with more volatility, mostly in liberal electricity markets like in Europe, due to their merit order effect and relatively low marginal costs. They criticise that this could potentially lead to market distortion and greater costs with additional subsidies and elaborate with some example cases like Germany. The same authors go further and introduce '*the Renewable Energy Policy Paradox*'. According to this concept, renewable energy policies can successfully stimulate the growth of renewable power supply in the short term. Nevertheless, the same policies can become less effective as the share of renewable energy increases. This issue arises in liberalised markets due to the intermittency of renewables and limitations of market design. Moreover, it raises questions about the feasibility of achieving full decarbonisation due to the failure to capture appropriate price signals in the absence of traditional electricity generation systems. Theoretical and practical explanations of this paradox underscore the need for additional policy and regulatory support to sustain renewable investments (2018). At this point, in its report assessing the organisational framework of the power system for the energy transition in a renewable future, IRENA (2022b) points out that government-led energy policy instruments reinforce the trend towards convergence between liberalised and regulated structures.

Especially across Europe, renewable energy investments towards the decarbonisation of electricity sectors are on the rise, and different policy and incentive instruments are in place to promote these investments (Pacesila, Burcea, & Colesca, 2016). The article by Kilinc-Ata (2016) examines the impact of renewable policy instruments on increasing the capacity of renewable energy sources in EU countries. The author's conclusion underscores the significance of most of policy instruments as powerful tools for advancing renewable energy adoption, but she notes that their effectiveness varies from country to country depending on the type of policy.

Furthermore, in their paper analysing the financing of variable renewable energy technologies in the UK, the Netherlands, and Poland and the various underlying dynamics, Iskandarova et al. (2021) indicate that focusing on the content of policies that promote renewable technologies solely cannot be sufficient and institutional settings and governance factors are also crucial in terms of shaping and implementing such support mechanisms. In this framework, the following section will cover the studies in the literature that focus on these dynamics.

2.2 The Role of Governance and Institutional Structure on Policymaking

The previous section discusses the patterns of renewable electricity policies within evolving market designs in the literature. However, sustainability transitions in energy sectors require a deliberate long-term planning owing to their intricate, multi-dimensional nature, involving diverse technologies, and multiple actors (Moallemi & Malekpour, 2018). This level of complexity generally brings about more than one policy as well as further strategies and different types of technologies to facilitate a transformative shift (Edmondson, Kern, & Rogge, 2019). Additionally, to make these policies well-functioning and to drive innovation, a favourable environment that includes adaptability towards transition in all governance aspects of power systems is vital (Lockwood, Mitchell, Hoggett, & Kuzemko, 2017).

Foxon, Hammond and Pearson states that: “The ‘governance’ of energy systems involves choices made by different actors within the sector, such as national and local policymakers, large firms and new entrants, financial investors and end-users, that give rise to changes to the system” (2020, p. 114). According to same authors, such actors pursue their own goals in the various phases of electricity generation based on different interests, which can either conflict or align during decision-making processes. Institutions also play a determining role in guiding and governing these processes through various regulations and arrangements (2020).

Scholars working on the governance of energy transitions have emphasised the significance of looking at politics beyond policy itself owing to its political character, and they also added that theoretical frameworks established by political scientists to clarify the dynamics underlying policymaking can be used to gain a deeper understanding of these processes (Lockwood, Kuzemko, Mitchell, & Hoggett, 2016; Geels, Sovacool, Schwanen, & Sorrell, 2017). For instance, according to Hall (1993), the policymaking process is interconnected and centres around defining goals, choosing the ways to achieve them, and continuously modifying and interpreting these ways to reach the intended outcomes in a particular field.

Ossenbrink, Finnsson, Bening, and Hoffmann's article highlights the importance of policy mixes, their development and implementation processes in sustainability studies. They don't just explain how set of policies and underlying factors can be understood effectively within the top-down approach referring to specific strategic objectives, but also delve into the function of governance forms in system change (2019). At this point, Frank, Jacob and Quitzow(2020) also

touch upon the importance of governance capacities, and cover this concept as follows: “... administrative faculties for policy-making within government, information and analytical capacities of government and non-government actors within the socio-technical system, and political capacities and networks for advocating change” (p. 3).

For neo-institutionalists, on the other hand, political and economic interactions are shaped by institutions through their standardised *practices, rules, and norms* in several ways, creating both avenues and barriers for policy (Kuzemko, Lockwood, Mitchell, & Hoggett, 2016; Finnegan, 2022).

Accordingly, Kuzemko, Lockwood, Mitchell and Hoggett(2016) state that the prevailing acceptance of certain ideas and narratives within institutions is encapsulated by the *policy paradigm* concept, and these sets of ideas eventually become integrated into the governance practices of organisations, both in formal and informal ways, as well as influencing their decision-making processes, and also resulting in preferred policy directions. They also explain after 1980s as neoliberal ideas centred around competition, economic efficiency, and market-oriented narratives dominated not only the economy as the fundamental context but also extended their influence on energy and environmental governance processes, where energy policy choices are formulated. The stories of liberalisation and privatisation of the electricity sectors handled in the previous sections should also be considered within this scope. However according to same authors, it would not be a correct assumption that all industrialised economies embraced the neoliberal paradigm in the same way and shaped their energy and climate policy entirely within this framework and the literature based on neo-institutionalist theory have explored capitalist economies in terms of institutional differences and relation of state with market. It evaluates how costs and benefits are distributed within these systems. Countries like the UK and the United States have generally adopted a less regulative approach, limiting the government’s function to a mediating level when it comes to the private sector. On the other hand, in some countries with a social democracy tradition, such as Germany and the Scandinavian states have more collectively and coordinated shaped interactions with the private sector (2016). Also, institutions are more inclined to use policy mixes that encourage the adoption of new technologies and share investment risks in these countries. (Ćetković & Buzogány, 2016; Rentier, Lelieveldt, & Kramer, 2023).

Besides, how the liberal or social democratic institutional roots of different countries are reflected in renewable energy policies is one of the main focal points of this study. Notably,

publications on Germany and the UK are prominent in this area. For instance, Toke and Lauber (2007), assess the British and German renewable energy policies in the light of the ideologies that form their institutional context. Similarly, Geels (2016) discusses the change in these policies over time by both considering the transition to renewable electricity as a socio-technical transformation story using MLP and focusing on the relations between different institutions, actors, and each other.

These studies indicate that the unique approaches, the institutional frameworks, and actor relations of both countries have played a decisive role in designing and pursuing their respective renewable energy policies and system transitions. The UK has mainly relied on market actors, whereas Germany has more stressed the involvement of small participants and new entrants to drive its power sector transition to renewables, with a focus on internalising external costs (Toke & Lauber, 2007; Geels, et al., 2016). Correspondingly, Germany's renewable energy policies, including FiT subsidies, prioritised public interest and aligned with the social market economy and ordoliberalist approach. Meanwhile, the UK used policy tools like certificate trading schemes for renewables that connect environmental goals with market-oriented ideas (Toke & Lauber, 2007). Additionally, Laes, Gorissen, and Nevens also included the Netherlands in the comparison list alongside the Germany and UK, discussing their governance strategies on energy transition. They examined Dutch *Transition Management (TM)* governance approach, which is based on mixed policy coordination mechanisms of different actors to steer the energy transitions intentionally (2014).

Furthermore, Kuzemko, Lockwood, Mitchell, and Hoggett also note that different domestic political dynamics should not be disregarded. They point out that in places with inclusive *proportional representation electoral systems* where green parties are more visible, environmental concerns may find a broader place in energy policies (2016).

On the other hand, Kern, Kuzemko, and Mitchell (2014) analysed the UK's energy policies and portrayed the conditions that lead to paradigm shifts. They argue that relying on conceptual approach based on *paradigms* alone may overlook some crucial changes and suggest that a more comprehensive understanding can be achieved by also studying the literature on sociotechnical transitions. The implication of authors here for the improvement of the literature in this direction reveals a gap for new research, emphasising one of the main starting points of my study.

2.2.1 Studies addressing policies and governance for renewable electricity in the UK and the Netherlands

Apart from the comparative studies including the UK and the Netherlands, some of which are mentioned above (Laes, Gorissen, & Nevens, 2014; Kern, Verhees, Raven, & Smith, 2015; Iskandarova, et al., 2021); there are also other papers in the literature that address renewable energy and electricity policies for the UK and Netherlands separately and examine them from various aspects. Woodman&Mitchell (2011) and Wood&Dow (2011) focused on the *Renewable Obligation* policy instrument in the UK, while Welisch&Poudineh (2020) evaluated the more recent auction system(*CfD*) through offshore wind. Smith, Kern, Raven, & Verhees (2014) investigated solar PV developments and the implemented *FiT* policy in the country. Foxon, Hammond and Pearson (2020) presented the story of the socio-technical transformation of the British power system by putting emphasis on actors and transition pathways.

In addition to Rooijen and Wees (2006) on green electricity policies in the Netherlands, Niesten, Jolink&Chappin (2018) and Abolhadi (2017) assessed Dutch policy instruments for renewables like *MEP* and *SDE* in the context of wind energy. Furthermore, the IEA's related report provides a comprehensive and updated overview about the whole Dutch energy system (2020).

Also, Lockwood, Mitchell and Hoggett (2022) analyses the evolution of the UK energy system in terms of its governance approach in the relevant chapter of the *Handbook of Energy Governance in the Europe*, while another chapter by Musch (2022) conducts a similar analysis for the Netherlands case.

2.3 Summary

The literature shows that policies play a pivotal role in accelerating renewable transition of power sectors, and market-based mechanisms have gained importance. However, finding the right balance between renewable and traditional sources by anticipating the possible consequences of the change process and designing effective policies that align environmental objectives with market functioning are essential. Exploring alternative market structures and incentive schemes is also significant to achieve a sustainable transition. Further research is needed to broaden insights into governance approaches, institutional diversity, and the role of politics alongside policies in addressing energy-related challenges. This would help uncover various underlying logic that are present in different countries. Comparative studies move

insights forward in this sense. As this chapter has revealed, although articles in the literature compare the Netherlands and the UK regarding energy policy and governance, more recent studies comparing only these two countries should be developed. To this end, this study will assess and compare the evolution of the power generation sectors of both countries by focusing on their renewable electricity policies.

3. Research Design

This chapter outlines the research design underpinning the study to comparatively assess the UK and Dutch policies for renewable electricity and their transformation. It will first explain the *Socio-Technical Transitions Theory* and *Multi-level Perspective* as the theoretical framework on which my research will be grounded. Then, it will explain the methodology carried out.

3.1 Theoretical Framework

In the previous chapter, it was explained in detail why it is crucial for energy infrastructures, especially the electricity generation systems, to switch to sustainable alternatives. It was also highlighted how complex this process can be. Therefore, this study employs the social-technical transition theory and its related concepts to analyse the complex nature of the electricity system shift and the underlying factors.

3.1.1 Socio-Technical Transitions

According to Geels, socio-technical transitions encompass more than just upgrading or altering technological systems. They also indicate modifications in social conventions, behavioural tendencies, institutions, and actor interactions. The primary objective is to comprehend how novel innovations and technologies can pose a challenge and create upheaval in established systems and how they reshape social functioning throughout the process (2004).

Since technological structures contain components that are deeply rooted over long periods of time and established practices, it is unrealistic to expect new technologies to cause sudden change from today to tomorrow; and it means that, to ensure a successful energy transition, it is imperative to first modify these existing elements and well-established routines (Markard, Raven, & Truffer, 2012).

“The electricity sector can be conceptualised as a socio-technical system, which consists of technologies, organisations and institutional structures” (Markard, 2018, p. 630). Therefore, addressing electrical systems in this context may allow a more informed and effective engagement in planning and policy making in energy sector, helping to overcome technological, institutional, and societal barriers and identify opportunities for adopting innovative and sustainable technologies.

In recent years, the Multi-Level Perspective has emerged as a well-structured and insightful tool for analysing and understanding socio-technical transitions (Geels, 2020). Therefore, it has been chosen to use this framework for conducting analysis since this study will basically deal with the renewable transition of power systems as a socio-technical system and relevant policies. The following section presents the key points which shed light on this research in the Multi-Level Perspective.

3.1.2 Multi-Level Perspective

Geels has taken a multi-disciplinary approach to unpacking complex elements underlying socio-technical transitions, drawing from evolutionary economics and technology studies. Therefore, same scholar integrated evidence from diverse literature and introduced a perspective that considers various levels of technological shift (2002). This set of levels, labelled as the Multi-level Perspective (MLP), is an analytical depiction of the layers of change (Figure 2).

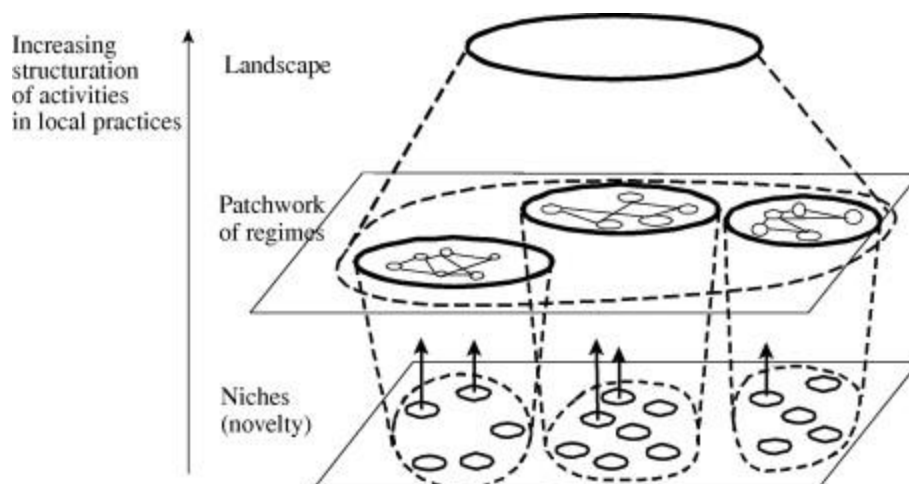


Figure 2. Levels of Multi-Level Perspective (Source: Geels (2002))

The landscape level affects both levels but categorises a broader context that points explicitly to external disposition (Geels, 2011). These may include macro-political developments and globalisation in the axis with neoliberal ideas, as well as international agreements, general political course in conjunction with demographic-cultural values, responses to crises emerging such as climate change and various other factors, events and circumstances that pose pressure for change on the current regime. Also, the implication of landscape developments on the niche side, such as contributing to an environment suitable for sustainable technologies and creating opportunities for them, should not be ignored (Bilali, 2019). Additionally, it is another fact that it takes quite long periods of time to observe such a level of change and its influences (Geels, 2011).

The socio-technical regime, on the other hand, identifies another analytical level in transition studies using MLP. It contains components that help explain the stability of a working socio-technical system (Geels, 2011). These include the actors and institutions with formal and informal rules and the established system's technical infrastructure and at this level, tangible rules based on legislation, like regulations and standards, are intertwined with intangible aspects such as policy paradigms and social norms (Geels, 2011; Bilali, 2019). Regimes are shown as prone to preserve their existing order against change, and innovations at this level are limited (Geels, 2019). "Stabilizing strategies used by regimes include lobbying as well as the formation of networks and alliances" (Bilali, 2019, p. 9). Large structures, comprising intertwined and interconnected layers of technological subsystems, such as electricity generation, have a far-reaching spectrum of influence, from institutions to end-user behaviour, and system-related dynamics show a strong tendency to *lock-in* discouraging the transition to a low-carbon energy infrastructure (Unruh, 2000).

Lastly, the niche level corresponds to *protected spaces*, which constitute the bottom layer of change. Radical and innovative initiatives are positioned at a level where intensive R&D activities take place, and successful ones can move to the higher level, thereby changing the existing regime (Geels, 2011; Dóci, Vasileiadou, & Petersen, 2015). However, this may require coping with a variety of challenges, such as altering user habits and upgrading infrastructure (Geels, 2011). Also, Fuenfschilling and Truffer (2014) state that protection at this point may be accomplished in some ways, like adjustment of the institutional environment or with the help of regulatory instruments like grants for R&D.

“Transitions are defined in the MLP as shifts from one socio-technical regime to another” (Bilali, 2019, p. 2). Now, in the overall picture, to destabilise and shift the regime in favour of niches, the landscape level brings *windows of opportunity* by exerting pressure on the regime from above. In contrast, developments at the niche level force the regime with new urges from the bottom (Geels, 2002).

Increasing structuration
of activities in local practices

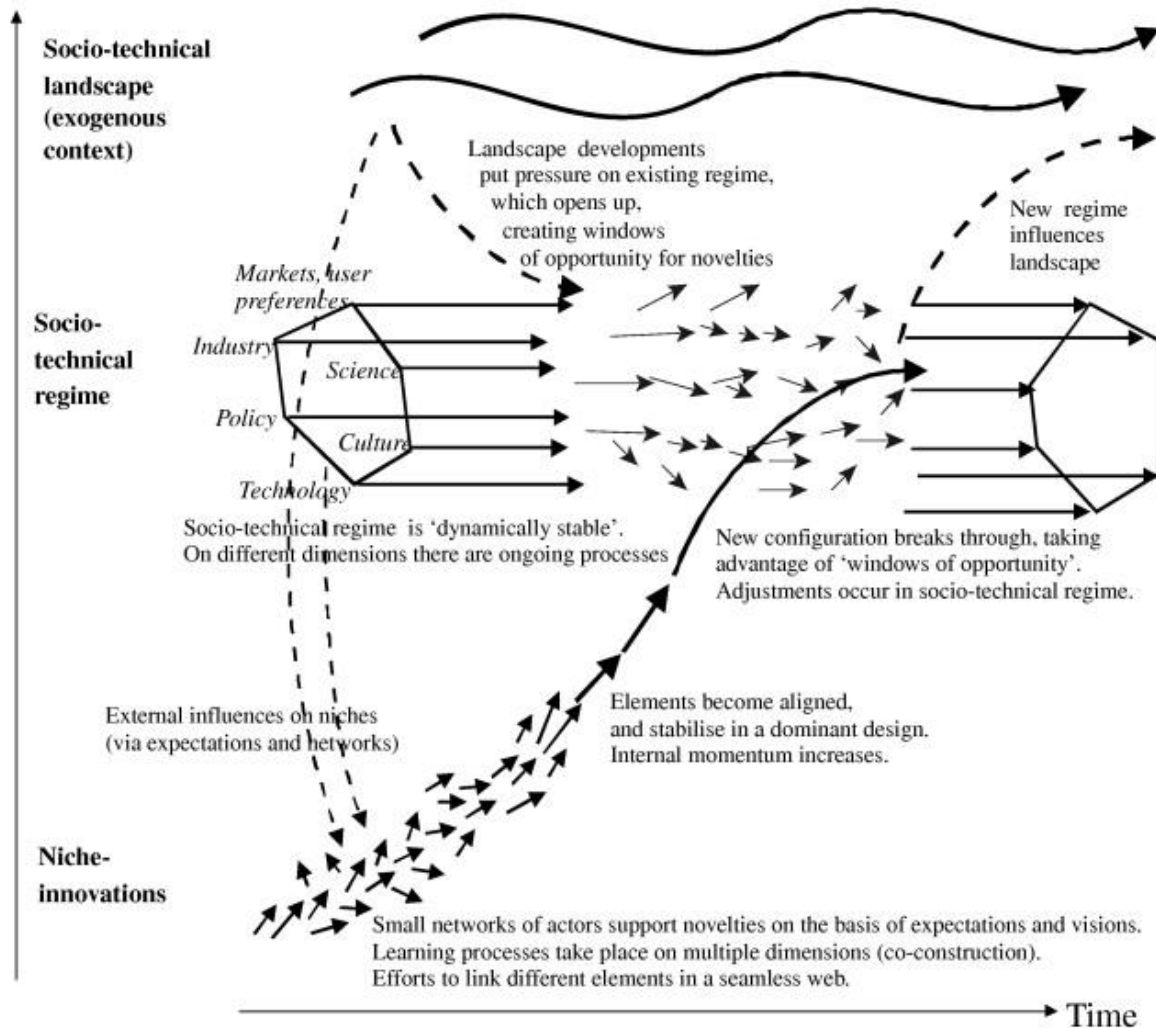


Figure 3. Transition process in MLP (Geels, 2011).

As can be seen from Figure 3, this process of socio-technical shift is not linear. Therefore, it takes place in four stages as '*emergence, take-off, acceleration and stabilisation*', and can follow different *pathways* of change according to the dynamics of the interactions between the levels (Geels, 2011).

To conclude, the case studies in this dissertation will examine the journey of wind and solar PV technology from niche to regime in selected countries and their policies to protect and stimulate the relevant technology. In this regard, the main interest will be on electricity production only, instead of the whole power system. For this reason, I adapt two simplifications applied by Geels et al.(2016) in their relevant article due to similar case limitations to this study. These simplifications in the socio-technical analytical framework for empirical investigation involve a closer focus on the following:

- (i) “technologies rather than broader systems
- (ii) formal rules and institutions rather than normative and cultural-cognitive institutions” (p. 898).

In this way, I aim to explore the technological changes and the governance processes associated with institutional ideas/rules in the renewable transition process with more detail. However, it should be noted that this simplification involves some limitations to the analysis of the *interpretative* aspects of the topic (Geels, et al., 2016).

3.2 Methodology

This research will use a comparative case study to understand the characteristics and dynamics of different sociotechnical transformations towards sustainability, as it will mainly address the diffusion of solar and wind technology in the electricity systems of the two countries.

“Adjustment to a new technology”, which this study also deals with, is listed by Sovacool, Axsen, and Sorrell (2018) as one of the examples of case studies, and given the definition of these types of studies as follows: “Case studies involve in-depth examination of particular subjects or phenomena as well as related contextual conditions, often using multiple sources of evidence (e.g. documents, interviews, direct observation” (p. 30).

In this qualitative research, while exploring the evolution of electricity systems, with a primary focus on policies for renewable electricity, I will uncover the broader internal and external factors at play in this process in light of MLP introduced in the previous chapter. Table 2 shows detailed distribution of the factors that this study will focus on analytically by MLP levels.

Scale	Analytical Focus on
Landscape	- Climate Commitments & Agreements - Paris, Kyoto, EU commitments for decarbonisation etc. - Domestic Political Trends / Governments and Coalitions
Regime	- Power Generation Market Structure from 2000 to 2020 - Governance Structures - Institutions - Policy Paradigms
Niche	- Policies for Renewables - Strategies, Regulatory Arrangements, Subsidies, Incentives - Key Developments related Solar PV and Wind Turbine Technology - New Technologies for more renewable penetration - Energy Storage Tech, Grid Technology Developments etc.
Years:	2000 2005 2010 2015 2020

Table 2. Factors this research handled based on levels of MLP. (Prepared by author based on (Bilali, 2019))

Before 2000, the share of electricity from renewables was insignificant in both countries (Our World in Data, n.d.b). Moreover, plans and efforts for transition are driven by a wide range of other factors, whose consequences are realized over long time periods (Geels, et al., 2016). For these reasons, I limited my unit of analysis to the renewable electricity policies of the two countries between 2000 and 2020.

My research question, which I have outlined earlier, will serve an *explanatory* purpose, as it is essentially seeking to provide an answer to *why* these systems have evolved differently, explaining strategies and policies used by the two countries for transitioning to renewable electricity (Zainal, 2007). This directly affects the data collection methods that I will use to conduct the research.

I used the '*Policies Database*' by the IEA (<https://www.iea.org/policies>, (IEA, n.d.)) which comprehensively covers the energy policies of member countries over time, as the primary source for obtaining key policy instruments for solar and wind-based renewable transition in the electricity sector. To identify appropriate energy policies for my study, I used filtering tool on the website. I selected the 'UK' for country categories, '*Electricity and heat generation*', '*Power generation*', '*Power, Heat and Utilities*' and '*Economy-wide (multi-sector)*' for the sector category, and '*Renewable Energy*' for the topic category. After applying these filters, I was able to select 23 national policies related to solar and wind technologies between 2000 and 2020 for the scope of my study. I repeated the same procedure for the Netherlands and extracted 22 national policy instruments that deal with solar and wind technology for electricity generation.

However, even if the key policy documents of the sector provide important information about the intentions and efforts of countries, more than considering them alone will be required to capture the overall picture of the energy transition. Therefore, a holistic view of the cases is sought by drawing on various other reliable secondary sources such as books, academic journals, articles, websites, and reports from various national and international organisations to take into account other developments such as historical, political, societal, economic, etc.

As a result, it will be aimed to make a comprehensive analysis by drawing insights from the policy documents obtained from the database, but not relying just on them, and also reviewing the literature around these policies.

3.2.1 Methods

3.2.1.1 Comparative Case Analysis

This study will conduct a comparative analysis to test the research question of the obtained qualitative data from policies and literature as well as quantitative statistics related to electricity sectors.

According to Liu, countries implement various policy combinations and legislative arrangements to support renewable energy concerning the goals and strategies adopted in their contexts. The comparative analysis method, which deals with multiple situations that may cover multiple times and places, is perfect for studying the policy environments of different countries and the factors that influence them (2019). The routes indicated by these policies and their closely related governance approaches are worth comparing regarding the experience and lessons they provide in the transition to low-carbon future (Laes, Gorissen, & Nevens, 2014). Consequently, within the possibilities allowed by comparative research, it is essential to recognise the policies that paved the way for the development of renewable electricity generation in both countries and their political, institutional, and social context in which these policies were formulated and enforced, and to analyse their similarities and differences.

3.2.1.2 Case Selection

The United Kingdom and the Netherlands were identified and analysed as cases for several reasons. The Netherlands, with nearly 18 million population and a GDP of 991 billion, and the UK, with a population of around 67 million and a GDP of 3.07 trillion (WORLDBANK, 2022), stand out as two important countries of Northwest Europe. Beyond the socio-economic context, the two countries also exhibit some similarities in their energy profiles. Despite some geographical differences, they have generally relied on fossil fuels, especially natural gas,

although the Netherlands has shown a greater dependence on it (Bhattacharyya, 2009). And natural gas is still the most important source of electricity in both countries, with a share of around 40% (Our World in Data, n.d.c). So, it can be inferred that the rise of renewable electricity is taking place in a similarly dominant natural gas electricity regime in both countries, which makes the comparison between the UK and Netherlands more sensible.

However, what is more interesting is the rapid decline in the share of coal, which stands out as the second most important resource for both countries, while renewables have grown significantly over the last decade (Our World in Data, n.d.d; Our World in Data, n.d.e). In particular, both countries have become the world's foremost electricity producers from offshore wind (Díaz & Soares, 2020).

Alongside these similarities, several points regarding the different political and institutional legacies of these two countries that affect their governance approaches were pointed out in the literature review chapter.

These factors make these countries attractive options for exploring how different energy governance approaches shape their policies for renewable electricity and thus transform differently the electricity system (Figure 4).

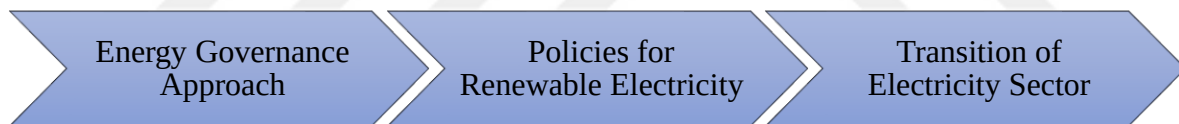


Figure 4. The core research idea (prepared by author)

In this respect, the results of this study are expected to reveal valuable clues in exploring the transition away from fossils and the adoption of renewable electricity sources through different policies adopted by different countries in their own contexts.

3.3 Limitations

I do not have an accessibility issue as I will focus on publicly available and transparent policy documents and existing academic literature. However, the review, compilation and analysis process have a time cost. Due to the time constraints of the dissertation and the difficulties involved in contacting experts in the energy sectors of two different countries in this limited time, I turned to secondary sources instead of conducting interviews and surveys. Future studies can capture deeper insights by using interviews and surveys to obtain purposeful data directly

from primary sources. Another reason for not focusing on policies before 2020 is to avoid exceeding the word limit required by the dissertation, while the two countries already considered offer a rich policy history. Additionally, since I do not have a Dutch language background, the documents, and articles I drew upon in this study about the Netherlands case are limited to publications in English. This implies relatively less in-depth research, notably for the Dutch case.

4. The Case of the UK

4.1 Landscape Drivers

The UK has been actively involved in global climate change efforts. The Kyoto Protocol, adopted in 1997, was a key milestone. As a party to the Protocol, the UK pledged to reduce emissions by 12.5% below 1990 levels during the 2008-2012 phase (UK NAEI, 2022). So, this commitment laid the foundation for the UK's subsequent climate policies.

The Labor government (1997-2007) led by Tony Blair took important steps towards addressing climate change and renewable energy policies (Geels, et al., 2016). This has been accompanied by increased public attention since the mid-2000s and was able also to unite politicians regardless the political sides on the severity of the matter, thereby laid the groundwork for raising targets within the framework envisaged by the EU and the implementation of the 2008 Climate Change Act (Lockwood, Mitchell, & Hoggett, 2022). Nevertheless, concerns over energy costs and security of supply shifted priorities again due to the impact of the escalating Russia-Ukraine tensions on the markets and the 2008 financial crisis in the world (Geels, et al., 2016). The coalition government that came to power under these circumstances has caused uncertainty for the energy sector and removed or cut subsidies for various renewable projects, particularly onshore wind (Geels, et al., 2016). The most significant landscape development that positively impacted renewables for the UK electricity generation sector in subsequent years was the dramatic cost fall seen globally in solar PV and wind equipment (Lockwood, Mitchell, & Hoggett, 2022). During these years and beyond public and political interest has grown, especially in offshore wind energy, unlike the joint opposition against the onshore wind (Kern, Smith, Shaw, Raven, & Verhees, 2014). The Paris Agreement marked another breakthrough for the UK, as the government ambitiously updated its targets in line with its mid-century net zero carbon emissions strategy and pledged to phasing out coal-fired power plants by 2024 (Walk & Stognief, 2022). Most recently, the governments of Theresa May and

Boris Johnson have also declared their willingness to support decarbonisation and low-carbon innovative technologies (Dell'Aquila, Atzori, & Stroe, 2020). Thus, the UK's engagement in these international agreements and the emphasis on clean energy sources by successive governments have provided a roadmap for the country's climate, energy and renewable electricity policies and led to significant changes in the electricity system landscape, affecting sociotechnical regime and niche levels.

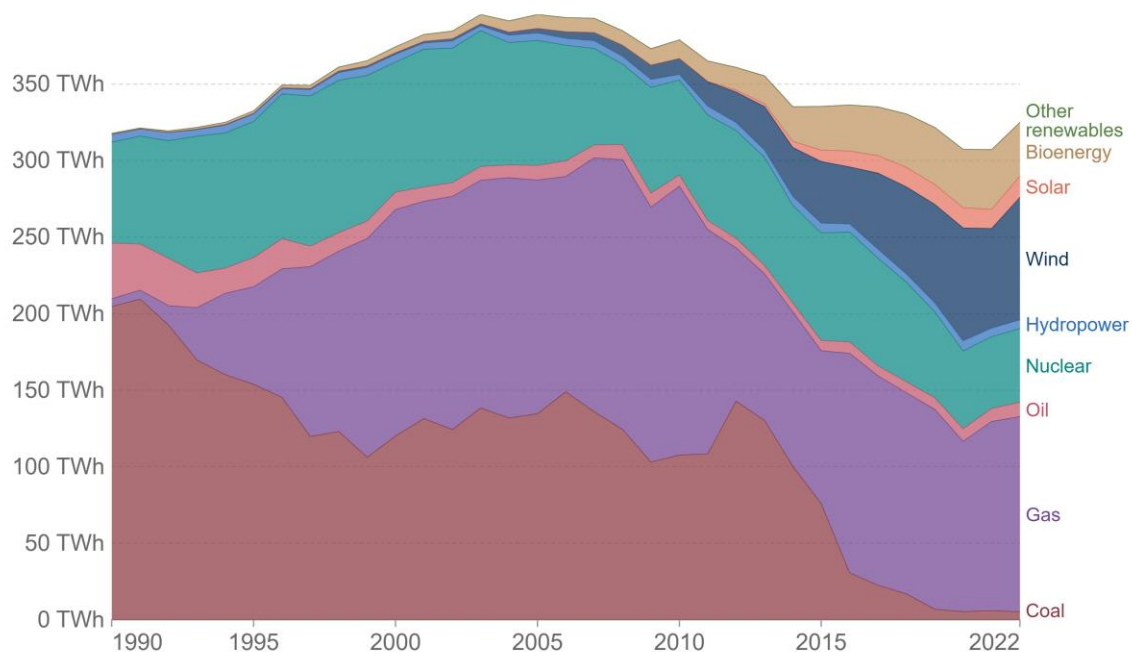
4.2 Regime Level Analysis

This section presents the market structure of the UK electricity regime and details of the energy governance approach with relevant institutions and actors.

4.2.1 Power Generation Market Structure

Over the two decades, the UK's electricity generation mix experienced a significant transformation. The process that followed the liberalisation of the electricity sector witnessed a "dash-for-gas" in the 1990s, but until that time, electricity generation was largely dominated by centralised and large-scale coal and nuclear power plants (Alderson, Cranston, & Hammond, 2012). Thereafter, the growth in total power generation was accompanied by an increasing amount of electricity from natural gas as Figure 5 shows. In contrast coal generation almost halved in the early 2000s compared to 1990 levels (Our World in Data, n.d.d). After this year, generating electricity from coal, which has experienced fluctuations after this year, is almost over in 2020 with remaining only two power plants in the entire country while renewable energy policies have borne fruit and green electricity investments have shown a steady rise during same period (Yang, Zhang, Zhao, Zhao, & Yuan, 2022).

Electricity production by source, United Kingdom



Source: Ember's Yearly Electricity Data; Ember's European Electricity Review; Energy Institute Statistical Review of World Energy
 Note: 'Other renewables' includes waste, geothermal, wave and tidal.
 OurWorldInData.org/energy • CC BY

Figure 5. Power Generation by source in the UK between 1990-2022(Our World in Data, n.d.d)

Therefore, renewables provided more energy than fossil fuels for the first time in 2019, significantly contributing to the steadily declining carbon emissions in the electricity sector (Yang, Zhang, Zhao, Zhao, & Yuan, 2022).

Although energy transition was one of the primary goals throughout the process, natural gas and nuclear energy have been seen as strategic resources and have continued to be promoted by government actors as low-carbon technologies with a centralised approach; also, these sources were further supported by new additional technologies and have largely maintained their share in the electricity mix until today (Lockwood, Mitchell, & Hoggett, 2022; Keay, 2016).

4.2.2 British Energy Governance Approach and Institutions

Several institutions and actors were at work in the UK for transitioning to renewable electricity. Although the central government has devolved some of its authority for the electricity regime to sub-government and municipalities, the centralised role and hierarchical dominance of the

government inherited from the *Westminster* tradition has remained over the energy and electricity system (Cowell, Ellis, Sherry-Brennan, Strachan, & Toke, 2017).

Following the liberalisation of energy markets, the *Department of Trade and Industry (DTI)* was the foremost institution for energy-related policies, and its authority is switched to *The Department of Energy and Climate Change (DECC)*, was established in 2008. But this ministry did not last long and after 8 years the *Department for Business, Energy & Industrial Strategy (BEIS)* took the responsibility. (Lockwood, Mitchell, & Hoggett, 2022). *The Climate Change Committee (CCC)*, also founded in 2008 in an independent status, have provided expert advice to guide emission reduction strategies for a low-carbon future for electricity and other sectors (Hammond & O'Grady, 2014). Its impact on the budget also makes the *Treasury* one of the key institutions in fiscal incentives for renewables (Cowell, Ellis, Sherry-Brennan, Strachan, & Toke, 2017). Local governments have had limited authority and resources despite their involvement in some planning procedures and steps taken in favour of decarbonisation at the local scale (Lockwood, Mitchell, & Hoggett, 2022). In addition, the independent commercial organisation the *Crown Estate*, which manages numerous property areas on behalf of the Crown, is a major player in terms of coastal rights of occupation for offshore wind energy developments (The Crown Estate, n.d).

The conditions of privatisation required an independent regulatory body to ensure fair competition and protect consumer interests. *The Office of Gas and Electricity Markets (OFGEM)*, which emerged for this purpose, is responsible for the supervision of the sector and sets regulations and licensing conditions for electricity suppliers and network operators (Rotaru, 2013). Apart from the '*National Grid*', functioning as the grid system operator, a number of companies responsible for the generation and supply of power are engaged in the UK electricity market, and the 6 incumbent companies also mentioned earlier have controlled the market with their large installed capacity, giving them substantial lobbying power on policies over time (Lockwood, Mitchell, & Hoggett, 2022). Finally, small renewable energy producers and cooperatives have become more visible in the post-2010 environment, yet they have remained subdued amidst a series of institutional contradictions in the following period. (Iskandarova, et al., 2021). NGOs have been instrumental in raising the voices of environmental concerns, which have struggled to find a chance for representation in parliament because of the majoritarian electoral system (Carter, 2014).

As a result, institutions which internalise liberalisation and embody efforts to combat climate change together with the decarbonisation of the electricity system stand out and the structure of government is essential. Concerns about security of supply also affect the country's energy governance and policy choices (Corner, et al., 2011). The roles played by the institutions introduced in this section for the transition to renewable solar and wind systems in electricity generation will be mostly mentioned in the following niche level assessment.

4.3 Niche Level Developments

4.3.1 Policies for Renewables

Since the early 2000s, the UK has implemented a range of policies to support the growth of renewable electricity. While some policies have directly targeted generation from solar and wind, most of the policies cover a more comprehensive range of renewable electricity sources. This section looks at these policies and the strategies pursued in the relevant period, giving clues to the interaction between the institutions and niche innovations.

4.3.1.1 Long-Term Strategies and Programs

Contributing to the decarbonisation of electricity generation through renewable technologies has been one of the pillars of the British transition story. Prior to 2000, the "Non-Fossil Fuel Obligation", which primarily focused on nuclear energy as well as renewable sources, stood out as legal legislation (Mitchell, 2000). The emphasis on increasing electricity supply from renewables was made in a tangible sense in the document published in 2000, which addressed the renewable obligation policy as a draft plan. According to this, 10% of the power generation was targeted to come from renewable energy sources by 2010 (IEA Policies Database, 2013a). The *National Renewable Energy Action Plan (NREAP)* published in the following years also brought new adjustments in accordance with directives of the EU, hence the government updated its target for renewable electricity to 30% for 2020 (DECC, 2010).

The plan highlights three critical aspects of the country's renewable energy strategy, which is noteworthy for their scope:

- (i) "Financial support for renewables
- (ii) Unblocking barriers to delivery
- (iii) Developing emerging technologies" (DECC, 2010, p. 6).

The further sections of the relevant strategy paper go on to assess existing and potential policy measures further chapter to fulfil this framework.

In recent years, the Paris Climate Agreement and the government's net-zero strategy have set the goal of decarbonising the electricity sector like other sectors by 2050, but the government ambitiously revised this target later for the electricity sector for 2035 (UK Government, 2021).

4.3.1.2 Support Instruments for Intermittent Renewables

Table 3 lists the key solar and wind energy-related policies implemented by the UK electricity generation sector between 2000 and 2020, according to their types and status.

Years	Policy Instrument	Policy Type	Status
2000	Renewables Obligation Plan	ST	Ended
2001	Climate Change Levy	FFI	In Force
2002	Renewables Obligation (RO)	RP	Ended
	Offshore Wind Capital Grants Scheme	FFI	Ended
	Major PV Demonstration Programme	FFI	Ended
	Energy Technology Programme	R&D	Ended
2003	Renewable Energy Guarantees of Origin (REGOs)	RP	In Force
2004	Energy Act 2004	ST	In Force
2006	Microgeneration Strategy	ST/FFI	Ended
	Low Carbon Buildings Programme	FFI	In Force
2007	Energy Technologies Institute	R&D	Ended
	Environmental Transformation Fund (ETF)	FFI	Ended
2008	Energy Act 2008	ST	In Force
	Climate Change Act 2008 as Amended		
2009	Low Carbon Transition Plan	ST	Ended
	Renewable Energy Strategy	ST	In Force
	Low Carbon Industrial Strategy (LCIS)	ST/R&D	Ended
2010	National Renewable Energy Action Plan (NREAP)	ST	In Force
	Feed-in Tariffs for renewable electricity for PV and non-PV technologies	RP	Ended
2011	Energy White Paper 2011	ST	Ended
2013	Green Deal	ST	Ended
	Electricity Market Reform (EMR) - Contracts-for-Difference (CfD) - Capacity auctions - Emission Performance Standard (EPS) - Carbon Price Floor (CPF)	RP	In Force
2014	Contract for Difference (CfD)	RP	In Force
2020	Ten Point Plan for a Green Industrial Revolution - Point 1: Offshore Wind Power	ST	In Force

Table 3. Policies for Renewables (wind and solar) in the Power Sector of the UK between 2000 and 2020 ST: Strategy & Target RP: Regulatory Policy FFI: Fiscal & Financial Incentives R&D: Research and Development Policies (Adapted from IEA Policies Database (IEA, n.d.))

A tax scheme covering various sectors and involving different taxation rates for different energy products consumed was launched(*Climate Change Levy*) in 2001 (IEA Policies Database, 2017). Under this scheme, renewable electricity producers were supported by receiving payments through a *tax exemption certificate* (Dell'Aquila, Atzori, & Stroe, 2020).

In the subsequent years, some grant programmes were announced, which included the financing of some initiatives to stimulate the expansion of offshore wind farms and solar PV technology as innovative and infant technologies (Offshore Wind Capital Grants Scheme, Major PV Demonstration Programme) (IEA Policies Database, 2014a; IEA Policies Database, 2014b).

In addition, the Energy Act 2004 not only designated *Renewable Energy Zones* for offshore wind projects, covering several coastal areas of the island, but also enacted detailed legislation to provide a favourable environment for the further advancement of this technology (IEA Policies Database, 2019a).

In 2002, an obligation system for renewables which was designed as a type of renewable portfolio standard, was introduced and served as the primary national support mechanism for renewable electricity generation in the UK during the first decade of the millennium. (Wood & Dow, 2011).

In their studies, Soroush et al. elaborate on several aspects of this support model. Accordingly, it was envisaged that certificates(ROC) would be awarded to the relevant producers for 2 decades regardless of technology and based only on the amount of electricity produced from specific sustainable sources, including wind and solar PV. At the same time, an obligation was imposed on electricity suppliers to submit to the Ofgem annually these certificates corresponding to a certain proportion of the electricity they supply. The rate was 3 per cent in the year it came into force and increased over time with new adjustments. This meant that electricity suppliers agreed to either purchase ROCs from any eligible green electricity producer if they do not generate their renewable electricity or pay a penalty of £30 for each megawatt-hour they cannot fulfil (2022).

Essentially, the main idea was to mobilise financial support for renewable electricity projects in a market-driven way through tradable ROCs that were sold by producers (Stennett, 2010).

However, beyond its complex structure, the inefficiency of the plan was also criticised in some ways during its implementation period (Woodman & Mitchell, 2011).

According to Lipp's research, unlike some European countries which adopted different fixed tariffs for renewable technologies as their support system in similar periods, the focus of the RO scheme operated in the UK was based on the quantity of electricity that had to be purchased. The price thus arose under market conditions, not through government involvement. Due to similar market-based rationales, there was neither discrimination nor prioritisation based on the type and nature of the technologies covered (2007). This hindered the fair distribution of risks across energy actors and favoured large-scale companies as well as low-cost established technologies over new entrants (Woodman & Mitchell, 2011). In this respect, it is not a coincidence that in the early period of operation of the RO plan, less costly and large-scale investments such as onshore wind gained momentum (Geels, et al., 2016). However, in the following period, this technology lost popularity with increasing local opposition due to various concerns, and related investments slowed down (Harper, Anderson, James, & Bahaj, 2019).

Geels et al. evaluate the policies in this era as follows: "Although renewable electricity grew from 3.0% in 2002 to 5.8% in 2008, renewables policy had several flaws, including incentives for utilities to underperform, uncertainties over longerterm policy commitment, and neglect of innovation" (2016, p. 908).

In order to meet long-term emissions reduction targets and to fix some of the flaws in the support system, an adjustment including a banding system was added to the RO plan in 2009 so that more costly technologies at an early stage of development could receive more certificates (and therefore more incentives) after this date (Gürkan & Langestraat, 2014). The subsequent years witnessed a faster growth of offshore wind capacity due to the revamped policy design; nevertheless, we should not forget about the willingness of decision-makers and the coordination of institutional actors such as DECC and the Crown Estate towards institutionalising support for this technology (Kern, Smith, Shaw, Raven, & Verhees, 2014).

The shortcomings and improvements of the RO plan have been discussed so far. However, the growing political significance of climate change put additional pressure on the regime to address landscape-level issues. As a result, new opportunities for niches have emerged. The Feed-in Tariff (FiT) scheme, in this context, was introduced by the government with the political influence of some non-governmental actors such as environmental NGOs in April

2010 to incentivise a range of small-scale renewable installations below 5 Megawatts. (Smith, Kern, Raven, & Verhees, 2014).

Iskandarova et al. investigated this scheme that offered payments to homeowners, small-scale businesses, and communities for the renewable electricity they produced. The payments were received whether the electricity was consumed on-site or exported to the grid within specific periods. The FiT plan made renewable power more financially attractive, facilitating the decentralisation of energy production, notably successful in driving the growth of domestic solar PV deployment. As a result, installing solar panels on rooftops became a common sight across the UK, as many individuals and small initiatives embraced the opportunity to generate their renewable electricity from solar (2021).

However, according to Smith, Kern, Raven, & Verhees, within a few years, this process evolved into a race to grab a piece of the pie as large-scale investors and companies pursued different methods to build larger solar farms to turn the advantageous tariff supports in their favour. The resulting picture provided a justification for the government, which had already been reluctant to introduce a small-scale FiT structure, to revise and limit the support structure (2014). Declining solar costs also played a role in this situation, according to DECC (2012).

Consequently, despite opposition from different quarters, no significant political outcome was achieved and several local community projects and solar PV investments, which had gained momentum under the FiT scheme, were disrupted (Iskandarova, et al., 2021).

As of 2020, the distribution of the capacity of solar and wind installations realised by benefiting from the plan is shown in Table 3.

Type of Technology	Rooftop PV (<50 kW)	Utility-scale PV (50-5000 kW)	Wind (100 kW-5000 kW)
Total Installation Capacity (GW)	3,91	0,97	0,74

Table 4: Total wind and solar PV installations by source receiving support under FiT up to early 2020, adapted from (Soroush, et al., 2022)

When 2019 came, the FiT scheme was abolished altogether, and a new scheme called *Smart Export Guarantee (SEG)* was introduced in the next year, allowing small-scale producers to receive support payments based solely on contracts with suppliers for exported electricity to the grid (Soroush, et al., 2022).

The RO was closed for solar PV and onshore wind projects up to 5 MW in 2015 and 2016 respectively, and eventually the entire implementation was utterly repealed in 2017 (Ofgem, n.d.).

It was replaced by the *Contracts for Difference (CfD)*, which was introduced as a component of the *Electricity Market Reform (EMR)* and become the key support mechanism of the country (Welisch & Poudineh, 2020). Based on contracts signed between owners of projects larger than 5 MW and a state-owned authorised company, the mechanism aims to support a variety of low-carbon technologies for large-scale new deployments (Banja, et al., 2017). The CfD system worked through competitive auctions moderated by the National Grid, where developers bid for contracts, and the projects with the lowest offers win the tenders (Soroush, et al., 2022). Accordingly, investors were contractually secured for 15 years at the auction-derived strike prices. In cases where the market price was lower than the determined price, producers who received payment for the difference are obliged to make a repayment that is reflected to consumers in the opposite scenario (Welisch & Poudineh, 2020). Thus, the CfD scheme not only ensures more stable and predictable conditions for renewable electricity producers against price fluctuations in the wholesale electricity market over the longrun but also protects end-users by preventing a potentially heavier financial burden from being reflected in electricity bills (UK Government, 2015).

Although the plan initially set out separate support structures for established technologies (e.g. onshore wind and solar PV) and early emerging technologies like offshore wind, after 2015, support was removed for new onshore wind and solar PV and largely shifted to offshore wind (Welisch & Poudineh, 2020). Therefore, the success of offshore wind energy in the UK was evident as it has gradually built up legitimacy and received support from private and institutional actors (MacKinnon, et al., 2022). Moreover, these auctions have also contributed significantly to lowering the costs of offshore wind over time. For example, the price that emerged from the auctions in 2017 dropped as low as £57/MWh, slightly above the market price, marking a point at which almost no subsidies were required (Welisch & Poudineh, 2020).

Apart from CfD, the other three mechanisms envisaged by EMR stand out as regulations that concern carbon-intensive electricity generation sources. While the *Emission Performance Standards (EPS)* imposes constraints on maximum carbon intensity that power plants can emit, the *Carbon Price Floor (CPF)* sets a stable floor price tax mechanism for these emissions, seeking to address the operational flaws in the *Emission Trading System* of EU in order to

support low-carbon technologies with the revenue raised (IEA Policies Database, 2015; Yang, Zhang, Zhao, Zhao, & Yuan, 2022). Finally, Capacity Auctions covered contracts, involving also centralized and traditional electricity providers, to safeguard the future reliability of the grid and security of supply (Liu, Wang, & Cardinal, 2022).

During the analysed period, while all these regulations and the fall in the costs of renewable technologies beyond expectations have made these resources more competitive against traditional fossil fuels in the UK, coal is no longer an attractive option on the regime side, and investment in renewable electricity, particularly in offshore wind, have increased substantially in the second decade of the century (Lockwood, Mitchell, & Hoggett, 2022; Yang, Zhang, Zhao, Zhao, & Yuan, 2022).

4.3.2 Key Developments in Solar PV and Wind Energy Technology

In 2002, the UK introduced an industrial R&D programme worth around £18 million for the development of projects for a variety of renewable and distributed systems, including photovoltaics and wind energy technologies (IEA Policies Database, 2021a). Additionally, government established an Institute with various engineering companies in 2008, aiming to increase cooperation between the government, universities, and industry (IEA Policies Database, 2021b). *The Low Carbon Industrial Strategy (LCIS)*, published the following year, emerged as a plan incorporating a wide range of supports and strategies, including R&D incentives for promising renewables (IEA Policies Database, 2021c).

It can be said that developments in solar panel technology have been largely limited in the UK. There have been a few R&D activities and efforts for institutionalised research programs for photovoltaics (Smith, Kern, Raven, & Verhees, 2014). However, the UK has not been prominent in industrial production and technological development for photovoltaics, as solar PV has remained largely export-oriented and has not grown beyond a weak sector that includes some initiatives for module installations and integration of panels into buildings (Smith, Kern, Raven, & Verhees, 2014; Lockwood, 2022).

Unlike solar, the UK has become one of the world's leading countries in offshore wind power over the period analysed. The initial large-scale project started to be built in 2003, and improvements in this technology niche in the country have enabled the installation of larger and more powerful wind turbines that can make effective use of the wind blowing from the ocean (Jennings, Tipper, Daglish, Grubb, & Drummond, 2020; Yang, Zhang, Zhao, Zhao, & Yuan, 2022). There has been already a technical know-how provided by the offshore oil and

gas industry (Greaves, et al., 2022). Beyond this, the new generation of power units benefited from the experience transferred from the previous generation, thereby contributing to the productivity of the sector, and various R&D activities developed around public, university and private sector collaborations have had positive impacts on installation/maintenance costs (Jennings, Tipper, Daglish, Grubb, & Drummond, 2020). Huge projects such as *London Array*, *Greater Gabbard* are impressive examples of the country's capacity to generate clean electricity from offshore wind resources (Díaz & Soares, 2020).

4.3.3 Technologies for More Intermittent Renewables Penetration

Based on the technical report of Climate Change Committee in the UK, the growth of the proportion of electricity from wind and solar across the country has also made it critical to tackle several technical challenges posed by intermittent generation. In this context, the UK has integrated up to 5 GW of interconnection capacity connected to Ireland, France, the Netherlands, and Belgium to compensate for some of the drawbacks of intermittent capacity by using the advantages of demand characteristics in different electricity markets. In addition, energy storage technologies in various types offer an innovative solution as another way to create further backup capacity. At this point, it can be said that the UK is still in its infancy in this technology with approximately 0.4 GW of *battery devices* integrated into the system (2019). In line with these developments, The Government and Ofgem (2017) have jointly published a plan to advance regulations of new and smart technologies that enhance grid reliability and flexibility in response to the inherent vulnerabilities of renewables.

5. The Case of the Netherlands

5.1 Landscape Drivers

For the Netherlands, known for its low-lying geography and vulnerability to sea level rise, issues such as water management and climate change have gained prominence over time (Kwadijk, et al., 2010).

Musch highlights different governments and political trends, as well as international commitments, have influenced the adoption of renewable energy by shaping the country's attitude towards climate change. While the influence of the EU and the UN on Dutch climate policies has grown since the 1990s, The country's recognition for aligning with EU directives and its proactive stance on liberalising energy markets became further evident in legislative

arrangements in the early 2000s. In addition to successive EU directives and participation in the EU Emissions Trading System (ETS), adherence to commitments under the Kyoto Protocol also have drawn a guideline for reducing emissions (2022).

However, as Verhees, Raven, Kern, & Smith note, neither renewable energy nor climate change matters were vital priorities for the centre-right coalition governments that took office in 2002 and 2003. Therefore, government partners VVD(Liberals) and CDA(Christian Democrats) opposed subsidy support during this period. Although the centre-left coalition government that took over power in 2007 started with ambitious goals and discourses for sustainable clean energy, in subsequent years, the economic crisis and cost concerns about renewable energy pushed political actors to be more cautious on this issue. The first Rutte coalition government, which came to office in 2010, stressed the role of the private sector and competition as part of the top-sector policies alongside subsidies (2015). The successive second and third Rutte governments have maintained this line (Musch, 2022). Briefly, we can see that coalitions and their changes often dominate the country's political context, and policies towards renewable energy have been affected by this.

The Paris Agreement can be cited as the most fundamental external event that has affected the energy and climate policy for the Netherlands and caused the country to seriously readdress its energy and electricity system (Dekker & Est, 2020). It should be recalled in this regard that the 2017 cabinet demonstrated its ambition to reduce emissions and pledged to phasing out from coal (Ćetković & Hagemann, 2020).

5.2 Regime Level Analysis

5.2.1 Power Generation Market Structure

The dominance of natural gas in the Netherlands, which was still the most important primary energy source in the 2010s, can be traced back to the discovery of a large gas reserve in Groningen in the late 1950s and the rapid evolution of the country's total energy supply in favour of natural gas over the following decades (Sovacool, 2016). The reflection of this situation in the country's electricity overview after 1990 can be seen in Figure 6, with a dominant share of electricity from gas.

Electricity production by source, Netherlands

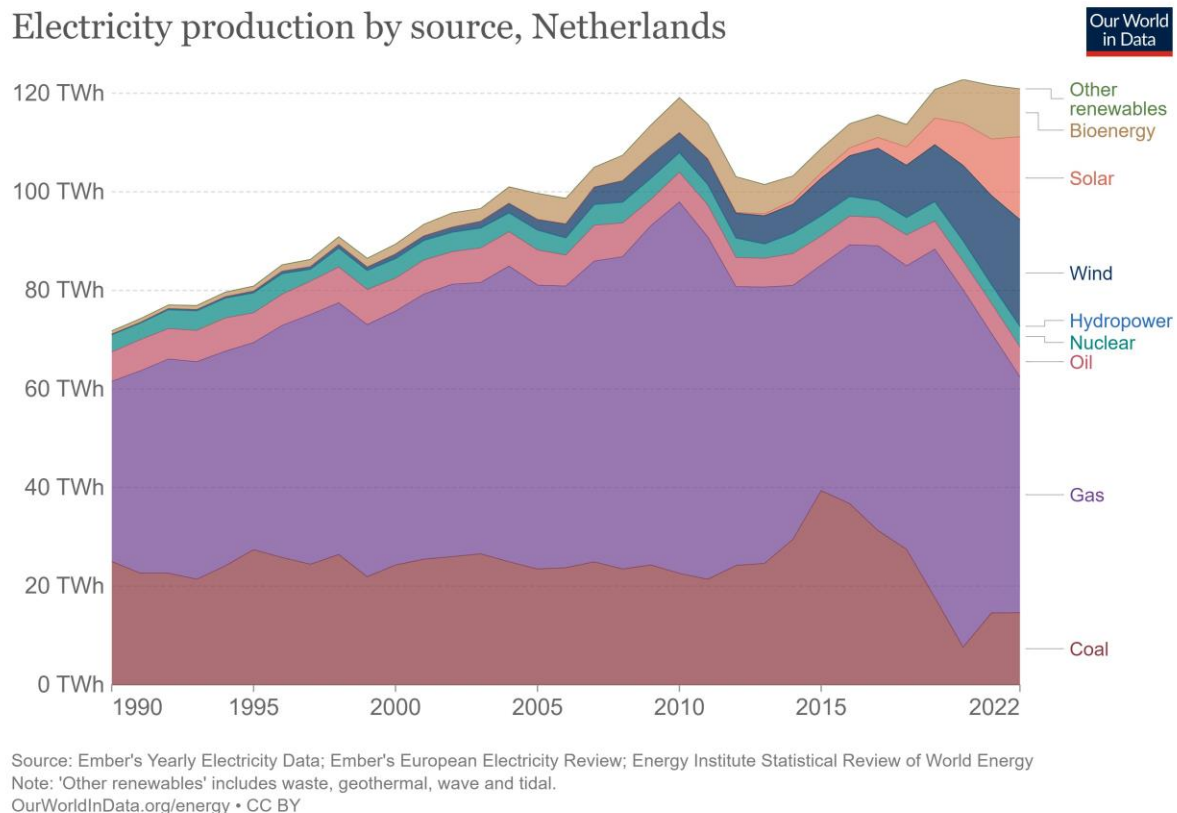


Figure 6. Power Generation by source in the Netherlands between 1990-2022 (Our World in Data, n.d.e)

Electricity from natural gas grew steadily in parallel with the country's upward trend in total power generation until the early 2010s. Following a fluctuating course afterwards, gas continues to be the primary fuel of electricity generation, albeit with a rapid downward trend in recent years. Coal-fired electricity generation, which had been the second largest contributor to overall production after natural gas for a long time, generally followed a steady trend between 20-25 TWh and experienced a sharp decline after 2015 (Our World in Data, n.d.e).

On the other hand, the renewable electricity capacity of the Netherlands has made substantial progress, with increases in electricity from wind since the 2000s and solar since the 2010s. Thus, a decline of 11% in carbon emissions linked to the heating and electricity sectors was observed between 2005 and 2018 (IEA, 2020).

Although the country has taken significant steps towards reducing its dependence on fossil fuels and decarbonising its electricity supply, centralised coal and gas-fired power stations still play an enormous role in the electricity generation sector in the Netherlands (Dekker & Est, 2020).

5.2.2 Dutch Energy Governance Approach and Institutions

The Dutch electricity market, which took on a competitive identity after the state-owned sector entered a process of unbundling activities with the *1998 Energy Act* and the abolition of regulation practices for electricity production, includes many different institutions and actors with sometimes conflicting interests (Kooshknow & Davis, 2018).

The Ministry of Economic Affairs had served as the central institution responsible for energy policy until the third Rutte government, when it was agreed that climate change policies would also be handled together with energy-related issues and *the Ministry of Economic Affairs and Climate Policy* was established (Musch, 2022). The fundamental unit of the Ministry in charge of carrying out policies on renewable energy technologies, such as subsidies and R&D incentives, is *the Netherlands Enterprise Agency* (IEA, 2020).

The Ministry, which has had a primary role in various negotiations conducted on energy, has largely transferred these negotiating powers to the *Social and Economic Council (SER)* over time. This council, founded in the 1950s as a central advisory body, has not only broadened its audience represented and mission but also become a collaborative structure related to energy and climate policies, bringing together many different segments of society such as many sector representatives, different stakeholders and interest groups, environmental organisations (Musch, 2022). The function of this council and some other institutions will be further clarified in niche level analysis. *The Netherlands Environmental Assessment Agency* is also an official scientific research institution that oversees the objectives set through analysis and projections with the aim of bringing an expert perspective to the country's climate and energy programmes (IEA, 2020). *The Ministry of Finance* and *the Ministry of Infrastructure and Water Management* are other ministries that have a say in different aspects of the formulation and implementation of renewable energy policies (Musch, 2022). Local and regional authorities are represented in energy and climate negotiations through umbrella organisations like *Provinces of the Netherlands* and the *Association of Netherlands Municipalities* while assuming responsibilities for the site planning and installation procedures at various levels (Musch, 2022).

Dutch Office of Energy Regulation (DTe) within the *Authority of Consumers and Markets (ACM)* is a regulatory and supervisory body in response to the liberalisation of the market and Tennet is the only state-owned monopoly responsible for high-voltage transmission, while 8 operators handle distribution (Kooshknow & Davis, 2018). Also, when it comes to electricity

generation side, there are many companies, but 4 of them are prominent in total capacity (Kooshknow & Davis, 2018). Renewable energy initiatives and solar and wind cooperatives, which combine production and consumption, stand out as another group of actors that have been expanding rapidly after 2010s (Proka, Hisschemöller, & Loorbach, 2018).

“The Dutch political system is often described as a consensus democracy. Problems and conflicts are resolved in such a system by intensive consultations and compromise” (Praag, 2017, p. 89). It is possible to find examples of this collaborative and corporatist approach in many different policy reforms in the past, and it would not be wrong to say that government actors have also employed the possibilities of the negotiation democracy tradition when dealing with energy policies, and the role of the Social and Economic Council, which includes a large number of different stakeholders, is valuable here (Musch, 2022).

The Netherlands also adopted a specific innovation-centred governance approach called “*Transition Management*”, which is designed to deliberately steer various sociotechnical systems, including energy, towards sustainable transitions (Laes, Gorissen, & Nevens, 2014). However, this strategy has been criticised for further complicating the coordination of the process and failing to produce effective policy mixes (Kern & Howlett, 2009). There was insufficient focus on social and institutional aspects related to the issue, niche actors could not be effectively engaged in the process against established structures and traditional administrative patterns, and this approach was later replaced by the energy *top-sector* model as a more competitive innovation policy strategy (Musch, 2022).

Dekker and Est (2020), on the other hand, claim that the country adopted a market policy paradigm for renewable energy after 2015 in line with the principles brought by the Paris Agreement, whereas before that, the main priorities of energy policy were affordability and reliability along with liberalisation, and explain this situation with the existence of a ‘*fossil energy market policy paradigm*’.

5.3 Niche Level Analysis

5.3.1 Policies for Renewables

5.3.1.1 Long Term Strategies and Programs

The Dutch government has conducted negotiations on targets for decarbonisation and scaling up renewables, encompassing many stakeholders and interest groups associated with the negotiating/corporatist culture in the country (Musch, 2022). Until the early 2000s, the targets

agreed with the various actors in the energy sector were generally pursued on a voluntary basis, and in this context, the first official goal for renewable electricity was mentioned in the policy document published by the *Ministry of Economic Affairs* in 1995. According to this, along with the 10% renewable energy target envisaged by 2020, it was aimed to increase the share of renewable electricity from sources like wind and solar in electricity consumption to 9% by 2010 and reach 17% by 2020 (Rooijen & Wees, 2006).

In its *National Renewable Energy Action Plan* presented to the EU, Similar to the UK, as a requirement of its membership, the Netherlands raised ambitiously its goal for renewable electricity to 37 % for 2020 while discussing in the same paper which legislation and support models could pave the way for this (IEA Policies Database, 2020). Also, within the top-sector policy framework, seven energy-related topics were prioritised, including offshore wind and solar photovoltaics. (Musch, 2022).

In the *Energy Agreement for Sustainable Growth(Energieakkoord)*, published in the following years as a result of the comprehensive negotiations and meetings carried out by *the Ministry of Economic Affairs* and *SER*, targets for the energy transition and support programmes for clean energy technologies were declared with wide participation of different layers of society, sector and governmental actors. According to this, it was decided to increase the proportion of renewable energy, which remained around 4% until 2013, to 16% by 2023, and a special emphasis was attached to investments to be realised in wind energy to achieve this goal. Also in the same agreement, issues such as saving measures to reduce annual energy demand, infrastructure/investment supports for small-scale local electricity producers from decentralised renewable sources and employment around renewable energy were also negotiated among related sides and various ambitious targets were set on these matters as well, re-emphasising the importance of reducing GHG emissions by 80% by mid-century within the framework of EU adaptation (Government of Netherlands, 2013; Musch, 2022).

Besides, according to its report, which deals in detail with the transition to sustainable energy after 2023, published by the Ministry of Economic Affairs in 2016 to broaden the vision drawn by the *Energieakkoord*: “Key issue is how to achieve a CO2 neutral energy supply system by 2050. In our energy policy, we will work on three main principles: 1) focus on CO2 reduction; 2) make the most of the economic opportunities that the energy transition offers and 3) integrate energy in spatial planning policy” (p. 3).

In the light of these principles and the new commitments imposed by the Paris Agreement, further negotiations were held to update the Energieakkoord of 2013. Accordingly, a national climate agreement (*Klimaatakkoord*) agreed upon in the late 2010s aimed to reduce emissions by almost half compared to 1990 levels by 2030 and laid out the country's roadmap in the field of energy and climate on the basis that consolidated collaboration again (IEA Policies Database, 2019b; Klimaatakkoord, 2019). What these latest objectives mean for the Dutch electricity sector corresponds up to 70% renewable generation out of the total mix by 2030 (IEA, 2020).

5.3.1.2 Support Instruments for Intermittent Renewables

Table below lists the main solar and wind electricity policies in the Dutch electricity generation sector between 2000 and 2020, according to their types and status.

Years	Policy Instrument	Policy Type	Status
2001	Renewables for Government Buildings	RP	In Force
	Green Certificate Trading	RP	In Force
2003	MEP: Environmental Quality of Electricity Production (Milieukwaliteit van de Elektriciteitsproductie)	FFP	Ended
2004	Energy Research Strategy (EOS)	ST-R&D	In Force
2005	Energy Tax Regime	FFP	Ended
2008	SDE (stimulerend duurzame energie): Renewable energy and CHP production aid scheme	FFP	Ended
2010	National Renewable Energy Action Plan (NREAP)	ST	Ended
	International Energy Programme	R&D	Ended
2011	Support scheme for solar panels	FFP	Ended
	Offshore wind energy Green Deal	ST	Ended
	Feed-in Premium Programme SDE+ (Stimulerend Duurzame Energie +)	FFP	In Force
2013	National Energy Agreement for Sustainable Growth	ST	In Force
	Energy Agreement for Sustainable Growth	ST	In Force
	Agreement on Energy for Sustainable Growth	ST	Ended
2015	Offshore wind tender regulation	ST	In Force
	Netherlands offshore wind tenders	RP	In Force
	Netherlands Offshore Wind Energy Act (Wet Wind op Zee)	RP	In Force
2019	National Climate Agreement - Emissions reductions goals	ST	In Force
	Integral Knowledge and Innovation Agenda (IKIA)	ST R&D	In Force
	Climate Agreement	ST	In Force
2020	Stimulation of sustainable energy production and climate transition (SDE++)	FFP	In Force
	Offshore Wind Energy Roadmap	ST	In Force

Table 5. Policies for Renewables (wind and solar) in the Dutch Power Sector, 2000-2020

ST: Strategy & Target RP: Regulatory Policy FFI: Fiscal & Financial Incentives R&D: Research and Development Policies (Adapted from IEA Policies Database (IEA, n.d.))

Until the early 2000s, unlike many other EU countries, Dutch steps to promote green electricity were based on policies encouraging demand rather than supply, such as exemptions from environmental taxes for standard end-users (Rooijen & Wees, 2006). The policy arrangement that envisaged meeting the electricity needs of government buildings through renewables at increasing rates over the years (IEA Policies Database, 2012) can also be considered within this scope.

Rooijen and Wees (2006) discussed the developments in the relevant years in their research. Accordingly, as demand-side policies were combined with the liberalisation of the electricity market, a boom on the demand side indeed occurred, with the number of renewable electricity consumers approaching 1.5 million. However, as supply-side incentives remained limited in the same period, this surge in demand was largely met by imported electricity, and some of the financial support flowed indirectly to producers in neighbouring countries. Although the *Tradable Green Certificate* system was also introduced during this period, this was on a voluntary basis, and the development of renewable electricity domestically was not as expected on the supply side. The same authors therefore explain the missed targets and these early years of the new century by characterising an uncertain market condition with unstable policies implemented (2006).

Ultimately recognising the need to incentivise green electricity supply beyond consumption, the government introduced a new feed-in tariff scheme, named *Environmental Quality of Power Production (MEP)*, with a proposal in 2002, amending the electricity legislation of that time; and it provided both a certain tax exemption amount and financial support that varied depending on the type of renewable technologies was intended to lower investment-related risks by encouraging renewable electricity production efficiently (Sambeek & Thuijl, 2003).

The table below shows payments under this tariff in Euros (€) for each kilowatt-hour of electricity generated from solar and wind.

Technology-energy source	MEP feed-in tariff (€)	Tax exemption (€)	Total support (€)
Onshore Wind	0.049	0.029	0.078
Offshore Wind	0.068	0.029	0.097
Solar	0.068	0.029	0.097

Table 6. MEP supports for electricity generation from wind and solar (€/kWh) - adapted from (Sambeek & Thuijl, 2003)

In the following few years, with the implementation of the *Energy Tax Regime* regulation, tax exemptions for consumers were gradually removed so that the supply-oriented feed-in tariff envisaged by the MEP was intended to be the active support policy thereafter (Rooijen & Wees, 2006; IEA Policies Database, 2013b).

However, the MEP scheme, which had triggered a revival in renewable electricity investments, was surprisingly closed in 2006 by the government, citing the heavy financial burden it caused (Niesten, Jolink, & Chappin, 2018). Instead, the government launched *the SDE (Stimulation of Sustainable Energy Production)* subsidy programme in 2008, which allocated the budget by type of renewable technology and also targeted sources such as biomass, and this programme also evolved into *SDE+* in 2011 (Banja, et al., 2017). As can be seen, although different support structures for renewables were presented, they were criticised for being far from the continuity and consistency required for a favourable investment environment. (Vasseur, Kamp, & Negro, 2013).

SDE+ set a long-term (15 years) feed-in premium (FIP) subsidy for renewable electricity generation without dividing the budget by technology types (IEA Policies Database, 2018). It allows renewable electricity producers to compete against fossil fuels by eliminating the disadvantage in their production costs and includes a guarantee payment where the subsidy amounts are adjusted annually based on the state of the power market and paid above the market price with an upper-cap (Banja, et al., 2017). The chart below demonstrates the annual distribution of budget amounts allocated for this program between 2011 and 2020:

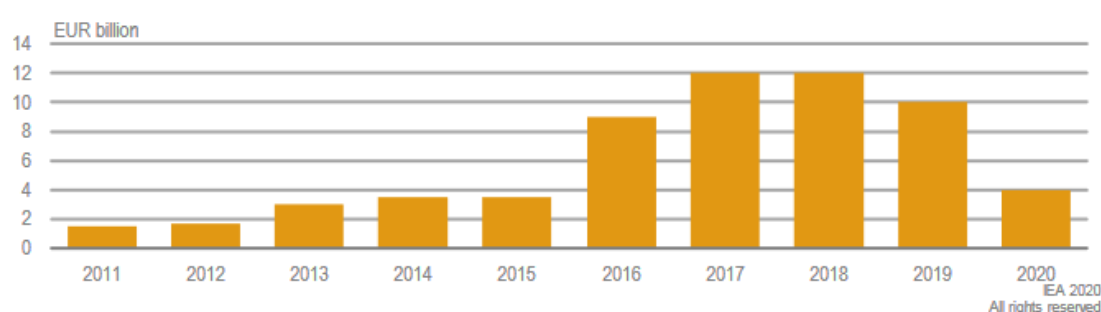


Figure 7. Annual budgets for *SDE+* between 2011 and 2020 (IEA, 2020)

The mechanism operates in the form of auctions in which renewable technologies within the scope of support compete with each other, and cost-effective projects are prioritised in the end; for this reason, it should be noted that it has been decided that the relatively more costly offshore wind tenders would be held separately from 2015 onwards (Abolhadi, 2017).

Along with a series of legislative arrangements to support offshore wind capacity enhancements, certain tenders were announced in 2015, notably for the Borssele region - Offshore wind tender regulation (IEA Policies Database, 2016a), Netherlands offshore wind tenders (IEA Policies Database, 2016b), Netherlands Offshore Wind Energy Act (IEA Policies Database, 2016c).

Thus, the fruits of the support for offshore wind by the parties involved in the 2013 energy agreement have begun to be seen. Factors such as the coordination of the Ministry of Economic Affairs and other governmental actors on this issue, effective legislative and policy regulations including the acceleration of bureaucratic processes, and TenneT's proactive support in the construction procedures of grid connections have helped reduce the risks and costs for investors in offshore wind projects while accelerating the expansion of this technology with accelerated momentum (IEA, 2020). In fact, over time, the decline in costs due to auctions enabled some offshore wind projects to win these tenders with price bids that would not need subsidy support for the first time in 2018, and moved towards the realisation of the offshore wind target set by *Energieakkoord* for 2023, much lower than the expected costs (IEA, 2020).

During this period, solar PV was also prominent in the projects approved under SDE+ (Banja, et al., 2017). A grant program worth 50 million Euros in total for panel purchases was already announced for private sector in 2011 (IEA Policies Database, 2013c).

In addition, the IEA examined the dramatic rise in small-scale solar PV in its relevant report. Accordingly, some further support tools, such as exempting solar-generated electricity for residences from some taxes/levies and receiving payments under the *net-metering scheme* for production exceeding annual consumption, have made electricity from small-scale solar PV financially attractive for households and small entrepreneurs. This resulted in a nationwide boom in small-scale solar installations in the 2010s. As of 2018, the Netherlands has become one of Europe's leading countries in terms of residential solar PV installations. In the same year, more than 700,000 households benefited from the net-metering system and this plan is expected to last until the 2030s (2020). Iskandarova et al. (2021) also underline the significance of the Dutch financial system, in which banks have a great influence and fund-raising solutions for small-medium-sized investor communities and cooperatives in this progress. On the contrary, onshore wind and large-scale solar deployment have not made much progress across the country due to reasons such as land use, grid-related constraints, and local resistance (IEA, 2020).

Recently, the SDE+ was superseded by SDE++ with some design alterations and additions. Consequently, while support for renewable technologies such as solar and wind is still available, other technologies that contribute to lowering carbon emissions have also been incorporated into the support scheme (IEA Policies Database, 2023).

5.3.2 Key Developments in Solar PV and Wind Energy Technology

In the early 2000s, the Dutch government placed special interest in sustainable transitions as a monolithic research field and adopted the *TM* approach, which prioritises innovation to deliberately drive the energy transition (Laes, Gorissen, & Nevens, 2014). A subsidy programme called *Energy Research Strategy* was also unveiled, which includes supporting scientific, innovative and sustainable research projects on a non-commercial basis (IEA Policies Database, 2021d). Attaching value to knowledge sharing beyond national borders, the government became a part of an *International Energy Programme* in energy research collaborations with various countries in 2010 (IEA Policies Database, 2021e). However, the *TM* policy, which encompassed all such transitional research experiments, was unable to break the influence of established actors and discourses over time and afterwards, the government preferred to carry out R&D activities mainly through the private sector (Laes, Gorissen, & Nevens, 2014). In this direction the top-sector policy launched in 2011, included promoting several sectors, notably the energy sector, for a competitive and low-carbon economy (Musch, 2022). This strategy was further expanded in 2019 in line with the targets envisaged by the Climate Agreement and replaced by a new mission-based framework called *Integral Knowledge and Innovation Agenda (IKIA)*, which also covers various innovation and R&D activities in the energy and power sector (IEA Energy Policies Database, 2021f). Renewables has also been an essential focus of R&D expenditures. For example, while they accounted for 43% of the overall R&D budget in 2018, almost three-fifths were dedicated to solar and wind technologies of this amount (IEA, 2020).

Despite having a substantial knowledge base relying on R&D, the Dutch PV industry progressed through an export-orientated entrepreneurial environment with limited growth. Nevertheless, it is worth noting that the country hosts a specialised and developed industry for supplying related components like semiconductors (Vasseur, Kamp, & Negro, 2013).

In the offshore wind industry and the manufacturing and supply of related turbines and systems, the country has taken advantage of capabilities from its history of offshore oil and gas

extraction, and the government has paid particular attention to creating various network organisations to develop this niche (Loos, Normann, Hanson, & Hekkert, 2021).

5.3.3 Technologies for More Intermittent Renewables Penetration

Although there is no specific regulation in force on energy storage systems, a roadmap about them was prepared by various universities and consultancy foundations for the Ministry of Economic Affairs in 2015, and in the following year, the government put this technology on its agenda to increase the reliability of the electricity and grid system (Musch, 2022). In addition to its already available interconnection capacity with Belgium, Norway, the UK and Germany; the Netherlands has also included Denmark through the *COBRA* cable system laid under the sea in 2019 thereby succeeded in raising its total capacity to over 7 GW (IEA, 2020).

6. Discussion

The previous chapters analysed the transition processes of the electricity generation systems in the UK and the Netherlands toward solar PV and wind renewable technologies regarding their related policies, and the transition patterns followed. The various implications pointed out by this analysis will be explained comparatively in this section, and the results will be discussed to answer the research questions on which the study is founded.

- Based on overall findings, as electricity systems moved towards a renewable transformation during the period analysed, the support policies and their design developed differently in both countries. The 2000s started in the UK with the implementation of a Renewable Obligation as a quota system as the primary policy for renewable electricity and niche technologies. This scheme was based on tradable certificates, aligned with the neoliberal perspective of the existing institutional structure. But it faced criticism for being too complex and risky for investors, and various modifications were subsequently made to improve it for costlier and emerging technologies. Initially, RO scheme favoured relatively more mature and cheaper onshore wind, but adjustments in policy design paid off and led to positive developments offshore as well. Small investors, on the other hand, were more disadvantaged against the established players under this plan, and investments generally remained large-scale during this period. Under these circumstances, with pressure from various environmental organisations, the government also introduced a fixed-rate feed-in tariff for small-scale projects, which brought about a boom in solar

PV. However, this situation lasted only a short time and the government, citing various misuse of the tariff and falling PV costs, tightened the scheme's benefit with new amendments. Thereafter, a reform was introduced in the electricity market, and the RO was plan was replaced by the new CFD scheme, which is based on the payment of a guaranteed strike price determined by auctions, regardless of market prices. This mechanism was designed as competitive auctions by type of technologies. This meant less risk for investors. Leiren, Inderberg, and Rayner explained this: "CfD provides a greater degree of price certainty for investors than the RO did, but less certainty than a fixed FiT" (2020, p. 40). While these auctions contributed to a significant reduction in offshore wind costs, it appears that institutional arrangements have also progressed in favour of offshore wind. Thus, offshore wind farms on various coasts of the island country have become familiar sight, as investments have increased rapidly until today. However, In the Netherlands, the process progressed more differently. In the early 2000s, while the liberalisation of the electricity market was ongoing, the government had adopted demand-driven policies to promote renewable electricity. This resulted in domestic supply failing to catch up with the internal growth in demand and caused the allocated resources to flow abroad. In the same period, green certificates were also introduced, yet they were voluntary and ineffective. The government was weak in tackling market uncertainties during this period. Later, this demand-side policy was abandoned, and the MEP plan, combining tax exemption and feed-in tariffs for producers, was introduced. However, this scheme was closed in a short time due to cost concerns and replaced by the SDE scheme in 2008. This scheme also did not last long, and with some design changes, SDE+, which did not discriminate by renewable type and worked through a premium over the market price, was introduced in the early 2010s. These unstable and frequently changing support programmes harmed the development of investments, contributing to market uncertainty. Niesten, Jolink and Chappin also argue that while support mechanisms have evolved from MEP to SDE and SDE+, respectively, each policy change has increased risks for investors in different ways due to their design features (2018). Eventually the government decided on SDE+ as the fundamental support instrument. The functioning of the SDE+ was based on competitive tenders, similar to the CfD, but it was technology-neutral. As more costly offshore wind could not compete with other technologies under this scheme, the government separated the tendering process for offshore wind, and institutions have begun to focus more on this technology. This has played a role in the rapid reduction of

costs, similar to the process seen in the UK, and has recently caused an expansion in offshore wind capacity. Figure 8 presents the electricity generated by wind, solar and other renewables, and the corresponding percentages between 2000 and 2020 in both countries. The dramatic increase in the UK's total wind capacity in the 2010s, notably linked to the developments in offshore wind, is clearly seen in this graph. In the Netherlands, the same time frame indicates a slower and moderate increase in wind capacity. Before the 2010s, it is observed that the total wind capacity in both countries recorded a slight but continuous rise. In addition, while the share and progress of solar electricity in total generation points to insignificant levels in the same first decade, both countries have witnessed substantial increases in solar installations after 2010s. It is noticeable that the Dutch PV deployment has been increasing sharply, especially after 2015 (IEA, 2022b; IEA, 2022c). The impact of some policy instruments like net-metering for small-scale (households, etc.) solar energy investors is crucial to this success.

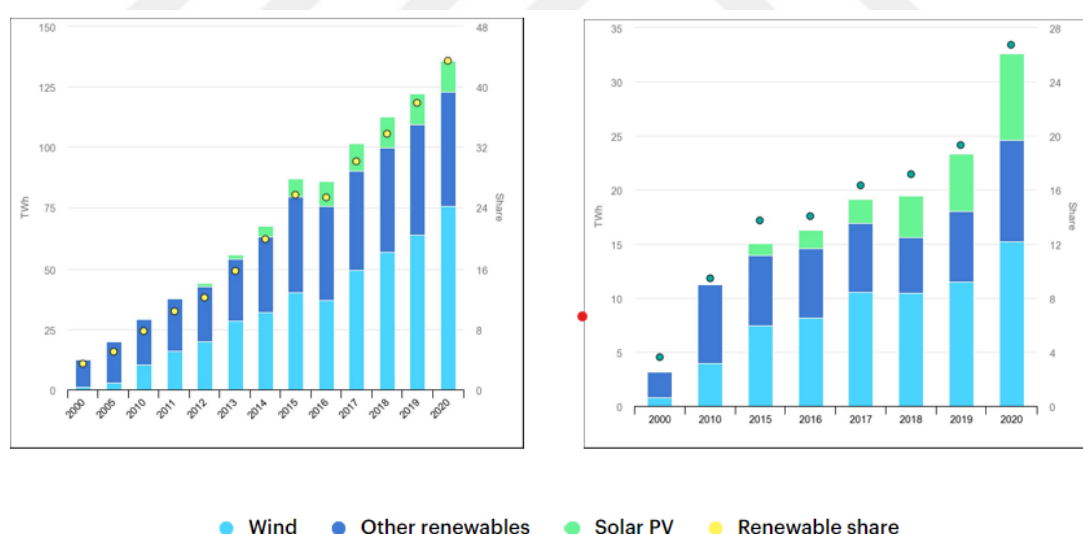


Figure 8. Renewable Electricity Generation in the UK and Netherlands respectively, 2000-2020 (IEA, 2022b; IEA, 2022c)

- As a result, while the share of electricity generated from wind and solar PV did not even reach 1 per cent for both countries in 2000, it reached close to 30% in the UK and barely above 19% in the Netherlands in 2020 (IEA, 2022b; IEA, 2022c). Although the efforts and policies implemented over the years have recently indicated a remarkable

momentum for the Netherlands, it seems still far behind the UK in adapting solar and wind PV renewable technologies to the electricity generation sector. There may be several reasons for this. One of them is discussed earlier regarding the fact that the UK has taken steps to minimise investment risks design its renewable energy policies, while the Netherlands has not been able to do so fully.

- The findings also suggest that the governance approaches followed by countries are essential when it comes to understanding the dynamics underlying these policies that drive the renewable transformation of electricity systems. Policy preferences for the energy transition generally favour centralised, large-scale technologies, implying the British tradition from the Westminster system with its hierarchical, centralised decision-making character. This framework aligns with the views of Geels, who argues that the UK institutional structure emphasises the legislative and commercial basis, and policies tend to support large installations in which incumbents instead of new, small-scale actors (2016). Moreover, the government's attachment to liberal ideas has influenced the design and formulation of energy policies in various aspects. The UK was already one of the earliest countries to liberalise its energy markets. In the 2000s, the fact that the market-based and technology-neutral RO served as the main support mechanism for a long time is clear evidence here. However, the government eventually switched the RO to a CfD scheme to make the support mechanism less risky and turned to offshore wind. Although this is perceived as a moving away from a market-oriented approach according to Leiren, Inderberg, and Rayner (2020), it was still possible to find some traces of the liberal paradigm in the design of the CfD for Onifade (2016), pointing to the use of the private law instead of public law mechanism for contracts as an example. The Netherlands also liberalised its electricity sector at the turn of the century in line with EU reforms and similarly adopted liberal principles as the UK. Nevertheless, the Dutch context and its consensus democracy tradition have led to pursuing a different path in formulating renewable energy policies in several respects. The corporatist governance approach prioritised umbrella organisations and council structures that bring together different interest groups and actors in decision-making processes. The important and active role of the *SER* in determining key policies and targets on energy and climate matters, such as the *Energy Agreement* and the *Climate Agreement*, also points to this (Musch, 2022). While a stronger and more inclusive stakeholder engagement has developed in the Netherlands than in the UK within a

corporatist framework, this has also meant that in policy-making processes, there has been an intensive negotiation of issues with all sides until a broad consensus is reached. Furthermore, unlike the UK, the Netherlands also attempted to implement a special Transition Management strategy for governing the transition, based on system innovation, but this made coordinating policies more difficult and complicated (Kern & Howlett, 2009). Therefore, it can be argued that these differences in the governance approaches between two countries explain why the Netherlands has been slower than the UK in generating policy responses and embracing renewables.

- In the process, both countries have strategically given importance to energy security and the role of natural gas in electricity generation. Musch also connected the slow increase in the Dutch renewable energy capacity to its reliance on gas resources (2022). Both countries are also trying to eliminate coal from their energy portfolios. However, the UK appears to be faster and more ambitious than the Netherlands.
- According to the results, public opinion and political trend is other crucial factor for renewable investments to progress in a favourable environment. Subsidies for renewables have been influenced by public opinion and the will of successive governments. Although both countries had some coalition governments in office during the period analysed, the Dutch proportional electoral system was more prone to coalitions, indicating a relatively more volatile political structure (Tsebelis & Crosson, 2020). Coalition changes and political strife, more frequent in the Netherlands, have also adversely affected the market conditions and support structures for renewables. The article of Loos, Normann, Hanson, and Hekkert confirms this situation for the Netherlands (2021). It was also seen that the politics of the two countries and their policies for renewables were affected by the 2008 economic crisis as an external landscape development. Our analysis also showed that both the UK and the Netherlands face challenges with local acceptance of onshore wind and large-scale solar due to land issues and other reasons. This poses an obstacle to earlier and rapid spread of renewables for both countries.
- Also findings of analysis show that production and advancement of photovoltaic technology remained weak in the UK during this period, while a more prominent sub-

manufacturing industry advanced in the Netherlands. Both countries have made improvements in offshore wind by using their existing offshore oil and gas know-how and capabilities. In addition, it seems that both countries are seeking to take precautions against the increasing integration of intermittent renewables by improving their connections with neighbouring countries and investing in energy storage systems. The importance of supporting developing technologies for the flexibility of the grid with further developments and effective policies is increasing day by day.

As a result, in both countries, the view of the established institutions in the regime towards niche technologies has changed over time, and efforts have been created to *protected spaces* for wind and solar PV with various policies and some landscape developments such as climate change have had a positive impact on this process by putting pressure on the regime. In other words, the niche-regime-landscape interactions that prepare the change according to MLP have developed in favour of renewable technologies and have created new windows of opportunity. Yet, this progress seems more accelerated in the case of the UK compared to the Netherlands and the reasons for this were generally discussed above.

7. Conclusion

This study revealed the impact of different policies and strategies for renewable electricity on the unique transformations of the UK and Dutch electricity generation sectors and found that differences in each country's own context also played a role in this process.

The UK's journey, which started with a neoliberal approach primarily using the RO scheme, shifted towards subsidies and auction contracts over time. Thus, with improvements in policy design and increased institutional support, renewable electricity, especially offshore wind, has made significant progress. In addition, the country's centralised structure coming from the Westminster system gave importance to supporting large-scale renewable investments.

The Netherlands shifted its targets and policies for renewable electricity from demand to supply-based policies at the turn of the century and built around basic guaranteed feed-in tariffs such as the MEP, SDE, SDE+ and SDE++. However, variable and inconsistent policies discouraged investors for a long time. Additionally, the corporatist approach dominated decision-making processes where objectives and strategies were decided through lengthy negotiations. While this contributed to a strong growth of small-scale investments, it sometimes delayed in developing policy responses.

To conclude, under what conditions and how the policies implemented by these countries have yielded results hold valuable lessons for future transitions. As Polzin, Egli, Steffen, & Schmidt state, the success of driving the transition to a sustainable electricity system and attracting investments for renewables largely depends on transparent, effective and predictable design of policy instruments that reduce investor risks and pave the way for appropriate market conditions (2019). It is also worth noting that there are different ways to decarbonise electricity systems and transition to renewables, and it is critical that ambitious targets should be complemented by an effective regulatory framework. However, this cannot be divorced from the contextual conditions and institutional traditions of countries.



8. References

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