Carbon lock-in or varieties of lock-in?

A study of the consequences of fossil fuel dependency on renewable energy policy

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Summary

Fossil fuel dependency, conceptualized by the theory of carbon lock-in, is an often cited explanation for resistance to change in the study of sustainable energy transitions. Although the concept of carbon lock-in provides a good description of the situation in many industrialized countries today, there are several unanswered questions regarding its implications for the politics of energy transition and the development of climate and energy policy. This thesis seeks to understand to what degree and in what ways carbon lock-in may influence renewable energy policy by performing a comparative case study of the renewable energy policy development in three countries that feature characteristics of carbon lock-in.

The mechanisms that lead to carbon lock-in are assumed to create mutual dependencies between fossil fuel industries and policymakers, and sustaining lock-in is therefore beneficial for these actors. Furthermore, they are assumed to form a fossil fuel industry-policymaker complex resistant to change towards renewable energies. In this thesis I find support for the expectation that renewable energy policies develop in a way that does not challenge the core interests of this complex in coal dominated Australia and Poland. Norway is a slightly different case. Although it holds important characteristics of a carbon locked-in country due to its high dependency on the petroleum sector in its economy, the electricity sector is almost carbon-free. However, the strong dependency on hydropower in the electricity sector in Norway seems to produce the same type of mechanisms as observed in the cases where fossil fuels dominate electricity generation.

Hence, these findings illustrate the need to distinguish between different types of energy related lock-ins, rather than assuming an overall carbon lock-in. Taking into account the potential variety of energy related lock-ins and the particular political and economic interests of the actors that may benefit from sustaining such lock-ins, may provide us with new insights about the development of climate and energy policy required for energy transition. This can help us take a step beyond the generic conclusion that carbon lock-in produces resistance to change towards low-carbon energy sources, and improve our understanding of why resistance to such change persists in some country contexts and not in others.

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All mistakes and inaccuracies remain my own.

Lysaker, 15.12.17.

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Abbreviations

AEMO	Australian Energy Market Operator
ARENA	The Australian Renewable Energy Agency
CCS	Carbon Capture and Storage
CEFC	The Clean Energy Finance Corporation
EEA	The European Economic Area
ESA	The European Surveilling Agency
ETS	Emission Trading Scheme
EU	The European Union
FiT	Feed-in Tariff
GDP	Gross Domestic Product
GVA	Gross Value Added
GWh	Giga Watt Hour
IEA	The International Energy Agency
IRENA	The International Renewable Energy Agency
LNG	Liquefied Natural Gas
MoEP	The Ministry of Energy and Petroleum
MRET	Mandatory Renewable Energy Target
MW	Mega Watt
NEM	National Electricity Market (Australia)
NFEPWM	The National Fund for Environmental Protection and Water Management

NREAP	National Renewable Energy Action Plan
NVE	The Norwegian Water Resources and Energy Directorate
OECD	The Organisation for Economic Co-operation and Development
PM	Prime Minister
PV	Photovoltaic system (solar energy)
R&D	Research and Development
RE	Renewable Energy
REC	Renewable Energy Certificate
RET	Renewable Energy Target
TIC	Techno-Institutional Complex
TWh	Terra Watt Hour
UNFCC	The United Nations Framework Convention on Climate Change
WCMG	Waste Coal Mine Gas

1 Introduction

Climate change is putting pressure on countries and industries to change their energy systems towards low-carbon sources including renewable energies (RE). Despite widespread knowledge about the detrimental effects of climate change, and the role fossil fuels play in creating them, progress in changing energy systems has been slow. Although the global production of renewable energy grew from 0,16 trillion kWh in 1990, to 1,4 trillion kWh in 2015 (World Bank 2017), renewable energy sources represented only 1,5 % of global primary energy supply in 2015 (IEA, 2017c, p. 3).[1] To achieve the global goal of de-carbonization it is important to understand the barriers that exist to further expansion of renewable energies.

The high dependency on fossil fuels has been conceptualized by the theory of carbon lock-in (Unruh, 2000, 2002). According to this theory, industrialized countries are in a state of lock-in into fossil fuel-based technological systems. This lock-in results from a “path-dependent process driven by technological and institutional increasing returns to scale” (Unruh, 2000, p. 817) that creates barriers to energy transition. “Even with the growing of evidence of substantial environmental risk, these forces can create pervasive market, policy and organizational failures toward the adoption of mitigating policies and technologies” Unruh claim (2000, p. 827).

Although carbon lock-in can be a fitting description for many industrialized countries today, there are many unanswered questions regarding how the carbon lock-in condition affects climate and energy policy. Carbon lock-in is most often seen in relation to socio-technical perspectives on energy transition (Kuzemko, Keating, & Goldthau, 2015, pp. 32–33). Such theories are good at describing the difficulty of change towards renewable energy sources, while the politics of energy transition and the actual consequences on policy outcomes are poorly understood by these theories (Kuzemko, 2013; Meadowcroft, 2009).

This thesis will therefore take a closer look at how fossil fuel dependency, as conceptualized in the theory of carbon lock-in, may affect energy transition, and in particular the development of renewable energy policy. I will do this by studying the development of renewable energy policy in three countries that have characteristics of carbon lock-in.

[1] Excluding hydropower and biomass.

1.1 Research question

The thesis considers the following research question:

To what degree and in what ways does carbon lock-in influence renewable energy policy?

The thesis has both an empirical and theoretical aim. Empirically, I wish to study the consequences carbon lock-in may have for renewable energy policy development. These findings will form the foundations for a theoretical discussion about the applicability and scope of the carbon lock-in theory in studying climate and energy policy. Therefore, this thesis is not studying the process of energy transition *per se.* Rather it touches upon the conditions for such transitions by studying how policies that may advance transition is affected by carbon lock-in.

The research question will be answered through a comparative case study of a set of countries with carbon lock-in characteristics.

1.2 Previous research

As mentioned above, the carbon lock-in theory is often seen in relation to socio-technical perspectives on energy transition (see for example Berkhout, 2008; Geels, 2005, 2010; Kuzemko et al., 2015, Chapter 1), and often used as an explanation of no or little change in transition towards low-carbon energy sources (see for example Brown, Chandler, Lapsa, & Sovacool, 2007; Foxon, 2002; Haley, 2011; Seto et al., 2016).

As this thesis aims to study the consequence carbon lock-in may have on policy outcomes, it relates to the literature on what explains the policy choices and design in comparative climate and energy politics. Furthermore, as renewable energy policy can contribute to reduce emissions when renewable energy sources replace fossil fuel energy sources, it cannot be seen isolated from the study of climate policy. Supporting renewable energy development is a common policy response in climate politics (Hughes & Urpelainen, 2015)[2]. Therefore, this section will review literature that seeks to identify the determinants of policy choice and design in national climate and energy politics. Also, as the carbon lock-in theory develops

[2] Although the main focus of this thesis is the environmental aspect of energy policy, it should be noted that renewable energy policy relates to the broader energy politics landscape which is also linked to development and security issues (see Kuzemko et al., 2015).

from the dependency on fossil fuels in many countries today, I will emphasize literature that shed a light on this type of dependency.

Regarding the study of comparative climate politics, Bernauer assesses that much more research is needed to “arrive at robust inferences about the factors that cause variation across political units in forms and ambition levels of climate policies” (Bernauer, 2013, p. 435). The literature on national climate policy consists largely of single case studies, and according to Boasson these studies “hardly speak to each other, and no particular explanations dominate the field of study” (Boasson, 2015, p. 4). She describes the “political science literature on climate-policy development [as] still in its infancy” (Boasson, 2015, p. 6). Looking at energy policy in particular, Hughes and Lipscy (2013) claim that an “important task of future research is to characterize the diverse set of preferences over energy policy and understand how they are aggregated into policy outcomes” (Hughes & Lipscy, 2013, p. 460). In this thesis, I follow up on this task by assessing whether carbon lock-in can explanation policy outcomes.

Drawing on the general comparative politics tradition Purdon (2015) point to institutions, interests and ideas as factors that “hold considerable promise in explaining domestic climate change politics” (Purdon, 2015, p. 2). Fossil fuel interests’ has been pointed to as an important factor that may influence climate and energy politics.

Christoff and Eckersley (2011) review literature on national responses to climate change, and tries to identify what characterizes leaders and laggards in environmental performance. They find that domestic veto players, like fossil fuel industry and labor unions, may overshadow the positive effect of factors associated with good environmental performance (Christoff & Eckersley, 2011, p. 445):

> While the presence of a strong national environment movement, and of green parties, is generally conducive to strong climate performance they are not always sufficient drivers, especially when they are faced with powerful oppositional players in a political system where public interest advocacy is overshadowed by well organized sectional interests or domestic veto players (Christoff & Eckersley, 2011, p. 445).

They conclude that the dependency on fossil fuels is a predictor of poor environmental performance, but not the sole explanation: “Much depends on the geographic distribution of fossil fuel resources, and the political institutions through which national climate discourses are filtered” (Christoff & Eckersley, 2011, p. 445).

In an article on drivers of national climate policy development, Lachapelle and Patterson (2013) found that among 19 countries with high CO_2 emissions, substantial fossil fuel exporters were “less likely than others to implement any type of climate policy” (Lachapelle & Paterson, 2013, p. 565). They put the finding in relation to the “entrenched power of fossil-fuel interests in these countries” (Lachapelle & Paterson, 2013, p. 565).[3]

There is also reason to believe that the degree or different aspects of fossil fuel dependency may result in different policy strategies. Purdon (2015) claims, looking at climate policies in general, that not all fossil fuel producing countries are laggards in climate policy development. “When the exploitation of fossil fuel is itself not particularly emissions intensive and undertaken largely for export, the economic interests of resource-rich states can go hand-in-hand with progressive climate action” (Purdon, 2015, p. 13).

Turning to renewable energy policy in particular, most studies focus on the effect of different policy instruments, like green certificate and feed-in tariff schemes, rather than the politics that shape the choice of instrument (see for example Jenner, Groba, & Indvik, 2013; Menanteau, Finon, & Lamy, 2003; Smith & Urpelainen, 2014). However, research has shown that there are big differences in the type and mix of policy instruments used to promote renewable energy across countries (Hughes & Urpelainen, 2015; Meyer, 2003). These differences are explained by a range of factors such as political system, green party representation, governments’ institutional capacity in the environmental field, public support for climate action and interest group dominance (see for example Aklin & Urpelainen, 2013; Hughes & Urpelainen, 2015; Yi & Feiock, 2014).

The interests of the business sector, environmental groups, consumers and political parties are also highlighted as important for the development of renewable energy. Investments in renewable energies “are influenced by political bargaining between business, government, and other interests over appropriate forms of regulatory intervention by government”, Hughes and Lipscy (2013, p. 460) claim. Furthermore, factors such as “stable and comprehensive policy frameworks, cross-sectoral coordination, and close but transparent state-industry relations together with target education and research, demonstration and development programs” (Ćetković & Buzogány, 2016, p. 643) are also emphasized in the literature as important for renewable energy development.

[3] By Unruh (2000) such entrenched interests are conceptualized as part of the concept of carbon lock-in. The analytical framework will discuss this more in-dept.

1.2.1 The contribution of the thesis

The literature review shows that a variety of factors have been identified as possible explanations for climate and energy policy outcomes. This thesis aims to contribute to former research in two ways. First, the thesis seeks to contribute to the research on the choice and design of climate and energy policy by looking at in what ways fossil fuel dependency, as conceptualized by the theory of carbon lock-in, can be one such factor. Second, as the carbon lock-in theory most often is seen in relation to literature on socio-technical innovations and transitions, this thesis also aims to develop the understanding of the carbon lock-in theory and in what ways it can be useful for policy studies.

To my knowledge, no research to date has looked at the empirically observable consequence carbon lock-in may have for climate and/or energy policy.

1.3 Thesis outline

This thesis proceeds as follows: Chapter 2 introduces the theory of carbon lock-in. It also develops the analytical framework of the thesis and provides general and specific expectations about how carbon lock-in may influence renewable energy policy in the country cases. In Chapter 3 I discuss methods and research design. Here I justify why a comparative case study approach is chosen in order to answer the research question. I also describe how cases are selected, the operationalization of indicators and the data-gathering procedures. Chapter 4 presents the three cases studies – Australia, Poland and Norway – and discusses individually how the findings match with the expectations from the analytical framework. Chapter 5 constitutes the comparative analysis. Furthermore, I discuss the findings in light of the carbon lock-in theory. Last, I provide some concluding remarks.

2 Theory and analytical framework

In order to analyze to what degree and in what ways carbon lock-in may influence renewable energy policy, we must arrive at a clearer understanding of the mechanisms that produce carbon lock-in and in what way it can influence policy-making. This chapter presents the carbon lock-in theory, and discusses some of its analytical weaknesses. I claim that a fruitful way of understanding politics and policy outcomes in a theory like carbon lock-in is to study the interest structures that the lock-in condition creates. Thereafter, I present the framework developed to study the theoretical expectations empirically.

2.1 Carbon lock-in: increasing returns mechanisms and path dependency

The idea of carbon lock-in builds on concepts of increasing returns and path dependency. The notion of increasing returns has been widely used in economics to describe the process that leads up to a lock-in condition, where the dominance of incumbent technological solutions prevent new innovation and improved technologies to enter the market (see Arthur, 1989, 1994). The logic of increasing returns and lock-in has also been used in institutional theory to explain the robustness and resistance to change in political institutions (see North, 1990; Pierson, 2000).

Increasing returns are often described as positive feedback or as a self-reinforcing process. In such a process, "the probability of further steps along the same path increases with each move down that path. This is because the relative benefits of the current activity compared with other possible options increase over time" (Pierson, 2000, p. 252). Therefore, increasing returns can be seen as a specific type of *path dependency* – a concept much used in social sciences, but often without clear definition of the mechanisms that create such dependencies (Pierson, 2000).

Arthur (1989, 1994) was a pioneer in identifying increasing returns mechanisms that produce the type of path dependency that may result in a lock-in situation. Although today a variety of such mechanisms can be identified (see for example Klitkou, Bolwig, Hansen, & Wessberg, 2015), four of the initial mechanisms that Arthur described are illustrative for the case of carbon lock-in. When these mechanisms work together it results according to him in a technological lock-in situation where alternative technologies are difficult to introduce to the market (Arthur, 1989).

First, large set-up and investment costs, i.e. to establish a coal firing plant, create incentives to continue down the initiated path. Therefore *economics of scale* will increase returns as costs are shared over more units, and incumbent technologies will experience “significant ‘sunk costs’ from earlier investments” (Foxon, 2002, p. 2). Second, *learning effects* contribute to reduce costs by improved products and specialized skills and production, and thereby make the chosen technology more attractive. Third, coordination or *network effects* happen when more users adhere to the same technology and/or infrastructure, making it more advantageous for others to adhere to the same technology. Last, *adaptive expectations* also come into play because the market will adjust its expectations and investments to the dominating technology as the market actors become “increasingly confident about quality, performance and longevity of the current technology” (Foxon, 2002, p. 2).

Though many of these mechanisms are highly relevant in economics, Pierson (2000) claim that increasing returns processes are even more vigorous in political processes than in economic. First, compared to economic markets, there is little competition and learning opportunities for political institutions. Failure and inefficiency is therefore more difficult to correct. Second, the short time horizons of many politicians may also favor existing paths as few wish to take high risks in fear of not being reelected. Last, there is a strong bias towards status quo built into many political decision-making processes and voting procedures. “Each of these features makes increasing returns processes in politics particularly intense”, Pierson (2000, p. 257) claim.

Building on the insights about the technological and institutional processes of increasing returns, Gregory Unruh (2000, 2002) introduced the idea of a particular *carbon lock-in* to explain the difficulty that industrialized countries, and the global community in general, experience in taking necessary action against climate change.

According to Unruh, the carbon lock-in condition develops “through a path-dependent process driven by technological and institutional increasing returns to scale” (Unruh, 2000, p. 817). These processes contribute to “perpetuate fossil fuel-based infrastructures in spite of their known environmental externalities and the apparent existence of cost-neutral, or even cost-effective, remedies" (Unruh, 2000, p. 817).

The result is what Unruh calls *Techno-Institutional Complexes* (TICs). TICs are composed of large "technological systems and the public and private institutions that govern their diffusion and use" (Unruh, 2000, p. 826). By this notion, Unruh captures the "idea that lock-in occurs through combined interactions among technological systems and governing institutions" (Foxon, 2002, p. 3).

Markets, business actors, political institutions and private consumers adapt their behavior and preferences in accordance with the dominating TIC, contributing to continued system growth and further lock-in. Technologies used in fossil fuel based electricity generation systems and transportation systems are examples of dominating technological designs that according to Unruh's theory have experienced both technological and institutional increasing returns, and contribute to carbon lock-in in industrialized countries.

According to Unruh, carbon lock-in will "hinder market and policy correction of externalities associated with carbon dependent technological systems, and slow the development of alternative technologies" (Unruh, 2000, p. 826). From this it should not be concluded that breaking the lock-in is impossible. There are many historical examples of such transitional changes, for example the change from biomass to coal in electricity and heating. However, Unruh claims that the lock-in condition will substantially slow down the transition process and "create barriers to new technologies" (Unruh, 2000, p. 828).

2.2 Carbon lock-in critique

The process of increasing returns and carbon lock-in provide a good description of the difficulty of energy transition in many countries today. Many industrialized countries are highly dependent on carbon based energy sources and systems in ways that correspond with the logic of carbon lock-in. However, although useful in descriptive terms, the carbon lock-in theory has some analytical shortcomings.

A common understanding of carbon lock-in is that it "generally constrains technological, economic, political, and social efforts to reduce carbon emissions" (Seto et al., 2016, p. 427), pointing to the path dependency created by increasing return mechanisms as the origin of these constrains. However, merely claiming that change is difficult as a result of carbon lock-in does not substantially improve our understanding of how and why these difficulties persist in some country contexts and not in others.

Socio-technical approaches to the study of innovations and transitions, like carbon lock-in, have been criticized for paying little attention to the politics of transition and the decision-making processes that influence transition (Kuzemko, 2013; Lockwood, Kuzemko, Mitchell, & Hoggett, 2013; Meadowcroft, 2009). This is despite the fact that these theories highlight governance and policy as key to transition success:

> There has been a tendency to focus on proscribing what individual policies could or should be rather than questioning the political and institutional circumstances that make the adoption of certain policies likely (Meadowcroft 2011: 73; cf. Shove and Walker 2007: 4). As a result, the politics of managed transition can come across as being quite straightforward in theoretical discussions, when the reality has been quite different in many countries (cf. Kern and Howlett 2009) (Lockwood et al., 2013).

Lockwood et al. further claim that these theories "have an inadequate account of politics, do not provide sufficient clarity about the role of agency in the energy system and do not provide an explanation of comparative difference in movement towards transition between countries" (Lockwood et al., 2013).

In an attempt to remedy some of these shortcomings, I argue that a fruitful way of understanding politics and policy outcomes in the theory of carbon lock-in is to study the interest structures that the lock-in condition has created, and identify those who benefit from sustaining lock-in. In the following section I develop a perspective that allows us to study the empirical consequences carbon lock-in may have on renewable energy policy. In doing this I build on insights from political economy literature and rational choice models.

2.3 Translating carbon lock-in into policy outcomes

In climate and energy politics, there are often conflicting interests regarding environmental protection, economic growth and job creation. As Carter puts it: "Inevitably, environmental policies will produce winners and losers. The challenge for governments is to balance competing interests" (Carter, 2007, p. 180). Although not explicitly discussed, interests are an important underlying factor in the theory of carbon lock-in.

As we have seen, lock-in can be understood as a type of path dependency that favors status quo. Status quo is preferred because “lock-in is not suboptimal from the point of view of those entities that benefit from it” (Seto et al., 2016, p. 428). Assuming a rational actor model, this will imply that lock-in is sustained as long as benefiters of lock-in have interests in and the ability to defend the status quo. Furthermore that “those with interests threatened by a transition will mobilize to maintain existing rules, institutions, and systems” (Seto et al., 2016, p. 435). Many actors can be said to benefit from a carbon lock-in condition, including fossil fuel industry, energy consumers and state governments. These can also be seen as the key actors in Unruh’s techno-institutional complex (TIC).

In this thesis, I focus on economic and political actors. As highlighted by the political economy literature and neo-pluralists, the relationship between economic and political actors is of particular importance for policy-making in liberal democratic societies (see for example Fligstein, 1996; Lindblom, 1977, 2001). This is because maintaining a stable economy becomes a key task for governments who wish to assure reelection and avoid harmful conflict with business interests (Lindblom, 1977). Although they may, business interests do not strictly need to lobby governments to maintain their interests. Moreover, “in accordance with the imperatives of capitalism and the pursuit of its own self-interest, [governments] will itself ensure that business interests are not adversely affected by its actions” (Howlett & Ramesh, 2009, p. 40). Therefore, a “central role of the state is to advance the general interests of capital” (Burnham 1990, as quoted in Geels, 2014, p. 26).

This can be observed as “policymakers and incumbent business actors tend to form close alliances because of mutual dependencies” (Geels, 2014, p. 26). These mutual dependencies are manifest in several ways. First, business and industry actors are dependent on governmental regulations and legal framework in order to perform their activities (Geels, 2014, p. 26). The government also shape the economic activity for example “through tariff protection, loans, cash grants, government purchases, patents, tax concessions, information and research services” (Geels, 2014, p. 26). Second, in capitalist economies governments depend on industry and business “to provide jobs, taxes, economic growth and dynamism” (Geels, 2014, p. 26). Political actors may also depend on industries and private companies as a source of votes and economic support for political parties (Hughes & Urpelainen, 2015, p. 55).

In a carbon lock-in condition, it is reason to believe that these dependencies are particularly strong. I point to two reasons why. First, the fossil fuel industry is exposed to increasing returns mechanisms because of its capital intensity (Hughes & Urpelainen, 2015, p. 57), and can provide high profits for the industry and the economy as a whole. Second, fossil fuels dominate several of the technological systems crucial for the functioning of modern societies, like electricity and transport. Therefore, policymakers are not only dependent on the industry for its contribution to economic growth, but also of the vital functions it provides to society. I claim that such mutual dependencies are the key to why the TIC and carbon lock-in produce resistance to change away from fossil fuels.

Expectations about renewable energy policy

Based on the discussion over, my general theoretical expectation is that the mechanisms that produce carbon lock-in create mutual dependencies between fossil fuel industry and policy-makers who benefit from lock-in in several ways. I assume that these are rational actors, with a primary interest to maintain lock-in, and furthermore that a change-resistance fossil fuel industry-policymaker complex develops. I use the notion fossil fuel industry-policymaker complex, rather than TIC, to highlight what I consider as the key actors that may benefit from sustaining the lock-in. When the complex is strong[4], the only renewable energy policies that are politically viable are policies that do not challenge the interests of the complex.

What type of policies then, will and will not be a challenge to these interests? In the case of renewable energy, such technologies can be a direct challenge to incumbents' interests if they can replace fossil fuels in electricity generation. In contrast to fossil fuels, most renewable energies are yet to benefit from the mechanisms of increasing returns (Foxon, 2002, p. 4). In most cases therefore, the costs of renewable energies are much higher than for fossil fuel energy sources. Also, there may be additional barriers to market entry for renewables, like infrastructure challenges. Consequently, state intervention is often needed in order to create profitability for renewable energy sources (Aklin & Urpelainen, 2013, p. 643). As Polzin et al. (2015) put it, the "ultimate requirement for a sustainable RE policy is a reduction of capital costs to create a level playing field with fossil fuel-based technologies which have been heavily subsidized in the past" (Polzin, Migendt, Täube, & von Flotow, 2015, p. 100). Therefore, policies that reduce costs and increased competitiveness of renewable energies must be seen as a challenge to incumbents.

[4] A strong complex is assumed when the electricity generation and the economy relies heavily on fossil fuels, in addition to public ownership in the industry. See next chapter for further details on operationalization.

As my expectation is that a strong fossil fuel industry-policymaker complex only allows for policies that *do not* challenge their interests, I expect that renewable energy policies in carbon locked-in countries will not reduce the costs and/or increase the competitiveness of renewable energies compared to fossil fuels. Four indicators of RE policy design will be studied in order to analyze this expectation. In the following I present the rationale behind choosing these indicators and a hypothesis about their nature in a carbon locked-in country. The next chapter deals with how these indicators will be measured.

First, the *level of support* is important in order to assure competitiveness, especially in countries where there are big cost differences between fossil and renewable energy sources. A slight cost reduction may not be enough to release investments in renewable energies.

> *H1: The level of support for is too low to trigger significant investments in renewable energies.*

Second, *predictability* is crucial for investors. In analyzing the decision criteria of investors in renewable energy, scholars have found that in addition to costs, the "perceived (market) uncertainty and political risk" (Polzin et al., 2015, p. 100) are the most important factors when making investment decisions.

> *H2: Renewable energy policies are unpredictable, and do not provide necessary long-term investment horizons for investors.*

Third, renewable energy policies may impose costs on fossil fuel industry, consumers or the state itself (Cheon & Urpelainen, 2013, p. 879). Therefore, the *cost allocation* is important because imposing costs on fossil fuels can be a way to level the playing field and increase competitiveness for renewables.

> *H3: If renewable energy policies impose costs on fossil fuel industry there will be exemptions or other compensations for the fossil fuel industry.*

Finally, the fourth indicator looks at which renewable energy *technologies* that receive support. There are big differences within the category of renewable energy in terms of technical maturity. If these differences are not taken into account in policy design, competitiveness for renewables compared with fossil fuel energy sources may not be achieved. Technological neutral policy schemes, on the other hand, benefit the most cost-effective renewable energies and stimulate to a little extent innovation and increased competitiveness of more immature renewables technologies (Mitchell, 2008).

H4: Renewable policy schemes will be technology neutral and thus benefit mature technologies rather than new renewables.

2.4 Summary

Table 1 provides a summary of the general and specific expectations of how carbon lock-in may influence renewable energy policy, as well as the indicators that will be used to assess these relationships. To probe the validity of the expectations, I will perform a qualitative comparative case study of the development of renewable energy policy in three country cases. The next chapter presents the research design.

Table 1: Analytical framework

<table>
<tr><td>RQ</td><td colspan="2">To what degree and in what ways does carbon lock-in influence renewable energy policy?</td></tr>
<tr><td>General expectations</td><td colspan="2">The mechanisms of carbon lock-in produce a strong fossil fuel industry-policymaker complex. Renewable energy policies will not challenge their core interests.
RE policies will not substantially reduce costs or improve competitiveness of renewable energies compared to fossil fuels (in electricity generation).</td></tr>
<tr><td rowspan="2">Indicators</td><td>Explanatory factors</td><td>Outcome</td></tr>
<tr><td>Fossil fuel industry-policymaker complex
✓ Fossil dependent electricity generation
✓ Fossil dependent economy
✓ State ownership</td><td>Renewable energy policy
✓ Level of support
✓ Predictability
✓ Cost allocation
✓ Technology</td></tr>
<tr><td>Specific expectations</td><td colspan="2">When the complex is strong, based on the indicators above, renewable energy policies are expected to have the following characteristics:
H1: The level of support for is too low to trigger significant investments in renewable energies.
H2: Renewable energy policies are unpredictable, and do not provide necessary long-term investment horizons for investors.
H3: If renewable energy policies impose costs on fossil fuel industry there will be exemptions or other compensations for the fossil fuel industry.
H4: Renewable policy schemes will be technology neutral and thus benefit mature technologies rather than new renewables.</td></tr>
</table>

3 Research design

This chapter describes the research design and methods, case selection, operationalization of indicators and data gathering procedures. Some challenges regarding validity and reliability will also be discussed.

3.1 Comparative case study

To answer the research question of this thesis I perform a qualitative comparative case study. George and Bennett (2005) define a case as an “instance of a class of events” (George & Bennett, 2005, p. 17), and the class of events that will be studied here is the development of renewable energy policies in a carbon lock-in condition. The comparative case study method is chosen for several reasons. First, in order to study the development and characteristics of renewable energy policy in carbon locked-in countries at the level of detail required to answer the research question, an in-depth analysis and small N-approach is appropriate. Second, as this thesis also has a theoretical aim to increase the understanding of carbon lock-in’s influence on policy process and outcomes, the case study method is well-suited. This method is praised for its strengths regarding testing and/or developing theory (George & Bennett, 2005). Third, applying a comparative approach allows for a better understanding of carbon lock-in dynamics across countries. It can also strengthen the theoretical discussion as it opens up for the possibility to study differences in carbon lock-in across countries.

A common critique of comparative small N-studies is that they often have too many variables and too few cases, which leads to over-determination and trouble isolating explanatory factors (Lijphart, 1975). By anchoring the explanatory factors in the theory, I have strived to compensate for these risks. Furthermore, alternative explanations will be dealt with in the analysis. Based on the empirical observations in this thesis, I will discuss the carbon lock-in theory’s applicability across countries, rather than to generalize the findings.

3.2 Case selection

As discussed in the previous chapter, carbon lock-in results from a path dependent process driven by both technological and institutional increasing returns mechanisms that provide the foundations for a fossil fuel industry-policymaker complex. In order for such a carbon lock-in condition to develop, I suggest that a significant share of the energy system and economic activity must be highly fossil fuel dependent. To select countries for the case study, I have therefore developed an index based on indicators that reflect this fossil fuel dependency, both in technological systems and in the economy. As the theory of carbon lock-in applies, according to Unruh (2000, 2002), to industrial economies and industrialized countries[5], the index is based on OECD-countries. The indicators are listed in Table 2, and described in detail in the Appendix 1. The choice of indicators is to some extent limited by the availability of data. The full index is presented in the Appendix 1.

Table 2: Carbon lock-in index indicators

Indicator	**Description**	**Source**
Fossil fuel energy consumption	% of total energy consumption.	World Bank
Fossil fuel electricity production	% of total electricity production.	World Bank
Added value by energy-producing activities	Energy producing activities as a share of total gross value added (GVA).	OECD Structural Analysis Database
Fuel exports	% of total merchandise exports.	World Bank

When compiling all indicators into one index, Australia, Poland and Israel are ranked on top (in that order). In these countries more than 90% of both energy consumption and electricity production comes from fossil fuels. Australia also has a high score on the economic factors, while the others two do not.[6] This may indicate that there could in fact be two different dimensions of carbon lock-in – one technological and one economic – which may be masked when the indicators are compiled into one index.

When looking at the technological and economic indicators separately, we see that Australia, Israel and Poland (in that order) top the technological dimensions, while Norway, Australia and Canada (in that order) top the economic dimension. Based on these scores, Australia, which has a high score on both dimensions, is a natural candidate for further study. Also,

[5] Unruh does not limit the drivers of carbon lock-in to the national context, however he also claim that these may as well be global (see Unruh & Carrillo-Hermosilla, 2006). However, as this thesis look at national renewable energy policies, I will focus on carbon lock-in at the country level.
[6] The index is an additive index where all indicators are given as a percentage share, and calculated based on their average share over the period studied (see Appendix 1 for details). The index could have been developed further by e.g. weighing the indicators, but as it is made for illustrative purposes to identify countries with high fossil fuel dependency, this has not been prioritized.

Poland is interesting, as it has such a high score on the technological dimension, while a low score on the economic dimension. Including Poland therefore allows assessing whether the economic dimension is a necessary condition for a carbon lock-in.

In addition to Poland and Australia, I have chosen to include Norway as a third case. In many ways, Norway can be understood as a carbon locked-in country. Norway is among the highest exporters of oil and gas in the world, and its economy is heavily dependent upon its petroleum sector (oil and gas) (IEA, 2011b, 2017a). Fuels represented 58% of total Norwegian exports in 2015. This is miles a head the next on the list of OECD-countries: Australia with 27% of total exports (World Bank). However, the Norwegian electricity generation is almost fossil-free and highly dependent on hydropower. In 2015, 98% of electricity generation came from renewables, of which 96% was hydropower (IEA, 2016c). This duality makes Norway an interesting case as it may inform the theoretical discussion of the carbon lock-in theory. By including Norway I can assess whether the effect of lock-in in electricity generation is carbon specific – or if there are similar mechanisms at play when a non-fossil source dominate the electricity generation.

Table 3: Two dimensions of carbon lock-in.

	Economic dimension	Technological dimension
Australia	✓	✓
Poland	–	✓
Norway	✓	–

One of the biggest challenges in any type of comparative research is the “difficulty of identifying cases that are truly comparable – identical or different in all respects but one” (Levy, 2008, p. 10). The cases in this study are not “truly” comparable in the meaning Levy here portrays. In fact, very few cases are in cross country research. However, the case study method allows for sensitivity towards such differences, and these will be discussed in the analysis.

3.3 Timeframe

The time period studied is 1990–2015. This period is chosen because most renewable energy technologies were too costly for commercial applications before the 1990s (Cheon & Urpelainen, 2013, p. 774). The period ends in 2015 because the policy database (see under) provides data only up to 2015.

3.4 Operationalization

3.4.1 Renewable energy policies

The outcome I wish to explain (i.e. *explanandum*) is the renewable energy policies in the country cases over the period 1990–2015. I look at policies targeting the electricity sector as this is one of the technological systems that have experiences the process of increasing returns and where fossil fuels dominate (Unruh, 2002). I focus on renewable policy schemes that are meant to increase the level of renewable energy generation and/or consumption in each country, and emphasize the main policy instruments in the period at study. Such policy instruments could be feed-in-tariff schemes, green certificate schemes, renewable energy obligations, renewable targets, etc. Policy schemes that are implemented to promote heat (for example from geothermal energy) fall outside of the scope of this thesis.

I assess renewable energy policies along the four indicators of renewable energy policy (see analytical framework).

The *level of support* is studied by looking at whether renewable energy policies are designed to assure renewables a price above, equal or under the electricity market price. This is because most renewable energy technologies at least historically, have been dependent on subsidies or a price guarantee to become profitable (Aklin & Urpelainen, 2013, p. 643). Also, assessing the level of deployment of new renewable energy during the period studied, or under a particular scheme, can provide an indication of whether the level of support has been high enough to trigger new investments in renewable energy.

Predictability is measured by assessing the duration of policies, and the degree to which policies are frequently ended or amended. However, the perceived predictability is not only dependent on the duration of policies. Studying how politicized renewable energy politics are will also give an indication of the perceived uncertainty about renewable energy market conditions.

Cost allocation is measured by studying how renewable energy policies are financed, and if they impose costs on fossil fuel industries. If they do, I will also consider if the fossil fuel industry is compensated for these costs, directly e.g. by achieving exemptions, or indirectly through e.g. support programs that benefit the fossil fuel industry exclusively.

Finally, the *technology* indicator is assessed by studying if policies are designed to promote specific renewable energy technologies, or if they are technology neutral.

3.4.2 Explanatory factors

The strength of the assumed fossil fuel industry-policymaker complex is assessed along three dimensions: electricity generation, economic impact and state ownership.[7] It should be underlined that the complex is a theoretical assumption, in the same way as Unruh's TIC. These indicators are therefore used to assess the likelihood that such a complex exists, and chosen because they are likely to contribute to mutual dependency between fossil fuel industry and policymakers. A high score on all three dimensions is interpreted as a strong complex. However, the important part is not to calculate an exact score, rather to get an impression of the strength of the interdependency between industry and policymakers.

First, a high score for electricity generation is defined as a situation where more than 90% of the electricity comes from fossil fuels.[8] Second, the economic dimension is accounted for in several ways. As well as looking at the share fossil fuels constitute of exports, I assess the fossil fuel industry's contribution to the economy in general. When the exports constitute more than 15%, it is defined as a high score.[9] Defining an exact threshold for a high and low score for the fossil fuel industry's contribution to the economy is not straight forward. The availability of comparable data for such an indicator is limited. However, OECD provides

[7] Some of the same indicators as for the carbon lock-in index are used. However, additionally indicators that were not available on a cross-country basis, but that can provide a better picture of the industry-policymaker complex are used for the three selected countries.
[8] The IEA average share of fossil fuels in electricity generation across IEA members in 2015 was 76% (IEA, 2016d).
[9] The average for the countries in the carbon lock-in index was 4% over the period 1990-2015 (see Appendix).

comparable data on energy-producing activities' share of GVA.[10] Looking at these numbers, we see that there are very few countries where these activities amount to 5% or more of GVA (see Appendix 1). I therefore assess 5% as a high score on this indicator. In addition, where such numbers have been available, I refer to the fossil fuel industry's share of GDP and/or of state revenues. I also include indirect impact of fossil fuel industry on the economy by looking at the number of fossil fuel industry jobs.

Finally, state ownership is assessed as important when the most dominant and/or majority of energy companies in the electricity sector are state owned. The state ownership may be as a majority or a minority shareholder, assuming that also a minority share create close ties and interviewed interests between industry and policymakers.

To the extent possible I assess how the overall indicators change over time, as well as compare with the development in the renewable energy industry.

3.5 Data

The thesis builds on data from official databases, statistics and documents, as well as secondary literature. In the following I describe the data gathering process, and discuss some challenges regarding reliability of data.

3.5.1 Renewable energy policies

The primary source of data on renewable energy policies is the IEA and IRENA's Global Renewable Energy Policies and Measures Database (IEA/IRENA 2017). This database provides a detailed description of RE policies across countries and over time. By applying different filters I can specify the policies that are relevant for the study of this thesis. In the following section I give a brief description of the criteria used to choose the policies to study.

All national policies (excluding sub-national policies) marked as 'in force', 'ended' or 'superseded' in the period 1990–2015, were selected. Furthermore, the sectors 'electricity',

[10] This measure summarizes the impact of industry activities in the three categories: Mining and quarrying of energy producing materials; Coke and refined petroleum products; Electricity, gas, steam and air conditioning supply. It should be noted that the last category does not distinguish between fossil and renewable energy sources. This is mainly a problem for Norway with its high share of renewables in electricity generation. Therefore, in the Norway case study, numbers that distinguish the impact of the fossil fuel industry are used.

‘multi-sectional policy’ and ‘framework policy’ (e.g. political strategies and White Papers), and the energy sources bioenergy, hydropower, ocean, solar and wind power, as well as the category ‘multiple renewable energy sources’, were specified.

The database also categorizes policy types and sub-types. The policy types included in this study are “Economic Instruments”, “Policy Support”, “Regulatory Instruments”, “Research, Development and Deployment (RD&D)” and “Voluntary Approaches”. I excluded policies under the category “Information and Education” as these are not directly instrumental in the development of renewable energy electricity generation. Policies that were not targeting renewable energy development directly or oriented towards international cooperation and/or development projects, were excluded.

Official documents and secondary literature is extensively used to provide more detail and context for the study of these renewable energy policies. Media reports are also used, mostly for recent policy developments, as a support when secondary literature on the topic has not (yet) been published.

These selection criteria have resulted in 41 policies for Australia, 17 policies for Poland, and 20 policies for Norway (see Appendix 2).

Reliability

The IEA/IRENA Global Renewable Energy Policies and Measures Database is available as an online database on the IEA’s webpages. It is updated on a regular basis, and IEA member country delegates are given the opportunity to review the information twice a year (IEA, 2017b). However, this is not a guarantee that all information in the database is correct. I have therefore cross-checked the information regarding the main schemes of interest with official documents and secondary literature. Where there have been discrepancies or unclear information in the database, I have relied on other sources. However, the general impression is that the database provides a precise overview of the general development of renewable energy policy in each country.

Another challenge to reliability is the fact that the database is updated by experts from different countries. Errors can be made, and filters and categorizations may have been understood and applied differently across experts. I have therefore assessed how the categorizations (i.e. the policy type) comply with the given description of the policies and how they are described in other sources, to reduce this source of inaccuracy.

3.5.2 Explanatory factors

Data for the explanatory factors are collected form official statistics, documents and databases. The open-access online data sources of the World Bank, the IEA and the OECD are widely used. Furthermore, I have consulted the IEA Country Reviews, and the online sources of national Bureaus of Statistics in Norway and Australia and other governmental institutions in all three countries. As these are credible international organizations and official governmental institutions it is reason to believe they provide reliable data.

4 Case studies

This chapter presents the empirical case studies of the renewable energy policy development in Australia, Poland and from 1990–2015. In assessing the country cases I focus on the policies that stand out as the most important for the development of new renewable electricity generation. Other policies will be briefly mentioned where relevant, while an overview of all renewable energy policies in the country cases can be found in the Appendix 2.

The chapter presents each case study in the following manner: First, I provide a brief background for each case, including key information related to the explanatory factors. Second, a chronological overview of the development of renewable energy policy is presented. The account is divided into several time periods. The first period is equal for all three cases: Prior to 2001. This is because very few policy developments happened before this year. The periods thereafter follow the respective change of governments in each country. Finally, the policies are assessed in relation to the indicators for renewable energy policy and the expectations in the analytical framework.

4.1 Australia

4.1.1 Background

Australia is the sixth largest country in the world but with a sparse population of approximately 24 million people. Australia is a federal state with six states and two territories. The federal parliament has two houses: the House of Representatives (150 seats) and the Senate (76 seats) (IEA, 2012, p. 16).

Australia has a substantial natural resource base, including coal, gas and oil, in addition to among the largest solar energy potentials in the world (IEA, 2012, p. 7). It is a net energy exporter, mostly to the coal and liquefied natural gas (LNG) markets (IEA, 2012, p. 16). In 2015 it was the world's largest coal exporter measured in volume (Department of Industry Innovation and Science, 2016b). Australia is among the OECD-countries with the highest greenhouse gas CO_2-emission per capita (IEA, 2016a).

Australia signed the United Nation Framework on Climate Change (UNFCC) in 1992. It ratified the Kyoto Protocol in 2007 with a target for the first commitment period (2008–2012) of 8 % increase in emissions above 1990-levels, and 0,5 % below 1990-levels for the second commitment period (2013–2020) (Climate Action Tracker Partners, 2017a). Australia signed the Paris Agreement in 2015 with a target of 26–28 % emission reduction compared to 2005-levels (Climate Action Tracker Partners, 2017a).

Electricity generation

The National Electricity Market (NEM) was established in 1989 and is a wholesale spot market (AEMO, 2015). The NEM covers most of Australia's territory with an interconnected grid.[11] Electricity generation in Australia is dominated by fossil fuels – mainly coal and gas. Between 1979 and 2010, the share of coal was never below 70 % of electricity generation (IEA, 2005, p. 95, World Bank 2017). In recent years the share of coal in electricity generation has declined because of the increase in gas and renewables, but also because of the total growth in electricity demand (Figure 1) (IEA, 2012, p. 89). Due to the increase in energy demand, the share of renewable energy actually declined from 11 % in 1990 to 8 % in 2000 (Climate Change Authority, 2012, p. 9)

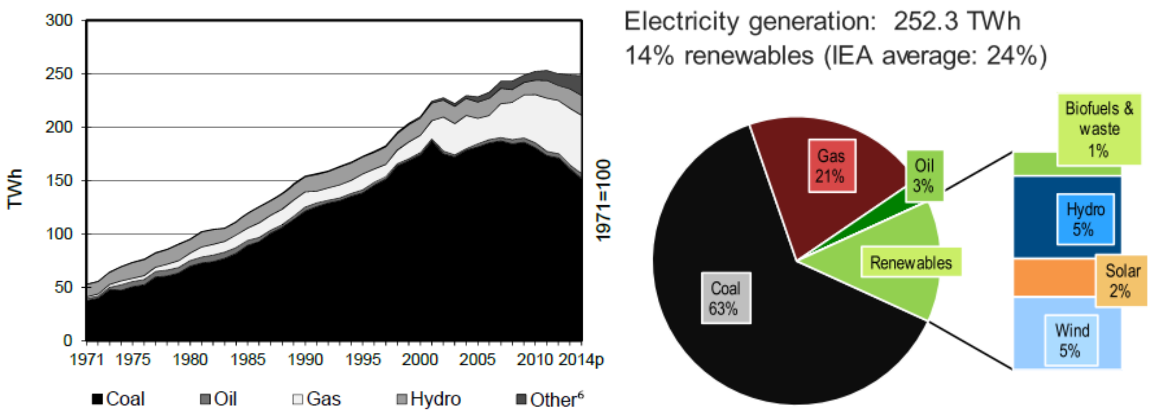

Figure 1: Electricity generation in Australia by fuel, historically (left) and 2015 (right). Sources (IEA, 2015, 2016a).

However, since 2000 the share of renewables has grown. Renewables amounted to 35,3 TWh in 2015, which represented 14% of total electricity generation in 2015. The main RE sources were hydropower (5 %), wind (5 %) and solar (2 %). Wind and solar were the fastest growing

[11] The Western Australia and the Northern Territory are not part of the NEM.

sources, with an average annual growth over the last ten years of 59,3 % for solar PVs and 23,5 % for wind power (Department of Industry Innovation and Science, 2016, p. 8).

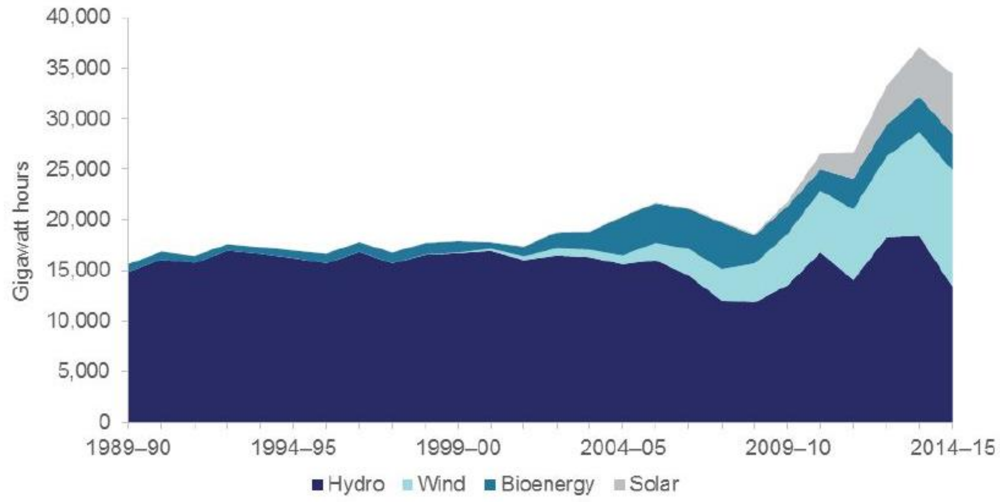

Figure 1: Renewable electricity generation in Australia by source, 1989-2015. Source: (Department of Industry Innovation and Science, 2016a, p. 20).

Economic impact

Australia has an important fossil fuel and mining industry. Australia is among the top 5 world exporters of mining products such as coal, LNG, iron ore and alumina (Department of Industry Innovation and Science, 2017). Most official statistics provide data for the mining sector as a whole. In the following I will thus provide an overview of the mining sector, and supplement with sources that provide fossil fuel industry data only.

Since 2003, Australia has experienced what has been called a “mining boom” with mining exports more than tripling from 2002 to 2012 (Tulip, 2014, p. 17). This boom has had a major impact on the Australian economy. Tulip (2014) estimated that the boom “raised real per capita household disposable income by 13 per cent [and] raised real wages by 6 per cent” (Tulip, 2014, p. 17).

In 2008–2009, the mining sector contributed 8% of GDP, employed 150 000 people directly and 505 600 people indirectly, and paid more than AUS $21 billion in State and Federal taxes (Roarty, 2010). In 2015–2016 the mining sector was the third highest contributor to GDP with 6,9 %, while the Services and Constriction sectors were the two biggest contributors (Office of the Chief Economist, 2016, p. 37).

According to the IEA, the energy sector in Australia contributed as much as 16% of GDP in 2012 (IEA, 2012, p. 7). Exports of coal and LNG contribute to a large share of Australian exports. From 1990 to 2005, fuel exports represented around 20 % of mercantile export, while the share has increased to approximately 30 % in recent years (World Bank 2017).

Regarding employment rates, the coal mining industry employed 50 000 in 2014, while the oil and gas industry employed 25 000 (Australian Bureau of Statistics, 2014). The number of employees in oil and gas has grown since 1990, particularly from the mid-2000s due to the 'mining boom'. The employment in the coal industry declined during the 1990s and reached a low-point of 14 000 in 2002, before the number of jobs raised to the current level of approximately 50 000, also due to the 'mining boom' (Australian Bureau of Statistics, 2014). According to the industry association Minerals Council of Australia, an additional 100 000 are currently employed indirectly in the coal mining industry (Minerals Council of Australia, 2017).

The electricity supply sector employed 65 000 in 2014[12], while gas supply employed 15,000 in 2014 (Australian Bureau of Statistics, 2014). Looking at the renewable energy sector, employment in this sector grew to 19,220 employees in the financial year 2011–2012, and nearly halved in the years that followed (Australian Bureau of Statistics, 2017). According to the Australian Bureau of Statistics 11,150 were employed in the renewable energy sector in 2015–2016.

State ownership

Coal, oil and gas companies are mainly privately owned in Australia. In the Australian electricity market all electricity retailers are private, while there is a mix of private and public ownership in generation, transmission and distribution (OECD, 2016). Of the approximately 300 electricity generators connected to the NEM, the majority of generators are privately owned in the states of Victoria, New South Wales and South Australia, while in Queensland and Tasmania most generators are owned by the government (Australian Energy Regulator, 2017, pp. 43–44).

[12] The statistics does not differentiate between fossil and renewable sources in electricity supply.

4.1.2 Renewable energy policies in Australia

In Australia the main renewable energy policy has been the Mandatory Renewable Energy Target (MRET), which was implemented in 2001 and later amended several times.

Prior to 2001: Preparing for the MRET

In Australia, few renewable energy policies were adopted in the early 1990s. Australia signed the Kyoto Protocol in 1998 as one of only three signatories that negotiated an increase in emissions compared to 1990-levels (Kent & Mercer, 2006, p. 1048). Although the conservative government led by John Howard refused to ratify the Kyoto Protocol in fear of the economic consequences for domestic and export oriented industry (The Australian, 2007), it also signaled that renewable energy was part of the government's plan to reduce emissions (Effendi & Courvisanos, 2012, pp. 246–247).

Preliminary work on a new support scheme for renewable energy started in 1998 when a Renewable Target Working Group was established (Kent & Mercer, 2006, p. 1048). The discussions and drafting process continued until the final Act was passed in 2000 (see next section).

According to the IEA/IRENA database, the majority of the policies implemented in the period before 2001 targeted R&D and RE industry development. Worth noting is also the AUS 495,3 million Solar Homes and Communities Plan which was a rebate program for solar PVs in private households and community buildings.

2001 – 2007: An uncertain future for the MRET

After years of drafting and negotiations, the Howard government's Mandatory Renewable Energy Target (MRET) scheme came into operation in April 2001 (Kent & Mercer, 2006, p. 1049). The MRET introduced a target of 9500 GWh new renewable energy generation by 2010. It has been claimed that the MRET target was decided after a long negotiation with affected parties where the energy-intensive industry was successful in negotiating a target that was "within their comfort zone but too low as a target to overcome commercialization barriers" (Effendi & Courvisanos, 2012, pp. 249–250).

The MRET established a market for renewable energy by introducing tradeable certificates, Renewable Energy Certificates (RECs). While renewable energy power stations create certificates, retailers and large electricity users were obliged by law to obtain a certain amount of RECs based on a percentage of their electricity purchases (The Clean Energy Regulator, 2016). RECs therefore provide producers of renewable electricity with an additional income to the electricity price. Households and small businesses could also obtain RECs on a voluntary basis for small-scale renewable energy installations.

In the early years of the MRET, several reviews created uncertainty about the scheme's future. First, the government appointed a committee to review the Australian energy market and provide recommendations for future developments in the energy sector in 2002. This review was named 'the Parer review' after its chair Warwick Parer, a former Minister of Resource and head of Australian Coal Exporters (Kent & Mercer, 2006, p. 1050). The review recommended to abolish the MRET on the grounds that it was not a cost-effective way of achieving emission reductions, and suggested to replace it by an emission trading scheme (ETS) (Effendi & Courvisanos, 2012, p. 249).

Second, a full review of the MRET scheme was initiated in 2003, only two years after its implementation. Since most Acts in Australia are reviewed after five years of implementation, the review was regarded by several concerned parties as premature (Kent & Mercer, 2006, p. 1051). This review received 248 submissions from different actors affected by the scheme, both opponents and supporters. The critics of the MRET wanted it abolished, claiming that the scheme would result in an intolerable increase in electricity prices and that it was not a cost-effective way to reduce emissions (Kent & Mercer, 2006, pp. 1054–1055).

The supporters of the MRET claimed that the current design made the scheme a weak instrument to increase the deployment of new renewable energy and develop the renewables industry (Kent & Mercer, 2006, p. 1052). There were several reasons for this.

First, the target was set at a level where it could be met by pre-existing generators, and would thus trigger few new investments and installations (Kent & Mercer, 2006, p. 1056). The supporters therefore advocated an increase in the target, as well as extending the scheme to assure more predictability for the renewables industry. Second, the inclusion of solar and heat pump water systems in the MRET contributed to a scheme that was "ill structured to generate large scale deployment of renewable energy" (Effendi & Courvisanos, 2012, pp. 249–250).

These two review processes were according to Effendi and Courvisanos (2012, p. 249) an important basis for the Howard government's decision in 2004 not to extend the MRET scheme beyond the current 9500 GWh goal by 2010. This was against the recommendation of the MRET review panel who recommended to maintain the MRET and to gradually increase the target to 20,000 GWh from 2010 to 2020 (Kent & Mercer, 2006, p. 1059). The government justified its decision on the grounds that the scheme was too costly, not cost-effective, as well as indirectly made the government "pick winners" in the electricity market (Effendi & Courvisanos, 2012, p. 249). The decision not to extend the MRET beyond 2010 led several State Territories to plan separate state-level renewable targets and support schemes (Climate Change Authority, 2012, p. 5).

The decision not to extend the MRET came alongside the Howard government's White Paper on Energy in 2004. The White Paper provided AUS 700 million to several research and development (R&D) projects, among others the AUS 500 million Low Emissions Technology Development Fund and the AUS 100 million Renewable Energy Development Initiative (Commonwealth of Australia, 2004). Solar energy was also prioritized through an AUS 94 million Solar Cities Program supporting the deployment of solar energy in urban areas across Australia (IEA/IRENA 2017).

As the majority of the funding in the Low Emissions technology Development Fund was designated for CCS projects, it has been claimed that the White Paper "made a strong commitment to other 'clean' technology, notably clean coal with carbon capture and sequestration" (Effendi & Courvisanos, 2012, p. 250). Kent and Mercer (2006, p. 1047) assessed the White Paper to "strongly favours a 'business-as-usual', fossil-fuel dominated future for the Australian energy sector" (Kent & Mercer, 2006, p. 1047).

2007 – 2010: Rudd increasing renewables ambitions

With the election of Kevin Rudd (Labor) as Prime Minister (PM) in late 2007, climate and energy issues were high on the new government's agenda. Rudd had raised these issues in his election campaign, and one of the first things he did after taking office in December 2007 was to ratify the Kyoto agreement (Curran, 2011, p. 1008). The Rudd government had a new take on climate and energy issues identifying "climate change as a critical moral and economic problem and promised a strong evidence-based policy response" (Curran, 2011, p. 1004).

Renewable Energy Target (RET)

As promised in the election campaign of 2007, the new government amended and expanded the MRET scheme in 2009 (Buckman & Diesendorf, 2010, p. 3370). The new Renewable Energy Target (RET) both increased the ambition and the duration of the scheme. The RET set a goal of 20% renewable energy in electricity generation by 2020. This would result in 45 000 GWh of new renewable electricity by 2020 (IEA, 2012, p. 73).

The RET also made a distinction between large-scale and small-scale renewable energy projects. This was largely due to the uptake of small-scale installations, such as solar PVs, which had been higher than expected. The costs of these installations had dropped. In addition they received subsidies from other programs, including sub-national renewable schemes. This "depressed certificate prices and discouraged investment in large-scale projects, which have very large capital requirements" (Climate Change Authority, 2012, p. 6). The RET scheme was therefore divided into two separate schemes in 2011, where the RET goal was to be met mainly through the Large-Scale RET (LRET) providing 41 000 GWh of the total 45 000 GWh (Climate Change Authority, 2012, p. 6).

The new RET was different from the MRET in several ways. First of all, the new RET included waste coal mine gas (WCMG)[13] as an eligible energy source under the LRET. Including this by-product from coal production as eligible for RECs was assumed to undermine "the effectiveness of the RET (…) and impacting the tradable price of the certificates" (Byrnes, Brown, Foster, & Wagner, 2013, p. 716). It has also been argued that including WCMG as an eligible source implied an indirect subsidy to the fossil fuel industry which already profits from policy and market advantages compared to renewables (Valentine, 2010, p. 3672).

Although stated in the RET Act of 2009, WCMG only became eligible from 1 July 2012 with a cap of 850 GWh each year (Climate Change Authority, 2012, p. 109). Due to protests, the WCMG target was also made additional to the RET target to avoid WCMG displacing renewables under the scheme. The inclusion of WCMG was further restricted by only allowing existing coal firing plants to apply for RECs (Climate Change Authority, 2012, p. 109). In the period from 2012 to 2015 seven power plants obtained RECs for WCMG (Clean Energy Regulator, 2016, p. 77).

[13] WCMG is a by-product from coal mining, mainly methane gas (Climate Change Authority, 2012, p. 108).

Why then was WCMG included in the scheme at all? The RET scheme was redesigned parallel to the negotiations on an emission trading scheme, and the government assumed that the ETS would be implemented and that the RET therefore could be gradually phased out (Valentine, 2010, p. 3671). Including WCMG was regarded as a transitional measure to compensate for the costs that an emission trading scheme would impose on coal firing plants (Climate Change Authority, 2012, p. 108).

The RET also provided partial exemption to emission-intensive and trade-exposed industries (only on electricity above the MRET 9500 GWh target). This was done, according to the Climate Change Authority, "to reflect the cumulative cost impact of the RET and anticipated carbon price on those industries" (Climate Change Authority, 2012, p. 6).

Other policies

In addition to the RET, the Rudd government proposed several other policy instruments that directly or indirectly affected renewable energy. Much time and effort was spent on trying to negotiate a carbon emission trading scheme (ETS) during Rudd's time in office. As noted earlier, the RET scheme was planned to be phased out when the ETS scheme was established. However, the Rudd government did not succeed, and had to withdraw the proposed ETS in April 2010 after two failed attempts to pass an ETS bill in the House of Parliaments (Curran, 2011, p. 1011).

In 2009 the Rudd government announced the "Clean Energy Initiative" with a budget of AUS 4,5 billion. This initiative included several projects to support low emission technology and industry development in Australia. Like the Howard's government's White Paper on Energy from 2004, CCS was included as a "low emission coal technology" and was designated the bulk of the funding. The Carbon Capture and Storage Flagships program was allocated AUS 2,4 billion of the Clean Energy Initiative's budget (The Department of Industry, Innovation, Science, 2009).

However, solar energy was also supported by the Initiative. The Solar Flagship Program was introduced with AUS 1,5 billion for construction and development of large scale grid-connected solar power stations (IEA/IRENA 2017). In addition, the Australian Centre for Renewable Energy (ACRE) was established to provide technical support and financial grants in all steps of the innovation process, and funding for deployment of new renewable energy in Australia. AUS 700 million was designated to ACRE's activities.

2010 – 2013: Gillard continuing down Rudd's road

Due to internal controversies in the Australian Labor Party, Kevin Rudd was replaced as PM by Julia Gillard in June 2010 (Kerr & Franklin, 2010). She held office, supported by the Greens and three independent representatives, until Rudd again became the PM in June 2013 due to Gillard's unpopularity before the upcoming election the same year (Rootes, 2014, pp. 166–167). Rudd's second period as PM lasted only for three months as Labor was defeated in the election. This section will focus on the two Labor government's policies up to the election defeat in September 2013.

RET review 2012

The Parliament had required the Climate Change Authority to review the RET scheme every second year from 2012 and on. The 2012 RET reviewed received in total 8660 submissions, and the review process showed that a majority of consulted stakeholders were positive towards the scheme (Simpson & Clifton, 2014). Only minor and incremental changes to the RET were adopted as a result of this review (Simpson & Clifton, 2014, p. 134).

The Clean Energy Future Plan 2011

The Gillard government proposed a Clean Energy Future Plan in 2011, making a new attempt to introduce a carbon price, as well as several changes to the renewable energy policy. The carbon price came into force 1 July 2012. In addition, the independent Climate Change Authority was established to provide expert advice on carbon pricing and other climate and energy issues (IEA, 2012, p. 49).

When looking at the renewable energy policy part of the plan, the Clean Energy Future Plan is essence an extension of Rudd's Clean Energy Initiative from 2009. The 2011 plan replaced Rudd's Australian Centre for Renewable Energy by a the new Australian Renewable Energy Agency (ARENA) as the main agency for providing R&D and support for commercialization of new renewable technologies (Byrnes et al., 2013, p. 715). Its objective is to improve "competitiveness of renewable energy technologies and increasing the supply of renewable energy" (IEA, 2012, p. 22). Three different innovation grant programs were established to support different stages of the innovation process. A whole range of existing programs were also incorporated into ARENA, including funding for CCS projects (Byrnes et al., 2013, p. 715). ARENA's activities were allocated AUD 3,2 billion (IEA, 2012, p. 22).

In addition, the Clean Energy Future Plan established a new AUS 10 billion (over five years) venture capital fund – the Clean Energy Finance Corporation (CEFC) – to "leverage private sector financing for renewable energy and clean technology projects" (Byrnes et al., 2013, p. 715). The fund would not provide any grants but is "intended to be commercially oriented and to make a positive return on its investments" (IEA, 2012, p. 22). The CEFC Act instructs the fund to invest in energy efficiency, renewable energy technologies, and low-emissions technology. However, it is up to the CEFC Board to define what is regarded as a low emissions technology (Commonwealth of Australia, 2012b).

The package also included several support measures for the fossil and steel industry, for example the AUS 1.3 billion Coal Sector Jobs Package, the AUS 70 million Coal Mining Abatement Technology Support Package and the AUS 300 million Steel Transformation Plan (Commonwealth of Australia, 2012a).

2013 – 2015: Abbott pulling the brake

The Liberal Party won the election in 2013, and Tony Abbott replaced Rudd as PM. Abbott had been a strong opponent of carbon pricing and an ETS, and was in general critical towards all environmental policies that could be disadvantageous for domestic industry and Australia's economy (Eckersley, 2013, pp. 391–392; Rootes, 2014).

Abbott's opposition to climate change action was manifest from his first day in office when he ordered the CEFC to stop investing, and to abolish the Department of Climate Change, the independent Climate Commission and the Climate Change Authority (Rootes, 2014, p. 171). Although Abbott did not get enough support to go through with all his desired changes of the climate and energy policy, he managed to repeal the carbon tax in 2014, which Abbott had sweared a "blood oath" he would annul (Bailey & Inderberg, 2018, p. 1).

RET review 2014–2015

The Abbott government had also promised to review the RET. The review was initiated in February 2014 and would last for 15 months (Commonwealth of Australia, 2017). The tedious review process, and the composition of the Review panel, among them climate sceptics and fossil fuel industry lobbyists, was interpreted as a sign that Abbott's real intention was to get rid of the whole scheme (Giles Parkinson, 2014).

According to Hua et al. the review process caused "a great degree of uncertainty in the renewable energy market and investment has significantly declined, with some investors leaving the country and employment in renewables dropping" (Hua, Oliphant, & Hu, 2016, p. 1046).

There was also important opposition to the proposed changes to the RET. The Clean Energy Council, the renewable energy industry's peak body, started a campaign to maintain the initial RET target, holding over 300 meetings with politicians and several demonstrations during the review period (Clean Energy Council, 2017). The Council also figured as a broker between the government and the Labor Party, who also was opposing drastic changes to the RET (Taylor, 2015).

In the end, the Government and the Labor Party came to an agreement. They agreed to maintain the RET but to lower its target from 41 000 GWh to 33 000 GWh by 2020 (The Clean Energy Regulator, 2016). In addition, emission-intensive trade-exposed industries were provided a possibility of total exemption from all RET costs (Commonwealth of Australia, 2017).[14] However, the injunction that the RET scheme should be reviewed every second year was abolished (Clean Energy Council, 2017).

ARENA and CEFC

The Abbott government also tried to abolish ARENA by proposing legislation that would *de facto* repeal its statutory existence, but failed to get the necessary support for the bill (McKenzie-Murray, 2015). Instead, Abbott was able to reduce the ARENA funding by AUS 435 million. This created uncertainty about future funding for several of the innovation programs related to ARENA's activity (Hua et al., 2016, p. 1047).

Abbott failed to gather support to abolish the CEFC. However, the government ordered the CEFC to stop investing in wind and solar farms in 2015, a decision that created big protests in the renewables industry (McKenzie-Murray, 2015). This was done with the argument that wind and solar were mature technologies, while the CEFC mandate was to invest in new emerging clean energy technologies (McKenzie-Murray, 2015).

[14] Including LNG and coal. See (Clean Energy Regulator, 2015) for full list of activities eligible for exemptions.

4.1.3 Discussion

In this section I discuss how the renewable energy policies in Australia match with the expectations of the analytical framework. First, I assess how the main renewable energy policies correspond with the expectations along the four indicators of renewable energy policy design. Thereafter I discuss the findings in relation to the explanatory factors.

Explanandum

The main renewable energy policy instrument in Australia has been the RET scheme, formerly known as MRET. It was implemented for the first time in 2001 under the Howard government, and later amended several times.

In terms of the *level of support*, a certificates scheme like the RET is initially meant to work as an economic incentive by adding a second source of income for power generators, in addition to the electricity price. It implies, however, that investors are dependent on the (fluctuating) price of both certificates and electricity.

Looking at the new renewable generation as a consequence of the RET may give an indication whether these prices were high enough to trigger the new capacity set by the RET target. If we look at the overall electricity generation from renewables, the share has increased from 8% in the budget year 2000/01, when the MRET started, to 14% in 2015 (Climate Change Authority, 2012, p. 9; IEA, 2016a). The renewable generation increased from 17,800 GWh in 2001/02 to 35,300 GWh in 2015 (Climate Change Authority, 2014, p. 11; IEA, 2016a).

However, looking at the new generation triggered by the certificates scheme in particular, it had contributed to 16 700 GWh of new renewable electricity generation by 2015 (large scale RET scheme) (Clean Energy Regulator, 2016, p. 15). In 2015 therefore, Australia was approximately half way to reach the 2020 (large scale) target of 33 000 GWh. According to the Clean Energy Regulator, who administer the RET, the small-scale scheme had contributed to the installation of 2.5 million small-scale systems by 2015, with a capacity of 8.9 million MWh per year (Clean Energy Regulator, 2016, p. 15). This shows that the RET scheme has been generous enough to trigger some new RE, but by 2015 not more than half of the (reduced in 2015) large scale target of 33 000 GWh by 2020.

Second, assessing *predictability*, there has been, as expected, considerate uncertainty and instability in the renewable energy policy framework in Australia, both in terms of changing policies and political uncertainty.

Of the 41 policies listed in the IEA/IRENA database for the period studied, 8 are in force by the end of the period. Most of these policies were implemented in the period 2008–2015. Among the 27 policies implemented over these eight years, only 7 are still in force. Of those that ended during this period, only a handful lasted more than three years. One explanation of this is the establishment of the ACRE, and later ARENA, that gathered many policies under the institutions' umbrella. However, this was also a period with high polarization between political parties over climate and energy policy issues like the ETS, carbon price and the RET.

Although the (M)RET-scheme is one of the longest lasting renewable energy policies in Australia, it has been accompanied by uncertainty about its future existence. The scheme was almost constantly under review, despite that former review processes had documented widespread support for the scheme among renewable energy industry and other concerned parties (Simpson & Clifton, 2014). In analyzing the submissions to the 2012 RET review, Simpson and Clifton (2014) observed a "review fatigue":

> In addition to the recurring theme of uncertainty surrounding on-going review processes, stakeholders also noted 'review fatigue', with ten review processes specifically related to the RET in the last five years, naught resulting in substantial changes to the policy framework (Simpson & Clifton, 2014, p. 131).

Furthermore, they claimed that "the review process is likely to have caused more harm than good purely by introducing a perception of policy uncertainty" (Simpson & Clifton, 2014, p. 134).

Shifting governments also had diverging views on the RET. As we have seen, the Howard Government decided in 2004 not to extend the scheme beyond 2010 (Effendi & Courvisanos, 2012, p. 250). However, when the Labor Party came into office in 2007, the scheme was extended and the target increased in 2009. The main opposition (the Liberals) opposed this extension, and wanted to reduce the scheme once in power, which was also what Abbott did while in office between 2014 and 2015.

Abbott's reversal of several climate and energy policies, in addition to several promises to change or scrap such policies, have also been suggested as an explanation for the decline in private investments in renewable energy from 2014 (see Figure 3) (Hannam, 2016).

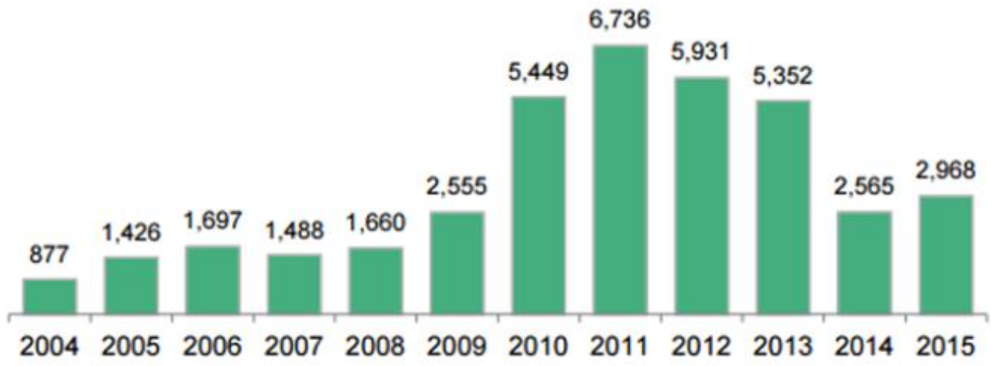

Figure 3: Clean energy investments in Australia (USD million). Source: Bloomberg New Energy Finance/ (Hannam, 2016).

Third, also the *cost allocation* in the Australian renewable energy policies fits well with the expectation from the analytical framework.

Although the (M)RET scheme imposed costs on retailers and large electricity users who were obliged to buy RECs, the scheme also gave considerable exemptions for energy intensive and export oriented industries (such as coal and LNG, the steel industry and others). The Abbott government in 2015 even introduce the possibility of applying for 100 % exemption from all RET costs for these industries. As Valentine (2010) point to out, giving such exemptions will "alleviate cost pressures for non-renewable electricity thereby imposing a further cost barrier to renewable energy integration" (Valentine, 2010, p. 716).

Although only for a limited amount, the inclusion of WCMGs as an eligible source for RECs provides another example of how RET costs are reduced for (in particular) the coal industry. The inclusion was meant as a compensation for the costs that the emission trading scheme would imply on coal firing plants. However, the eligibility of WCMG was not removed as the ETS failed and the carbon price was repealed.

The extensive support for low emission technologies, which in many cases meant CCS, also compensated the fossil industries for the development in climate and energy policy. These programs have tended to come hand in hand with developments on energy and climate policy, regardless of political affiliation. The Howard Government's White Paper of 2004, the Rudd government's Clean Energy Initiative in 2009 and the Gillard government's Clean Energy Future Plan from 2011 all provides examples of this.

It should not be neglected that there is also extensive programs available for research, technology development and innovation in the renewables sector. However, many of the innovation funds and grants in the database require private funding in addition to state funds or loans. This is a way of making sure that the most profitable projects are realized, on the other hand, for a nascent industry it is not evidently the case that the private capital needed to release the funds is available. As the renewable technology becomes increasingly competitive and cost-effective, this problem might be reduced. The establishment of ARENA and the CEFC in 2011 is also important in this regard as they complement each other in providing funding in all stages of the innovation process and investment capital.

Finally, regarding *technology*, the main support scheme in Australia – the (M)RET – is a technology neutral scheme. The scheme has stimulated the most cost-effective renewable technologies; approximately three quarters of the new generation came from wind power (Byrnes et al., 2013, p. 716; Climate Change Authority, 2014, p. 11).

Despite that Australia has among the world's greatest potential for solar energy (IEA, 2012, p. 7), solar energy was only 2% of the total electricity generation in 2015 (IEA, 2016a). Solar technologies is also pointed out as the big "loser" in the RET scheme (Byrnes et al., 2013, p. 716). Looking at the broader portfolio of renewable energy policies in Australia, there have been several programs outside the RET targeting solar energy in particular, many which have a focus on small-scale and households systems (IEA/IRENA 2017). Furthermore, some States have adopted separate feed-in-tariffs for solar energy (Kent & Mercer, 2006, p. 1047). However, most of the solar potential in Australia remains to be exploited.

Explanatory factors

Climate and energy politics in Australia have been described in the literature as characterized by an approach of "no regrets", meaning that policy developments should not "disadvantage industry and Australia's existing sectoral arrangements" (Curran, 2011, p. 1006). This view fits well with the expectation about a strong fossil fuel industry-policymaker complex. Fossil fuels dominate electricity generation in Australia, as well as both the coal and LNG industry make important contributions to the economy.

A tight relation between industry and policymakers has been highlighted as an important explanation for the energy policy of the conservative Howard government in the 1990s:

> This political alliance between incumbent fossil fuel industries and the conservative Howard Government made for a relaxed approach to energy policy that is consistent with the use of fossil fuels in electricity generation (Effendi & Courvisanos, 2012, p. 249).

This alliance has also survived political shifts. Kevin Rudd's Labor government, that took office in 2007, had a much bigger emphasis on climate and energy politics than his predecessors, but did not succeed with its ambitious climate and energy policies. Curran (2011) regarded the Rudd government's scope of action to be conditioned by Australia's "resource profile and its related government - business relations politics" (Curran, 2011, p. 1005). Although Rudd managed to increase the RET scheme substantially, concessions were also given to the fossil and energy intensive industries by allowing WMCG and exemptions from the RET.

Furthermore, Schläpfer (2009) claims that the "primary problem facing the renewable energy industry in Australia is the refusal of the government to create a framework that allows the environmental savings of these technologies to be presented as a market price factor or offset" (Schläpfer, 2009, p. 458).

However, there are also signs that the renewable energy interests are growing and increasing their relative importance compared with the fossil fuel industry. There has been a growing bottom up-demand from several state territories supportive of renewable energy development. In absence of necessary action from the federal government, these states have adopted their own legislation to promote renewables, like FiT schemes for solar energy and separate renewable energy targets (Kent & Mercer, 2006, p. 1047).

Under the 2014–2015 RET review the renewable industry associations also organized demonstrations and lobbied for the government to keep the RET target (Clean Energy Council, 2017). The Clean Energy Council, which is the main business association representing the renewable energy industry, also functioned as a broker between the Abbott government and the Labor opposition (Taylor, 2015). The increased strength of the renewable interests may be one of the reasons why Abbott did not manage to get support for several of the measures his government wanted to implement.

4.2 Poland

4.2.1 Background

Poland is the ninth largest country in Europe measured in size, and has a population of 38 million people (in 2014) (IEA, 2016b, p. 17), which makes it the sixth most populous country in the EU. Formerly a satellite state of the Soviet Union, it became a democratic republic in the aftermath of semi-free elections and a negotiated power handover in 1989. Today Poland has a two chamber parliament: the 460 member lower house (*Sejm*) and the 100 member Senate (*Senat*) (IEA, 2016d, p. 17). Poland joined the EU in 2004.

Poland has extensive coal resources, as well as some natural gas, but are highly dependent on oil and gas imports from Russia (IEA, 2011a, p. 24). Reducing its dependency on energy imports has been a key issue in Polish energy policy, and the government's response has mainly been to increase its coal production and nuclear power (Ancygier, 2013a, p. 178). Poland experienced a considerable decrease in CO_2-emissions after the fall of communism: A decline of 37 % from 1989 to 2002, mainly due to modernization of its industry (Ancygier, 2013b, p. 77). However, in recent years the decline has flattened out.

Poland is a signatory to the United Nation Framework on Climate Change (UNFCC) since 1992, and it ratified the Kyoto Protocol in 2002 with a target of reducing emissions by 6 % for the first commitment period (2008–2012). For the second commitment period and within the Paris Agreement of 2015, Poland is committed to the common EU 2020 and 2030 goals (see below).

Electricity generation

The electricity market in Poland is dominated by vertically integrated state-owned companies (see below). However, liberalization of the electricity market is ongoing due to EU regulations (IEA, 2016b, pp. 23, 77–78). Almost the entire electricity generation has historically been dominated by coal (see Figure 4). 2009 was the first year when coal represented less than 90 % of all electricity generation (World Bank 2017).

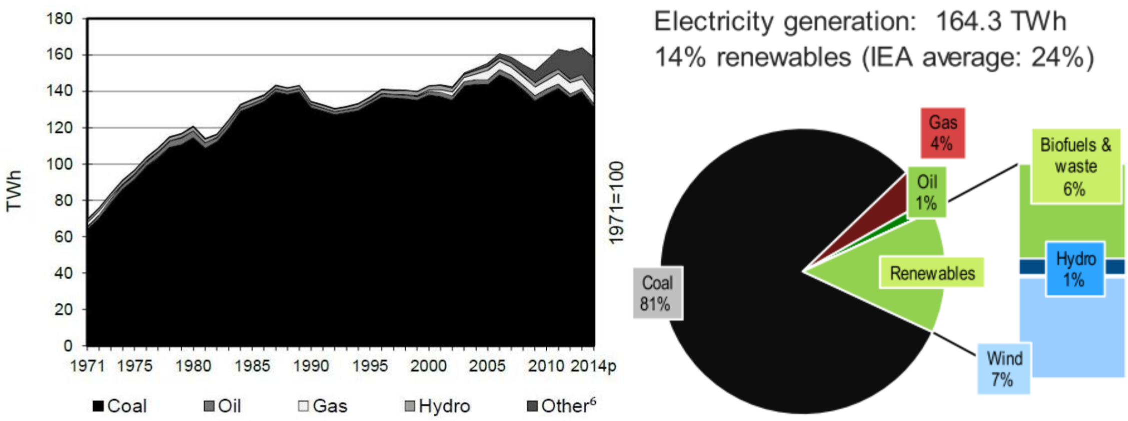

Figure 4: Electricity generation in Poland by fuel, historically (left) and 2015 (right). Sources (IEA, 2015, 2016d).

The share of coal in electricity generation has declined from 97 % in 1995, to 92 % in 2005, and to 81 % in 2015 (IEA, 2016b, p. 74). Gas has increased to 4 % of electricity generation in 2015, and oil represented 1 %.

Consequently, most new generation has come from renewables. The growth in renewable energies started in the beginning of the 2000s (see Figure 5). Renewable energy constitutes 14 % of electricity generation in 2015, with biomass and waste (6 %) and wind power (7 %) as the main sources. In sum, the renewable energy generation in 2015 was 22.7 TWh (IEA, 2016, p. 97).

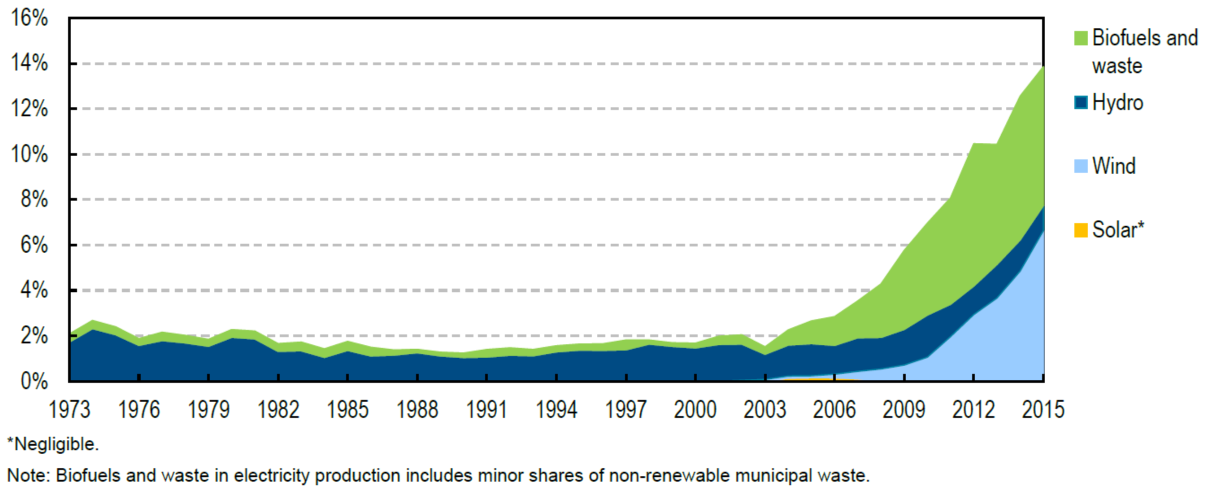

Figure 5: Renewable energy in Poland as a percentage of electricity generation, 1973-2014. Source: (IEA, 2016b, p. 97)

Economic impact

Energy-producing activities constitute on average 6 % of GVA in the period 1990–2015 (Appendix 1). Looking at the coal mining sector in particular, the added value to the Polish economy sunk from 1,8 % in 2005 to 1,1 % in 2013 (Bukowski, Maśnicki, Śniegocki, & Trzeciakowski, 2015, p. 10). The industry's contribution to GPD-growth has been close to nil since 2005 (Bukowski et al., 2015, p. 10).

Although historically among the world's largest coal exporters, fuel exports in Poland have declined over the period, from 12 % of mercantile exports in 1990 to 3 % of mercantile exports in 2015 (World Bank 2017). Since 2002 the share has not exceeded 5 %. The reduced exports is related to low productivity, and difficulties to reduce costs compared with many other competing coal producing countries (Bukowski et al., 2015).

In 1989 the coal mining sector employed 415 740 people, and the number fell to 135 704 in 2003 (Ancygier, 2013a, p. 172). In 2016, the coal mining industry was estimated to employ about 100 000 people directly, and up to "three times this number in indirect employment" (IEA, 2016b, p. 11). In 2010, the renewable energy sector consisted of 340 companies employing a total of 19 115 people (Ancygier, 2013a, p. 256)

State ownership

The four biggest energy companies in Poland are the predominantly state owned companies PGE Capital Group (57 %)[15], Tauron Capital Group (30 %), ENEA Group (52 %) and ENERGA Group (52 %) (Enea, 2017; ENERGA, 2017; PGE Group, 2017; Tauron, 2017). In sum, these controlled 69 % of electricity production and 89 % of electricity distribution in 2010 (Ancygier, 2013a, p. 176). These companies are coal dominated, but some also produce minor shares of renewable energy, mainly hydropower, biomass co-firing and to a lesser degree wind power (Ancygier, 2013a, pp. 173–175).

PGE, which is the biggest electricity producer in Poland, has close ties to the government as several key leaders come from positions in the Ministry of Economy, Ministry of Treasure or the Parliament (Ancygier, 2013a, pp. 173–174). In the wind power sector, European companies dominate (Michalak & Zimny, 2011, p. 2340).

[15] In brackets, the current percentage share held by the Polish state. ENERGA is the only company where the state's share has changed substantially in recent years, from 84 % in 2012 (Ancygier, 2013a, p. 177).

4.2.2 Renewable energy policies in Poland

Renewable energy policy in Poland has mainly developed as a result of Poland's EU commitments. The main policy instrument throughout the period at study has been a renewables obligation and certificates system implemented in 2005.

Prior to 2001: The outset of renewables in post-communist Poland

In the 1990s, renewable energy emerged as a new energy issue in Polish politics resulting in a set of first RE support measures. Mainly motivated by the wish to reduce air pollution from the burning of coal, Poland adopted a legal framework to encourage renewable energy development in the early 1990s, (Ancygier, 2013a, pp. 238–239). Renewable electricity was for example given exemption from excise tax in 1991 (IEA/IRENA 2017).

Between 1993–1999 a feed-in-tariff (FiT) for renewable energy with a capacity below 5MW existed in Poland, "helping the nascent industry to take root, but providing very limited investment stability" (Szulecki, 2017, p. 10). Despite that the tariffs were approximately 30% above market price, they were too low to trigger any big investments. Also, the system of announcing the tariff price one year in advance did not provide any long term stability for investors (Szulecki, 2017, p. 10). Moreover, small hydropower plants were the main benefiters from the scheme (Ancygier, 2013a, p. 239).

The FiT was replaced in 1999 by an ordinance from the Ministry of Economy that obliged energy companies to purchase all available renewable electricity from sources smaller than 5MW (Ancygier, 2013a, p. 239) at a "price equal to the highest energy tariff of that company" (Szulecki, 2017, p. 10).

In 1997, the anti-communist and pro-European Jerzy Buzek became Prime Minister for a majority government consisting of the center-right parties Solidarity Electoral Action (AWS) and Freedom Union (UW). Poland, as an aspiring EU member, was influenced by the European Commission's increasing attention to renewable energy, manifest in the Commission's two White Papers on energy and renewable energy in 1995 and 1997 (Szulecki, 2017, p. 10).

These White Papers were important for the adoption of the Energy Act in 1997 which "for the first time comprehensively regulated all issues concerning the energy sector" (Ancygier, 2013a, p. 240). Regarding renewable energy, the Act in its initial form obliged electricity distributers and retailers to purchase the available renewable energy. However, the Act would be amended several times in the following years (Ancygier, 2013a, p. 240). In 1999 the Parliament adopted a resolution asking the government to prepare a strategy for renewable energy development in Poland and a Renewable Energy Act (see below) (Ancygier, 2013b, p. 78; Szulecki, 2017, p. 10).

2001–2005: Preparing for EU-membership

In the years before Poland became an EU member, it developed energy policy strategies to suit EU policy. The Development Strategy for the Renewable Energy Sector was presented in 2000, and adopted by the Polish Parliament in 2001. This policy document set a goal of 7,5% renewable energy in gross electricity consumption by 2010 (Jankowska, 2011, p. 167).

After the 2001 elections, a new coalition government composed of the Democratic Left Alliance (SLD) together with Labor Union (UP) and the agrarian Polish People's Party (PSL) took office. Leszek Miller (SLD) became the PM. This government was more skeptical towards renewable energy developments. They perceived it as a threat to the interests of the coal mining sector and the agricultural sector (Szulecki, 2017, p. 11).

This change in attitude was clear both in climate and in energy politics. While the former government had put emphasis on RE development as an important measure to reduce CO_2-emission, the Miller government's climate strategy from 2003, known as *Poland's Climate Policy*, "did not contain any provisions for a move to low-carbon generation" (Szulecki, 2017, p. 11). The Miller government also tried to undermine and drastically reduce the 7,5% target set out by the former government, but did not succeed faced with the EU negotiations (Ancygier, 2013b, p. 79). This target was incorporated into the EU Enlargement Treaty when Poland became an EU-member in 2004, thus making the goal legally binding (Szulecki, 2017, p. 11).

Membership in the EU also implied the obligation to implement the 2001 EU Directive on Renewable Energy and adopting a new support mechanism to increase the share of RE (Ancygier, 2013b, p. 79). Work on a Renewable Energy Act was ongoing, and the first draft was presented in 2003 (Ancygier, 2013a, p. 245). Delayed by 18 months, a new scheme was introduced in October 2005, which was to be the main renewable energy policy instrument in Poland for the next 10 years (see next section).

2005–2007: Introducing a green certificates scheme

The 2005 parliamentary elections led to a change of government. This time, Lech Kaczynski from the conservative-right Law and Justice Party (PiS), became the PM for a coalition government together with the nationalist League of Polish Families (LPR) and the Self-Defense of the Republic of Poland (SRP) (Szulecki, 2017, p. 12). Kaczynski was seen as a "conservative climate sceptic and his party has been characterized as 'climate deniers' " (Skjærseth, 2014, p. 34).

Renewables quota and green certificates

With the Renewable Energy Act of 2005, a renewables quota obligation accompanied by a green certificates scheme was introduced as a means to meet the target of 7,5 % renewable energy in gross electricity consumption by 2010. Under the scheme, all electricity suppliers had to provide a certain percentage of electricity from renewable sources (IEA, 2011a, p. 138). This could be achieved by buying green certificates from producers of renewable energy.

Traditional sources of renewable energy, like wind, hydro and solar, were eligible renewable energy sources under the scheme. Already existing hydropower from decades-old hydro-power plants were also included and "rewarded in the same way as wind and solar energy" (Szulecki, 2017, p. 13). In addition, biomass co-firing in coal power plants was regarded as a renewable energy source under the scheme (Szulecki, 2017, p. 13). The co-firing ratio was set to a minimum of 30% biomass and 70% coal (Szulecki, 2017, p. 17).

The result was a big increase in biomass co-firing, and biomass co-firing and hydro power obtained the bulk of certificates. In 2006, 30% of the renewable energy under the scheme came from biomass co-firing. In 2011, this share had increased to 46%, while hydropower constituted 23% (Ancygier, 2013b, p. 79). According to the IEA, the dominance of biomass contributed to weaken the price of certificates and "made them unattractive to investors in newer technologies" (IEA, 2016b, p. 103).

However, in times of high certificates prices the scheme also attracted considerable investments in wind energy – both from national and international investors (Michalak & Zimny, 2011, pp. 2337–2338). Although from very low levels, the wind power capacity grew on average by 107,7 annually from 2000 to 2009 (IEA, 2011a, p. 135). By the end of 2009 the total wind energy capacity in Poland had increased to 724 MW (Michalak & Zimny, 2011, p. 2338). However, the share of wind power in the total electricity generation had only reached 0,7 % in 2009 (IEA, 2011a, p. 63).

The scheme was technology neutral. The quotas were set at the same price for all types of renewable energy, and therefore did not take into consideration the different installation costs and potential of the different sources (Szulecki, 2017, p. 12). "This led to windfall profit for those investing in the cheapest sources of energy and practically no chance for more expensive energy from photovoltaic panels to develop" (Szulecki, 2017, p. 12).

If the renewable energy quota was not fulfilled by energy suppliers, a substitution fee had to be paid. The rate of the fee was set on a yearly basis depending on the price of electricity. In times of high prices, the fee would be reduced. Therefore, in some instances it would be cheaper for the electricity producers to pay the fee rather than to buy certificates (Szulecki, 2017, p. 13). The income from the fee (and penalties) was channeled into the National Fund for Environmental Protection and Water Management (NFEPWM). These revenues were earmarked investments and development of renewable energy, but from 2010 they were also used for other purposes (IEA, 2011a, p. 139).

Consolidation of energy companies

An important development in this period was the consolidation of the many energy producing companies in Poland. This process was largely motivated by EU pressure to modernize the country's energy market, and resulted in the creation of four big vertically integrated energy companies in 2007: PGE, Tauron, Enea and Energa (Szulecki, 2017, p. 13). As these were predominantly state owned companies, they "could count on the strong support of the government" (Ancygier, 2013b, p. 80).

According to Ancygier and Szulecki (2014), the "big four" exercised considerable influence on the government's stance in energy and climate related matters, especially regarding EU-policies: "the consolidation of the energy sector in 2007-2008 and close links between the government and the energy companies changed Warsaw's perception of the European renewable energy and climate policy" (Ancygier & Szulecki, 2014, p. 18).

2007–2015: Opposing EU climate and energy measures

In 2007, the liberal-conservative Civic Platform (PO) formed a government with the agrarian party PSL led by Donald Tusk (Szulecki, 2017, p. 12). This government would stay in power until late 2015.

The negotiations about the EU's energy and climate policy up to 2020 (the so-called 2020-targets) started in 2007. These consisted of a legal package with binding differentiated targets for emissions reduction, energy efficiency and renewable energy, as well as the EU Emissions trading system (EU ETS) and support for CCS projects. According to Skjærseth (2014) the interests of the coal industry was decisive for the Polish government's stance on the EU 2020 targets. With regard to the renewable energy target and Directive, Poland was worried that it would force the coal dependent country to invest in costly renewables (Skjærseth, 2014, p. 14).

However, in the negotiations Poland put most of its effort into opposing the EU ETS.[16] Poland achieved a generous emission target (14 % increase compared to 2005-level), as well as several concessions on the EU ETS (Skjærseth, 2014, p. 18). The RE target was somewhat higher than Poland first wanted, but as biomass co-firing was regarded as an eligible source of renewable energy, the target of 15% renewables in gross consumption by 2020 was accepted (Skjærseth, 2014, p. 18).

During the months of negotiation, the EU climate and energy policy became increasingly unpopular in Poland. Jankowska (2017) claim the perception of renewable energy had changed from being an instrument in climate policy to becoming a threat to the national economy. Alongside the official negotiations between the member states, Polish industrial interests, that claimed that the EU package would have "disastrous effects" on Poland, also spent time and effort advocating their stand towards Brussels (Ancygier, 2013b, p. 83).

The implementation deadline for the 2009 RES Directive was in December 2010, but Poland took its time. Poland submitted a National Renewable Energy Action Plan (NREAP) to the

[16] See Skjærseth (2014) and Ancygier (2013) for a thorough account of Poland's position in the EU 2020-negotiations.

Commission (with a six month delay), reaffirming the goals set for Poland by the RES Directive – 15% renewable energy in final energy consumption by 2020. According to the plan the goal would be met mainly by biomass, wind power and a 100MW new hydropower plant. Except from these general measures, no concrete new RE policies were suggested. According to Jankowska the NREAP was designed to "involve the conventional energy industry in the development of renewable energy" (Jankowska, 2017, p. 150). PM Donald Tusk flagged that Poland would fulfill its 2020-target, "but nothing more" (Szulecki, 2017, p. 15). This was interpreted as "a clear message to the investors not to invest in the development of a low-carbon industry in Poland" (Ancygier, 2013b, p. 91).

Drafting a new RE Act

Despite this, work on a new Renewable Energy Act had started. The reason was that The Energy Act from 1997, which regulated parts of the renewable energy policy, had been amended over 50 times and "was becoming increasingly illegible" (Ancygier, 2013a, p. 250). Therefore, several RE Act drafts came to the table from 2011 (Szulecki, 2017, p. 14). The first draft was presented in December 2011 and was heavily criticized by the renewable energy sector that claimed it reduced the profitability of the wind energy and made support schemes less predictable (Ancygier, 2013a, p. 251).

Allegedly, as a response to the heavy criticism of the proposed RE Act, a separate Department of Renewable Energy was created within the Ministry of Economy. This led to a radically different drafting process, where the RE industry was invited to repeated consultations (Ancygier, 2013a, p. 252). In 2012, a new draft proposed a relatively generous FiT for RE installations under 200 kW, and to reduce and ultimately scrap the support for biomass co-firing and existing hydro power (Szulecki, 2017, p. 14). However, this met strong opposition from domestic as well as foreign fossil fuel industry in Poland:

> The large coal-based energy companies were opposed: indeed, the French utility GDF Suez in Poland responded by threatening to take legal action, as the company had invested in a power plant for co-firing biomass with coal (Skjærseth, 2014, p. 26).

In March 2013, the Commission proposed daily penalties as the RES Directive was still not fully transposed (Skjærseth, 2014, p. 25). Poland's response was to adopt an amendment to the certificates system, and thus putting an end to the proposed FiT scheme. The amendment was a 'minimum solution' in order to satisfy the Commission (Skjærseth, 2014, p. 25).

At the same time, negotiations were ongoing in Brussels about the EU’s 2030 targets. Poland’s stance was that it would oppose any targets that would increase energy prices for industry or consumers. Prime minister Ewa Kopacz, who replaced Donald Tusk when he became President of the European Council in 2014, promised the Polish Parliament that she would oppose any deal with such an outcome (Evans, 2014). After important concessions had been given on the EU ETS and emissions target (Darby, 2014; Ed King, 2016), Poland accepted the overall goals of 40% emission reduction, 27% renewable energy and 30% energy efficiency by 2030. However, this time there were no differentiated national targets regarding renewable energy.

Agreeing on an auction scheme

A new draft of a RE Act came to the Polish Parliament in late 2013. This time a completely new scheme was proposed – an auction-based system – and thus “erasing two years of drafting and consultations“ (Szulecki, 2017, p. 15). After another tedious drafting process, the Renewable Energy Act adopting the auction-based renewable energy scheme was finally passed in the Parliament in 2015. Moreover, the Act also introduced a support scheme for micro-installations and prosumers (see below).

The new Act replaced the quota obligation and green certificates that had existed as the main renewable energy support scheme for more than ten years. The first auctions were scheduled for January 2016, but later delayed until July that year (Szulecki, 2017, p. 16). The Act was changed several times before the first auction in July 2016.

With the auction based system the government calls for yearly tenders for a certain amount of renewable energy (with a maximum of 26% of the energy mix) (Szulecki, 2017, p. 17). In the tenders the government defines which sources and technology will fulfill the quota, as well as setting a reference price for each type of renewable energy technology (Szulecki, 2017, p. 17). According to the IEA, the Polish authorities has stated that “reference prices will be determined at a level that will ensure that about 80% of the projects will be profitable” (IEA, 2016b, p. 104). Co-firing with biomass is an eligible source under the scheme. The ratio biomass-coal was changed from 30/70 under the certificates scheme, to 20% biomass and 80% coal in the new auction scheme (Szulecki, 2017, p. 17).

The Renewable Energy Act was “criticized for its complexity (144 pages of detailed regulations) and high upfront costs necessary to participate in the auction, which makes it difficult for new actors, such as municipalities and cooperatives, to participate” (Szulecki, 2017, p. 16).

Prosumer legislation

At the local level the interest for renewable energy had grown since the early 2000s (Jankowska, 2017). Alongside the negotiations about the auction scheme, demands for a policy to promote micro-installations and prosumers increased. A MP from the PSL party suggested an amendment to the RE Act to introduce a prosumer-tariff. This proposal was “supported by unprecedented media campaign by NGOs and RE industry actors” (Szulecki, 2017, p. 16).

The amendment was passed against the will of the main party in government (PO), and introduced a feed-in tariff for RE sources up to 10 kW installed capacity (Jankowska, 2017, pp. 147–148). The legislation was changed when the conservative-right Law and Justice Party (PiS), supported by the agrarian party PSL, came back into power after winning the Parliamentary elections in November 2015. Instead of the FiT, prosumers were now subject to a net-metering system, “receiving no payment at all; rather for each 1 kWh delivered to the grid could get 0.35-0.7 kWh back” accounting for grid services that prosumers benefit from (Szulecki, 2017, pp. 16–17).

This was not the only support measure for small-scale and local RE generation implemented in this period. In 2014 and 2015 two prosumer programs (PNL 600 million and PLN 800 million respectively) were established within the National Fund for Environmental Protection and Water Management (NFEPWM). The programs provided financial support to households, housing communities and local governments for electricity and heating installations (IEA/IRENA 2017).

Investment loans

Several loan based schemes have also been established in recent years to provide financial support and loans for renewables projects under the NFEPWM. The NFEPWM was established in 1989 and receives finances both from domestic, EU and international level to support a wide range of environmental projects (IEA, 2011a, p. 25; The National Fund for Environmental Protection and Water Management, n.d.).

From 2010, the NFEPWM provides low-interest loans to purchase and install renewable energy – both at large and small scale (IEA, 2016b, p. 106). The budget from 2010–2015 was approximately EUR 580 for renewable energy development (IEA, 2011a, p. 26). Co-financing of RE projects also came from EU structural funds, in total EUR 730 million between 2007 and 2013 (IEA, 2016b, p. 108).

In 2014 the PNL 420 million budget (between 2014 and 2020) BOCIAN program was established to provide soft loans for renewable energy development. The level of support is differentiated between different technologies, e.g. PV solar systems can get loans covering up to 75% of capital investments, while wind farms only get 30%. Co-generation with biomass is also included in the scheme and can get up to 75% of costs covered by the loan (IEA/IRENA 2017).

4.2.3 Discussion

In this section I discuss how the renewable energy policies in Poland match with the expectations of the analytical framework. First, I assess how the main renewable energy policies correspond with the expectations along the four indicators of renewable energy policy design. Thereafter I discuss the findings in relation to the explanatory factors.

Explanandum

The main renewable policy instrument in Poland has been the certificates scheme from 2005.

Regarding the *level of support*, the scheme introduced an economic incentive for renewable energy investments as the certificates provided an additional income to the electricity price. However, by the inclusion of biomass co-firing as an eligible source of certificates, most certificates were provided for biomass co-firing (Ancygier, 2013b, p. 79). Together with the inclusion of existing hydropower plants as eligible for certificates, this resulted in low certificates prices and made the scheme less attractive for investors in other renewable energy sources like solar PVs (Szulecki, 2017, p. 12). In 2010 almost 5,6TWh was produced with biomass co-firing. This was more than the total amount of other sources of renewable energy – which was approximately 4TWh in 2010 (Ancygier, 2013a, p. 256).

However, the scheme also contributed to develop wind power. Wind power contributed 7% of electricity generation in 2015. How has this development been possible under the scheme conditions described over?

First of all, in times of high certificates prices, the certificates scheme has provided a reasonable profit for developers of wind power. Second, the early wind development in Poland (from 14Gwh in 2001, to 135GWh in 2005) is also related to expectations that EU membership would "lead to the creation of a more favorable support mechanisms for renewable energies in the near future" (Ancygier, 2013a, p. 246). Most wind development has also been driven by foreign companies and investment (Michalak & Zimny, 2011, p. 2340).

The overall assessment is therefore that the level of support has been too low to trigger the full potential for renewable energy in Poland, except from biomass co-firing, which is a disputable renewable energy sources. It is also worth mentioning that the level of support is not necessary improved in the new auction-based scheme and prosumer legislation. The prosumer legislation provides support below market price, while the auction system is set up to release only the cheapest bid for a limited volume of renewable energy decided by the government each year (Szulecki, 2017). Therefore, the future prospects for renewable energy in Poland are not necessary improved by these schemes.

Second, assessing *predictability* we see that uncertainty about scheme conditions, especially during the drafting of a new RE Act from 2012 and on, have contributed to considerate instability for investors in renewable energy.

Although many policies maintained for years, frequent changes to legislation have reduced the overall stability of the schemes. One example is the Energy Act, which has been amended more than 60 times and grown ten times its initial size since its adoption in 1997 (Szulecki, 2017, p. 4). Another example is the tedious drafting process of a new RE Act that started in 2011 and lasted until 2015. It has been claimed that the slowdown in wind investments is due to the regulatory uncertainty under this period (Adam Easton, 2013). Since Poland's entry to the EU in 2004, there has also been continued uncertainty about the implications for Poland of the EUs energy and climate policy.

Additionally, the certificates scheme was also associated with uncertainty due to the unpredictable certificates price. Further, the submission fee, which was meant to punish noncompliers with the certificates scheme, was set only a year in advance and "added to the general business instability" (Szulecki, 2017, p. 13). The prospects for predictability are not necessarily improved by the new auction-based system. As the price and volume of different renewable energy technologies are announced only a year in advance, it provides even shorter investment horizons than the former certificates system.

Nonetheless, there has been a large degree of consensus in Polish politics regarding climate and energy policy. Political controversy over these issues has been more pronounced between Polish politicians and the EU level, rather than within Polish politics. In the Polish case, it seems that uncertainty regarding renewable energy policies to a lesser extent is created by the political differences in Polish politics, but by uncertainty about how EU obligations will influence domestic climate and energy policy.

Third, regarding *cost allocation* the finding is also in line with the expectation. The main scheme in Poland, the certificates scheme, imposed costs on energy suppliers that obliged to buy certificates. As the Energy Regulator Office regulates the retail electricity price in Poland (IEA, 2016b, p. 89), the increased costs cannot be fully compensated for by transferring them onto the consumers' electricity bill. However, the inclusion of biomass co-firing – which means that the coal industry too can earn from the scheme by selling certificates if they use co-firing – must be seen as an indirect cost-compensation to the coal industry.

Last, *technology neutrality* has been a key feature of the certificates scheme in Poland. However, since the scheme does not take into consideration the different installation costs and potentials of the different sources of renewable energy, it ends up benefiting the most mature and cost-effective sources (Szulecki, 2017, p. 12) – which in this case has mainly been biomass co-firing and to some extent existing hydro power and wind (IEA, 2011a, p. 13).

It should be noted, that some of the more recent innovation programs differentiate between different sources of renewable energy (IEA/IRENA 2017). Also, the 2016 auction based system set quotas differentiating between RE sources. However, these differentiations seem to be a result of political preference toward certain renewable energy technologies, rather than as a way to even out the playing field between different technologies.

This impression is further strengthened by the recent legislation limiting wind power development in Poland. The 2016 Wind Power Act limit the distance from wind farms to nearest residential building, national parks or forest to ten times the height of a wind mill (i.e. approximately 1,5–2 km) (IEA, 2016b, p. 105). Further, the Act increased the property tax for owners of wind mills. According to the Polish Wind Energy Association (PSEW) “such drastic measures are unique in the world” (as cited in Szulecki, 2017, p. 17).

Explanatory factors

A striking feature of the Polish case is the dominance of the coal industry, with a high share of electricity generation and strong state ownership. The impression is also that the RE policies have not challenged the interests of the fossil fuel industry-policymaker complex. RE policies in Poland seem to “fit the interests of the large coal plants” (Skjærseth, 2014, p. 31). With the inclusion of biomass co-firing as a renewables source, the policies have been “tailored to absorb, not transform, the Polish coal strategy” (Skjærseth, 2014, p. 28).

This point has also been made by Jankowska (2017) who claims RE policy in Poland has been designed to “serve the conventional, coal-based energy industry” (Jankowska, 2017, p. 151). According to her, this is a result of the strategy to keep state ownership in the major energy companies as well as “the very strong political influence and political closeness of the conventional energy industry (…) in contrast to rather week and not very well organized RES industry” (Jankowska, 2017, p. 151).

Ancygier (2013a) also highlights how state ownership in the energy sector increases the mutual dependency between industry and policymakers, and makes renewable energy less attractive to invest in:

> An increase in the role of renewable sources of energy would limit the market share of the conventional energy companies partly owned by the government. That would not only reduce the proceeds from the dividend to the state’s budget, but would also have a negative impact on the profits of these companies, often managed by people who earlier worked for the government (Ancygier, 2013a, p. 259).

However, the development of wind power in Poland should not be neglected. Wind power now constitutes the largest source of renewable energy in Poland, and in 2015 Poland had the seventh largest wind power capacity in the EU (Szulecki, 2017, p. 4). Also, the interest for renewable energy has increased at the local level, which has resulted in new prosumer legislation in 2015 (Jankowska, 2017).

There have also been signs that the coal industry is losing some of its importance. The Polish coal industry has struggled to reduce costs and increase productivity compared to other coal producing countries. Both the coal exports and the employment rate in the coal industry have dropped drastically since 1990. Still, Poland's RE strategy, in its current form, has not and probably will not transform the energy sector. Though a large majority of existing coal generators are aging, which could provide a window of opportunity for moving from coal to renewables, the Polish strategy seems to be to replace coal with coal (Skjærseth, 2014, p. 22).

The Polish energy strategy highlights the need to strengthen energy security and to keep electricity prices low, rather than energy transition. No political parties are currently advocating a transition from coal. As Jankowska states, among the parties in the Semj "climate change is still largely unimportant and hardly treated as a serious political matter, unless climate change policy appears in the discussion as a threat to the Polish economy" (Jankowska, 2017, p. 146). Furthermore, "no party has taken a clear position on limiting the role of coal in the economy (Bukowski, 2013:197)" (Skjærseth, 2014, p. 39). For the time being, the fossil fuel industry-policymaker complex in Poland stays strong.

4.3 Norway

4.3.1 Background

Norway is a constitutional monarchy with a parliamentary democracy, and has a population of 5,2 million people (IEA, 2017a, p. 15). Legislative power is held by a one chamber parliament (*Stortinget*) with 159 representatives.

Norway is rich on natural resources, and is among the highest exporters of oil and gas in the world (IEA, 2017a, p. 9). It is also rich on renewable energy resources, mainly hydropower and onshore and offshore wind power (IEA, 2017a, p. 135). It is among the IEA countries with the highest share of renewables in its total primary energy supply (IEA, 2017a, p. 125). Norwegian CO_2-emissions increased by 4,2 % from 1990–2015 (SSB, 2016b). However, CO_2 per capita is lower than in many other IEA countries (IEA, 2016c).

Norway signed the United Nation Framework on Climate Change (UNFCC) in 1992, and ratified the Kyoto Protocol in 2002. Its target for the first commitment period was an 1 % increase in emissions above 1990-levels, while for the second the target was set to 16 %

below 1990-levels (Climate Action Tracker Partners, 2017b). Norway signed the Paris Agreement of 2015 with a target of 40 % emission reduction by 2030, compared to 1990-levels, achieved in accordance with the EU (Climate Action Tracker Partners, 2017b).

As a member of the European Economic Area (EEA), Norway shares internal market legislation with the EU, including energy related directives and regulations (IEA, 2017a, p. 16).

Electricity generation

The Norwegian energy market was deregulated by the Energy Law of 1990 introducing a wholesale competitive electricity market. A common electricity market between Norway and Sweden was established in 1996, the NordPool, which now consists of all Scandinavian countries (Blindheim, 2013, p. 340).

Norway's electricity generation is almost entirely based on hydropower. Most of Norwegian hydropower was built in the period between 1970 and 1985 (Christiansen, 2002, p. 236), and the development of new hydropower leveled out in the 1990s (Blindheim, 2013, p. 339).

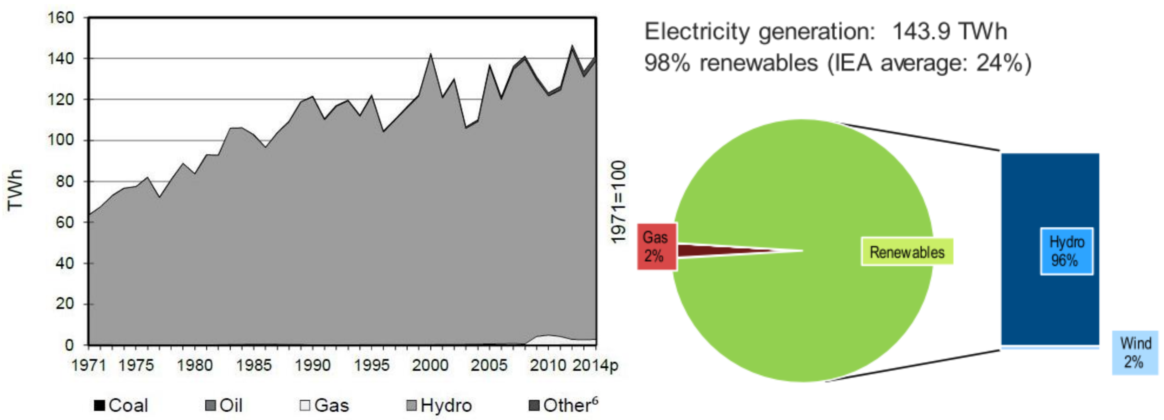

Figure 6: Electricity generation in Norway by fuel, historically (left) and 2015 (right). Sources: (IEA, 2015, 2016c)[17]

In 2015, hydropower represented 96 % of energy generation (IEA, 2016c). From 2000 and on wind power has grown, but only to 2 % of total generation in 2015 (IEA, 2016c). Gas constituted the remaining 2 % of electricity generation in 2015 (IEA, 2016c).

[17] 'Other' includes geothermal, solar, wind, biofuels and waste, etc. (IEA, 2015)

Economic impact

Norway has a large petroleum sector, mainly oriented towards exports. Income from the sector plays an important role in the national economy. Since 1990 the share of petroleum related income has increased considerably, with 2006 as the top year where 24 % of GDP and 38% of state revenues were petroleum related (Figure 7). In recent years there has been a downward trend. In 2015 it represented 15 % of GDP and 20 % of state revenues.

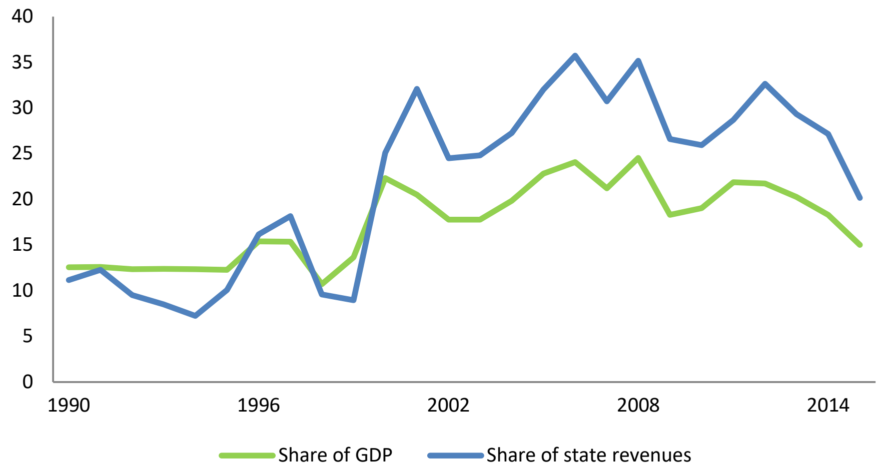

Figure 7: The Norwegian petroleum industry's share of GDP and state revenues, 1990-2015. Source: (Norskpetroleum.no, 2017).

Fossil fuels represent the majority of exports from Norway – on average 59 % of exports in the period 1990–2015 (min: 43 % in 1998, max: 70 % in 2012) (World Bank 2017). This is the highest among OECD-countries. Norway also exports electricity (hydropower) which amounted to NOK 4,4 billion in 2013, while technology export from the renewables industry was at NOK 5 billion (MoEP, 2016a, p. 69). Oil and gas exports, however, amounted to well above NOK 600 billion in 2013 (Norwegianpetroleum.no, 2017b).

The petroleum sector employed 206 000 people in Norway in 2015 (SSB, 2016a). Including those who indirectly work in the industry, mainly contractors that provide goods and services for the industry, the number was estimated to 330 000 in 2014 (Norwegianpetroleum.no, 2017a). A study performed in 2013 on behalf of the Ministry of Petroleum and Energy showed that approximately 22 000 were employed in the renewable energy industry, both directly and indirectly (providing goods and services to the sector) (MoEP, 2016a, p. 78).

State ownership in the energy sector

The Norwegian electricity sector is dominated by state owned companies. The municipalities, country authorities and the state owns as much as 90 % of all production capacity (MoEP, 2016a, p. 70). Among the grid owning companies, the big majority is also publicly owned, mostly by the counties or municipalities.

In 2015 183 companies produced electricity in Norway, however, the 10 biggest electricity producing companies provides 70 % of installed capacity (MoEP, 2016a, p. 70).

4.3.2 Renewable energy policies in Norway

This section presents the development of renewable energy policy in Norway from 1990–2015. The main schemes in Norway during this period were a wind energy target set in 2000 and a green certificates scheme, which was initiated in the early 2000s and realized in 2012.

Prior to 2001: Electricity shortage opens new opportunities

From the beginning of the 1990s awareness about environmental degradation grew in Norway, and renewable energies were highlighted as one of several means to mitigate climate change in several White Papers on environment and energy issues in the late 1980s and early 1990s (Christiansen, 2002, p. 238). At the time, there were no integrated regulatory framework for renewable energy support,[18] though scant R&D projects had been developed since the late 1970s (Christiansen, 2002, p. 237). These were instrumental in the set-up of Norway’s first wind farm in Vikna in the region of North-Trøndelag in 1991 (Christiansen, 2002, p. 238).

Due to low rainfall and increasing demand for electricity, Norway experienced periods of electricity shortage and high prices between 1997 and 2001 (Ydersbond, 2014, p. 19). Increasing prices and the fear of shortage raised the debate about alternative and supplementary electricity sources to hydropower. The government’s suggested solution was to improve energy efficiency and diversify the energy mix, primarily by developing natural gas and wind power (Blindheim, 2013, p. 340).

[18] Hydropower development in Norway was not supported by direct subsidizes until the introduction of the green certificates scheme in 2012 (see below) (Linnerud & Simonsen, 2017, p. 561)

A 25 % investment subsidy was introduced in 1998 to promote wind power,[19] as well as a 50 % exemption of electricity surcharge for domestic wind power production (this lasted from 1998 to 2004) (Buen, 2006, p. 3892). Introducing natural gas on the other hand, became an extremely controversial issue,[20] and resulted in the resignation of the centrist Kjell Magne Bondevik led Government in 2000 (Boasson & Lahn, 2017, p. 193).

On the same day as the government resigned, the Storting adopted a target of 3 TWh new wind power by 2010 (Boasson & Lahn, 2017, p. 193). The Storting also decided to establish Enova, a state enterprise under the Ministry of Petroleum and Energy (MoPE) with a mandate to finance cost-efficient renewable energy development and energy efficiency investments (Boasson & Lahn, 2017, p. 193). Enova was the "first public Norwegian body to give support to renewable energy production" (Ydersbond, 2014, p. 20). An important reason why Enova was established was to implement the 3 TWh wind power target (Blindheim, 2013, p. 340).

2001 – 2005: Wind power in the air

Discussions about establishing a new green certificates scheme started only months after the decision to set the wind power target and establish Enova. This was mainly driven by electricity utilities and environmental organizations lobbying from for such a scheme (Boasson, 2015, p. 113). Sweden had decided to introduce a domestic green certificates scheme from 2003, and the supporters argued that it was natural to develop a common scheme between the two countries that already shared the Nordpool electricity market (Blindheim, 2013, p. 340).

The Labor Party, which had succeeded the Bondevik government after the natural gas-crisis in 2000, was back in opposition after losing the elections in 2001. Together with the parliamentary majority they instructed the Bondevik-led centrist-conservative minority coalition to start negotiations with Sweden (Boasson, 2015, p. 113). However, according to Boasson the negotiations with Sweden were not high on the political agenda before 2005, mainly because "politicians were not strongly committed to any particular support scheme design, and tended to support the green certificate in order to communicate their symbolic support for renewable energy" (Boasson, 2015, p. 118).

[19] The subsidy was reduced to 10% in 2001, but increased again to 25% in 2004 (Buen, 2006, p. 3893).
[20] See Boasson (2015, ch. 4) for a thorough discussion of the natural gas conflict.

In 2004 two important innovation and research programs were established (IEA/IRENA 2017). First, the Environmental Technology Program ('Miljøteknologiordningen') was established under Innovation Norway to provide grants for pilot and demonstration projects initiated by Norwegian enterprises. Second, The Clean Energy program ('RENENERGI') under the Norwegian Research Council was established to support research on renewable energy technologies and energy systems.

2005 – 2013: Green certificates negotiations stops and starts

A red-green coalition government formed by the Labor Party, the Socialist Left Party and the Centre Party (agrarian) took office in 2005. This government held office until 2013.

While the negotiations about a common certificates scheme with Sweden were ongoing, the new government began to worry about the increase in electricity prices that the scheme would bring about (Boasson, 2015, pp. 119–120). The scheme was going to be financed by consumers with an increase on the electricity bill, and it was assumed that the higher the renewables target imposed by the scheme the higher the price increase would be. Therefore, Norway started working for a lower target, and came on a collision course with Sweden who wanted a high target for Norway. This was because the Swedes were afraid that a low target would only realize the least costly project – which were presumed to be Norwegian hydropower (Boasson, 2015, p. 120).

Norway stopped the negotiations with Sweden in 2006, a decision that created strong reactions among those who had been lobbying for the scheme for years (Boasson, 2015, p. 120). The government therefore started working on an alternative policy scheme financed by the state and not the consumers. However, the proposition was met with resistance by the European Surveilling Agency (ESA) who claimed it was not in line with the EU's guidelines for competition and state aid (Boasson, 2015, p. 120). The negotiations with Sweden were therefore picked up again in 2008.

The wind power target

The ongoing green certificates negotiations created uncertainty about the Enova scheme, and some investors were expectant to make their wind power investment decisions (Blindheim, 2013, p. 342). In fact, Enova did not offer any grants for wind power development in 2006 and 2007, claiming in their annual report that this was due to the ongoing negotiations with Sweden (Blindheim, 2013, p. 343). Figure 8 shows Enova's funding to wind power from 2001–2010. It shows that funding was slow in the beginning of the 2000s. The funding picked up after the negotiations with Sweden had failed, although too late to reach the 2010 target (Blindheim, 2013, p. 342).

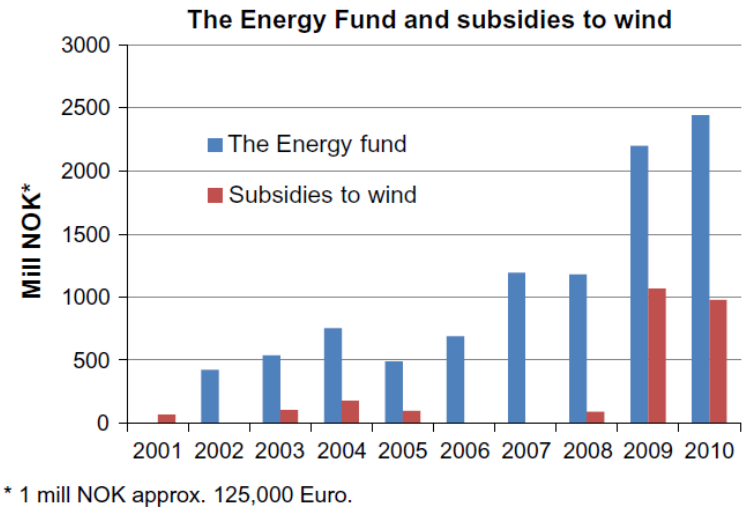

Figure 8: Enova's allocation from the MoPE to the Energy Fund[21] (blue), and granted subsidies to wind power (red). Source: (Blindheim, 2013, p. 342)

It should be noted that the discussions about the common green certificates scheme with Norway and Sweden was not the only source of uncertainty. Wind power developers also awaited whether they could participate in the Dutch green certificates scheme and whether a common green certificates scheme in the EU would materialize (Buen, 2006, p. 3893).

By 2010, Enova had granted support to 1 TWh wind power, while concessions had been given for 2 TWh (Blindheim, 2013, p. 344). "Subsidies from Enova, therefore, triggered only 50% of the energy volume that could have been realized by 2010" Blindheim (2013, p. 344) claim.

Blindheim (2013) also points to several other reasons why the target was not met, among them lack of political will and unstable regulatory framework, too slow concession processes, lack of local acceptance of wind power and grid challenges in certain regions of Norway. The MoPE's explanation to the Parliament why the target was not met highlighted "project costs and low electricity prices" (IEA, 2011b, p. 88).

[21] The Energy Fund covers Enova's support schemes for renewable energy and energy efficiency measures as defined in Enova's allocation letter from the MoPE.

Green certificates scheme with Sweden

Norway and Sweden reached an agreement on a common green certificates scheme in December 2010, which would be operational from January 2012 (Boasson, 2015, p. 122). The common target was set to 28,4 TWh new renewable electricity supply by 2020, with Norway contributing 13,2 TWh (MoEP, 2016a, p. 197). Under the scheme, renewable electricity producers receive certificates for each MW they produce. These certificates can be traded to energy suppliers who are obliged by law to fulfill a certain quota of renewable energy. The size of the quota change each year adjusting to the overall goal of 28,4 TWh by 2020 (IEA, 2011b, p. 86, 2017a, pp. 130–131). Certificates are provided on a 15 year basis. Therefore, those who enter the certificates market at the final entry deadline in 2020, can sell certificates until 2035[22] (MoEP, 2016a, p. 197).

According to Bang and Gullberg (2015) the motivation for adopting a green certificates scheme had changed since the initial discussions in 2000. In the beginning, the scheme was motivated by the need to diversify the electricity mix due to the high dependency on hydropower. However, following increased energy production from 2007, this need was not as urgent as before, and the motivation changed towards meeting its obligations in the RES Directive (Gullberg & Bang, 2015, p. 103). The government's White Paper on Energy from 2016 also states that the scheme was introduced "as a part of Norway and Sweden's obligations under the renewables Directive" (my translation) (MoEP, 2016a, p. 197).

The RES Directive obliges Norway to increase its share of renewable energy in final energy consumption to 67,5% by 2020. According to the IEA, this target was already met in 2010 when 69% of energy consumption was renewable (IEA, 2017a, p. 130)[23].

Other policies

During their period in power, the red-green coalition initiated two broad climate agreements ("Klimaforliket" 2008 and 2012) with the parties in the Storting (except the Progress Party). These agreements indicated the main targets and policy measures for Norwegian climate and energy policy to 2020 (See Regjeringen.no, 2014). In terms of renewable energy, these policy

[22] In the 2016 White Paper on Energy this was extended to 2036 (MoEP, 2016a).
[23] The IEA use slightly different calculation methods than the EU, however, the IEA number illustrates that Norway's RE goal is clearly within reach.

agreements implied increased funding for R&D. The R&D funding for renewable energy and CCS more than tripled from 2007 to 2010 (IEA, 2011b, p. 22).

Several programs to support climate friendly research, innovation and technological development have been established under Enova, Innovation Norway and The Norwegian Research Council (like the research program ENERGIX, Centres for Environment-friendly Energy Research and the Climate and Energy Fund in Envoa (see Appendix 2). Political parties have tended to overbid each other in their budgeted support to the funds and institutions that support low carbon technology and CCS.

Research and development for offshore wind power has also been prioritized, examplified by establishing two Centres for Environment-friendly Energy Research dedicated to offshore wind (The Research Council of Norway, 2017). The Storting also adopted a national strategy on offshore wind in 2010 and established funding through Enova for offshore wind technology development and demonstration (IEA, 2011b, p. 90).

According to Ydersbond, the decision to support offshore wind was closely linked to the conditions in the oil and gas market:

> When oil and gas prices were falling and it seemed that the oil reservoirs in the North Sea would soon be depleted, greater attention was paid to offshore wind in particular as a source of industrial opportunities. However, discoveries of new petroleum fields led to less attention and investment in offshore wind (Ydersbond, 2014, p. 20).

2013 – 2015: Deciding not to extent green certificates

After eight years with the red-green coalition government, the Conservative Party formed a minority government with the Progress Party (populist right), supported by the Liberals and Christian Democrats, in the fall of 2013. This government has advocated for a stronger alignment with the EU in climate and energy policy, striving for a common target with the EU regarding carbon emissions, energy efficiency and renewable energy by 2030 (Ministry of Climate and Environment, 2015). Furthermore, it also focused on R&D for renewable energy technology development.

Due to lower electricity prices than expected, discussions started on what signals to send to renewable energy investors about the green certificates scheme which was planned to end in

2020. The answer came in 2016. Although beyond the scope defined for this thesis, I will mention this briefly.

In the White Paper on Energy that was presented in 2016, the government proposed to abolish the green certificates scheme with Sweden when the current agreement ends in 2020(MoEP, 2016a). Producers of renewable energy who enter the market in Norway after 2021 will therefore not gain certificates. The decision is explained by the forecasted electricity surplus in the Nordic electricity market in the coming years, and the fear of a drop in electricity prices if more electricity is introduced to the market (MoEP, 2016b). The government does not propose any alternative support scheme for renewable energy, other than highlighting hydropower as Norway's key priority in electricity generation. Future renewable energy development will therefore be based on market signals.

4.3.3 Discussion

In this section I discuss how the renewable energy policies in Norway match with the expectations of the analytical framework. Like the other case studies, I will first assess how the main renewable energy policies correspond with the expectations along the four indicators of renewable energy policy design. Thereafter I discuss the findings in relation to the explanatory factors.

Explanandum

The main renewable policy instruments in Norway has been the wind power target from 2000 to 2010, and the common green certificates scheme with Sweden, which was initiated in the early 2000s and came into operation from 2012.

First, the findings regrinding the 2000–2010 Enova scheme for wind production indicate that the *level of support* was too low. By 2010, only 1 TWh of wind power was realized with the Enova support, while concessions had been given for up to 2 TWh (Blindheim, 2013, p. 344). The Enova funding in itself was therefore not enough to trigger wind power development, although other factors also came into play (see below).

It is interesting to note that although it was a political goal to diversify the electricity mix, hydropower developed (unsubsidized) over the same period. From 2001–2010, 322 small hydropower plants gained concession to produce a total of 4 TWh per year, while 9 larger hydropower plants gained concession to produce 0,6 TWh per year (Angell & Brekke, 2011, p. 90). The hydropower generating capacity increased by 1567 MW from 2000 to 2010 (IEA, 2017a, p. 126).

From 2012 the common green certificates scheme with Sweden came into force. For Norway the target was set to 13,4 TWh new renewable energy by 2020. Like the certificates schemes in Australia and Poland, it provides an additional source of income to the electricity price for developers of renewable energy. However, the scheme has not resulted in considerable amounts of new renewable energy in Norway. By January 2016, the scheme had contributed to 2,2 TWh in Norway, and 11,6 TWh in Sweden (MoEP, 2016a, p. 197). In Norway, most of this increase came from small-scale hydropower (85%), with wind power contributing the remaining 15% (NVE & Energimyndigheten, 2016). In comparison, the scheme resulted in a considerate increase in wind power (76%) and biomass (18%), while solar and hydropower had contributed the remaining 6% of new generation in Sweden (NVE & Energimyndigheten, 2016).

According to the Government's White Paper on Energy, the reason why the scheme had produced so little new renewable energy in Norway is due to a surplus of electricity in the Nordic electricity market (MoEP, 2016a, p. 198). The surplus also resulted in reduced prices, and thereby reducing profitability for potential investors. The green certificates scheme is pointed to as one of several reasons why prices fell, in addition to developments in the European electricity market, lower demand than expected and high inflow from hydropower (MoEP, 2016a, p. 34). Figure 9 shows the development of the electricity spot price in Norway from 1990–2015. Therefore, it seems to be low demand and low profitability in the Nordic electricity market, rather than the level of support itself, which explains the low investments in renewable energy under the green certificates scheme in Norway.

Worth noting is also that the support for offshore wind has not resulted in any new deployment in Norway. The first planned offshore wind park with concession from the NVE was put on hold in 2012 (Lie, 2013). The developers blamed the lack of political support and that the grants from Enova were too low. In particular they claimed that the government had changed its policy towards renewable sources as a result of increased optimism in the oil and gas sector due to high oil prices and new discoveries on the Norwegian continental shelf (Lie, 2013).

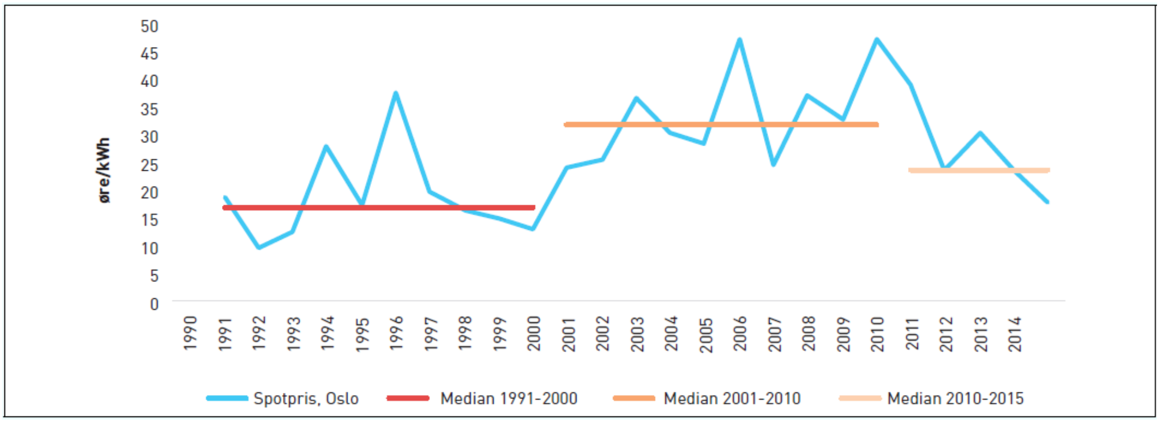

Figure 9: Norwegian spot price of electricity, 1990-2015. Source: (MoEP, 2016a, p. 34).

Looking at the funding for research, development and innovation, the level of support is very high in Norway. According to the IEA Norway is "one of the leading countries in public spending on energy RD&D per gross domestic product" (IEA, 2017, p. 11).

The second aspect of renewable energy policy is *predictability*. In the Norwegian case, the long-lasting discussions and negotiations over the green certificates scheme that started in the early 2000s, and was not realized before 2012, created considerable uncertainty about both the existing Enova scheme and about future support schemes. Several scholars have pointed at the uncertain regulatory framework as the main reason why little development has happened in non-hydro renewable energy in Norway (see Blindheim, 2013; Boasson, 2015; Buen, 2006; Christiansen, 2002; Ydersbond, 2014).

In terms of political risk, it can be argued that the field of climate and energy politics has become more politicized over the period studied. The dominating view of the two biggest parties in Norwegian politics – the Labor Party and the Conservative Party – has been that climate measures should be done as cost-effective as possible. These parties argue that action should be taken outside Norway because domestic measures are expensive, especially as the electricity generation is already carbon-free. However, since 2000 Norway has had many minority governments with small parties in powerful positions, which has led to concessions in domestic climate and energy politics (Boasson & Lahn, 2017). One such example is the electrification of the Utsira High which assures a join power supply from land to the several important petroleum installations (Statoil, 2012). These developments have created a more politicized climate and energy politics.

Third, in terms of *cost allocation*, the Norwegian case is different from the two others. Most Norwegian schemes have been in the form of subsidies and investment support (mainly through Enova), as well as larger R&D funds. However, the 2012 green certificates scheme imposes costs on consumers, as the scheme is financed by an increase in the electricity price. No particular compensation is given to the energy sector.

The final indicator is the *technologies* that receive support. Several policies have targeted wind power, like the support schemes for onshore wind 2000–2010, and offshore wind power legislation and support programs in Enova from 2010. On the other hand, the green certificates scheme is a technology neutral scheme. As it benefits the most cost-effective technologies, the bulk of new production in Norway is in small hydropower as a result of the scheme.

Explanatory factors

Looking at the industry-policymaker complex in Norway, it seems as though there may be both a fossil fuel industry- and a hydropower-policymaker complex. The oil and gas sector plays an important role both for state revenues and exports, while hydropower totally dominates the electricity generation. Further, the state owns key companies in both sectors.

To what extent then, has the renewable energy policy in Norway challenged the interests of these complexes? Although natural gas was opposed as a source of electricity in the early 2000s, the renewable energy policies have not been in conflict with the main interests of the oil and gas sector as this industry is highly export oriented. As long as the petroleum industry has had a market elsewhere than Norway, the developments in the domestic electricity market have not really been in conflict with it.

Regarding the hydropower complex, the renewable policy development has not challenged their interests or the hydropower dominance in the electricity sector in any way. Although the wind power target was adopted to reduce the dependency on hydropower, supported by a broad political consensus after several electricity shortage crises (Christiansen, 2002, p. 236), more hydropower than wind power developed over the target period. In addition to lower costs and more mature technology, Blindheim (2013) claims that the way in which hydropower is taxed, combined with public ownership, can explain why unsubsidized hydropower development was preferred over subsidized wind power:

> A great amount of the tax flow from hydropower production is re-allocated to the municipalities in which the plants are located – the same municipalities who are generally the owner of the utilities. The tax burden on wind power is lower than on hydropower and the municipalities' tax income from wind power is lower, therefore. Because of that, the public owners will most likely allocate money to hydropower projects (Blindheim, 2013, p. 345).

As Christensen also points out, the "reliance on low energy prices to uphold activities within the energy-intensive industries" as well as infrastructure "based predominantly on centralized base load generation" also favored hydropower development (Christiansen, 2002, p. 242).

As we have seen, the negotiations about a green certificates scheme happened parallel to the wind power target. Both the environmental lobby and the hydropower sector supported the scheme – with the energy industry association Energy Norway and the state owned Statkraft as the main advocates representing the hydropower sector (Gullberg & Bang, 2015, p. 107). The hydropower sector was supportive of the scheme because the technological neutral design would trigger the least costly investment, i.e. hydropower. Further, increased production from existing installations was included as eligible, which would also benefit the already existing hydropower infrastructure (Linnerud & Simonsen, 2017, p. 560).

However, important actors in the hydropower industry, including both Energy Norway and Statkraft, have changed the attitude towards the scheme as electricity surplus has contributed to lower electricity prices. They both support the government's decision to end the scheme in 2021(Energi Norge, 2016; Statkraft, 2016). The government also highlighted in the White Paper on energy from 2016 that the green certificates scheme will not be extended in order to assure a profitable development of renewable energy, highlighting the hydropower sector as the backbone of Norwegian electricity supply (MoEP, 2016a, p. 187).

5 Analysis

This chapter looks at the findings from the case studies in a comparative perspective. First, I assess the theoretical expectation that a fossil fuel industry-policymaker complex exist in the country cases. Thereafter I compare the outcome on the indicators of renewable energy policy design and discuss to what extent these findings fit with the expectation that renewable energy policies will not challenge the interests of the complex. Finally, I see the findings in relation to the carbon lock-in theory and point to some distinctions that should be made when addressing carbon lock-in in climate and energy policy.

5.1 Fossil fuel industry-policymaker complex

In Chapter 2 I argued that the increasing returns mechanisms that create the particular type of path dependency described as carbon lock-in, produce mutual dependencies between fossil fuel industry and policymakers for which the lock-in condition is not sub-optimal. I assumed that these dependencies create a change-resistant fossil fuel industry-policymaker complex, and I expected that when this complex is strong, renewable energy policies will not challenge its primary interests to maintain lock-in.

A set of indicators is used to assess the degree of mutual dependency and the likelihood that such a complex exists. I have assessed the degree to which fossil fuels are important in the electricity sector and the economy, as well as the ownership structure in the fossil fuel industry (see Table 4).

Table 4: Explanatory factors

	Electricity generation	**Economic impact of fossil fuels**	**Ownership**
Australia	Coal dominated	Big	Mainly private
Poland	Coal dominated	Moderate	Mainly public
Norway	Hydropower dominated	Big	Mainly public

Although different, a form of incumbent industry-policymaker complex seems to be existent in all three cases. In Australia, the coal industry, and to some extent the gas industry, dominates the electricity generation. Both are important for the country’s economy. After the “mining boom” from 2003 and on, the importance of both coal and LNG exports have grown. Also, calculations show that this boom has contributed to increased purchase power and higher wages in Australia (see Tulip, 2014). Most fossil fuel companies are privately owned. This may be related to the fact that Australia has a liberal economic model (LME) (as defined in Hall & Soskice, 2001) that favors private ownership. Despite the lack of state ownership, the fossil fuel industry-policymaker complex in Australia is assessed as strong.

In Poland, the complex is also assessed as strong. Coal dominates the electricity sector and has, at least historically, played an important role in the economy. Poland was among the biggest coal exporting countries up to the 1990s (Szulecki, 2017, p. 7), but coal exports have, as we have seen, dropped thereafter (World Bank 2017). Although coal is no longer as important for the economy as a whole, it is still the mainstay in domestic electricity generation. There is also a widespread state ownership in key Polish energy companies. The impression from the case study is also that, the importance of coal in electricity generation and the state ownership contribute to maintain close ties between the industry and policy-makers, even though the industry is not as important (anymore) for the economy as a whole.

Norway is a particular case as it has a dominant oil and gas industry in its economy, and a dominant hydropower industry in its electricity generation. The petroleum sector is a big contributor to the national budget and employment, as well as to Norwegian exports. Over the period studied Norway top the list of OECD-countries with the highest share of fuel exports – 59% of Norwegian exports between 1990 and 2015 (World Bank 2017). Further, key companies in the petroleum sector, with Statoil as the largest, are state owned.

Additionally, hydropower has been subject to many of the same increasing returns mechanisms as fossil fuels. High investment costs, infrastructure built around hydropower, learning effects and adaptive preferences as more hydropower is developed, have contributed to a strong preference towards hydropower in the Norwegian electricity sector. Also, the policy framework and ownership structure imply that the hydropower sector in Norway share important similarities with an industry-policymaker complex in a fossil fuel dominated electricity system. The impression is therefore that there are two distinct industry-policymaker complexes in Norway – one carbon related and one hydropower related.

5.2 Renewable energy policies: a challenge to incumbents?

The main expectation regarding renewable energy policies has been that they are not a challenge to the interests of the industry-policymaker-complex if they do not substantially reduce costs or improve competitiveness of renewable energy sources compared to fossil fuel energy sources. This I have assessed along four indicators: *level of support, predictability, cost allocation* and *technology*. These indicators are discussed for each country case in the former chapter. In the following I look at them in a comparative perspective. Table 5 summarizes the main findings for each country.

There are several similarities between the main renewable energy policy instruments in the three country cases. All three countries have had technology neutral green certificates schemes among their main renewable energy policies during the period studied.

Table 5: Main RE policies and indicators compared

Main scheme	Level of support	Predictability	Cost allocation	Technology
Australia: (M)RET	Too low to reach target	Very unpredictable	Certificates impose costs, but with compensation	Neutral
Poland: Green certificates	In periods too low due to low certificate prices	Very unpredictable	Certificates impose costs, but with compensation	Neutral
Norway: Wind power target and green certificates	Too low for wind power. Weak demand side for certificates	Somewhat unpredictable	Subsidies for wind. Certificates impose costs. No compensation	Some wind specific policies, and neutral certificates

Regarding the level of support the expectation was that it would be too low to trigger substantial investments in renewable energies. The green certificate scheme guarantees have in times of high prices of both certificates and electricity prices been generous enough to trigger important investments, in particular for wind in Poland and Australia. However, the level of unpredictability related to the support schemes have played in on the investment horizons. It therefore seems that a much bigger potential could have been released with more stable and predictable conditions for renewable energy development in all three countries. This is most evident in Australia, which is not on track to meet its RET target, much due to the unpredictability regarding the RET scheme and controversies over climate and energy politics in general.

Furthermore, the technology neutral design has led to investments primarily in the most cost-effective and mature technologies. In Poland this has been biomass co-firing, in addition to wind power. The certificates scheme in Australia has primarily triggered wind power. Despite its huge potential for solar power it is only in recent years that solar power has increased substantially, however, still only 2% of total electricity generation in Australia. However, in both countries fossil fuels continue to dominate the electricity generation. In Norway, which is dominated by hydropower in the electricity sector, the certificate scheme has resulted primarily in new small-scale hydropower.

Looking at how costs are allocated, we see that although the certificates schemes impose a cost on fossil fuel electricity suppliers, the schemes in Poland and Australia have provided important exemptions and compensations for incumbent fossil fuel industry. In Poland the coal industry has been included in the scheme by allowing biomass co-firing (30% biomass and 70% coal) as eligible for certificates under the same conditions as renewable energy sources like wind power and solar power. In Australia fossil fuel industry and other industries have been compensated by opening up for exemptions from liability for trade-exposed energy intensive industries. Further, allowing (although limited amounts of) waste coal mine gas as eligible for certificates has also been a way to compensate the coal industry for the RET costs.

In both countries, although to a lesser extent in Poland, the development of renewable energy policies has been followed by increased support for R&D and low-emission technologies like CCS. These programs can also be seen as a compensation to the fossil fuel industry, and a way to include them in a low-carbon transition. Although electricity generation in Norway is carbon-free, Norway is among the OECD-countries that have provided most support for large CCS and climate technology R&D programs (IEA, 2017a, p. 11).

In Norway the picture is slightly different than in Poland and Australia due to the strong petroleum industry *and* hydropower sector, which, as described over, may in fact form two distinct industry-policymaker complexes. The renewable energy policies in Norway have not really challenged the interests of either. The oil and gas industry is mainly export oriented, and thus domestic electricity production is not in conflict with their exports. The wind power target (which was not reached) did not really challenge the hydropower-complex as the hydropower development continued alongside the support for wind power. As we have seen, the infrastructure and ownership structure in the hydropower sector was pointed to as a reason why the wind power target was not met (see Blindheim, 2013). Furthermore, the green certificates scheme was also in line with the hydropower complex' interest because it would benefit from the scheme as it was designed to trigger the most cost-effective investments, which in Norway by all means are hydropower.

In sum, the case studies support the general expectation that renewable energy policy has been developed in a way that to a large extent does not challenge the industry-policymaker complex. Rather, the policies seem to incorporate the interests of incumbent industries in electricity generation – coal in Australia and Poland, hydropower in Norway. The policy schemes in themselves have not substantially reduced costs and/or increased competitiveness of (new) renewable energies compared to the dominating industry in electricity generation in any of the three countries.

However, it should not be neglected that renewable electricity generation has grown in all three countries over the period studied. In Norway, however, the development of new renewable energy has been negligible due to the adequate and flexible hydropower resources already installed, and the flexibility of the common Nordic electricity market. Although clearly below the IEA average of 24% renewable energy in electricity generation, renewables has grown to 14% of total electricity generation in both Poland and Australia in 2015 (IEA, 2016a, 2016d).

I argue that these developments are despite, and not because of, the policies adopted. There are two explanations for this that should be highlighted. First, the overall technological development of renewable energy technologies in recent years has reduced costs of renewable technologies dramatically, and improved investment conditions regardless of the domestic RE support policies in the three country cases. None of the countries studied here have been the main drivers in these technological developments.[24]

Second, external pressure has played a significant role for renewable energy policy development in all three countries. Australia's international commitments to the Kyoto Protocol has been used as a justification for adopting renewable energy measures, among them the initial MRET (Effendi & Courvisanos, 2012, pp. 246–247). Australia's responsibility in international climate politics was also used as an important justification for the Rudd and Gillard governments' climate and energy policies (Curran, 2011; Eckersley, 2013).

In Poland, the EU has played a key role. Quoting Szulecki: "It is probably not an exaggeration to say that without the EU, Poland might not have had RE support at all" (Szulecki, 2017, p. 19). However, the resistance toward the EU measures has been strong at the domestic level, and Poland has strived to achieve its renewables obligations at the lowest cost possible (Jankowska, 2017, p. 150). The controversy with the EU Commission on the implementation of the RES Directive is a good example of the strong resistance towards the EU level: "The government's strategy was only to water down its provisions in national legislation, avoiding the alternation of the existing system for as long as possible" (Szulecki, 2017, p. 14).

The EU has also influenced the implementation of domestic renewable energy policies in Norway. With the EEA agreement Norway is obliged to implement the RES Directive. According to Gullberg and Bang (2015), complying with EU obligations was one of the main reasons why the green certificates scheme with Sweden was adopted in 2012 (Gullberg & Bang, 2015, p. 103). The EU has also played an impact on Norwegian policy development as the ESA has interfered in Norwegian renewable energy policy to assure that they are in line with the EU's competition regulations (see Boasson, 2015, ch. 5).

The overall impression based on the case studies is therefore that the incumbent industry-policymaker complex has been resistant to change, although not unaffected by technological development and external pressure, like international commitments. The international pressure and the increased domestic renewable energy capacity are also likely to have strengthened domestic renewable energy interests compared to fossil fuel interests. The

[24] It should be noted that Norwegian companies have contributed to offshore wind technology development. The primary example is Statoil's Hywind windmill. Norwegian companies like Statoil and Statkraft are also involved in offshore wind development outside Norway. However, Statoil's main activities are still in petroleum.

increased strength of the renewable energy interests was clearly visible in the 2014–2015 RET review process in Australia, where renewable industry interests campaigned to keep the RET and also acted as a broker between the government and the opposition. In Poland the demands for, and later adoption of, prosumer legislation is another example of growing renewable energy interests in Poland. If these interests continue to unfold, they can become a stronger challenge to the incumbent industry-policymaker complex than currently is the case.

In the next section I discuss the implications these findings may have for the carbon lock-in theory.

5.3 Carbon lock-in: a particular type of lock-in?

The Norwegian case illustrates that hydropower has been favored in electricity generation in a similar way as coal in Poland and Australia. As argued over, there are indications of a hydropower industry-policymaker complex resistant to change in the electricity sector in Norway. At the same time, Norway has traits of a carbon-based complex due to its high dependency on the petroleum sector in its economy and strong state ownership.

The expectation that renewable energy policy will not challenge the interests of the incumbent industry-policymaker complex, could be transferred to the study of climate policy – namely by claiming that climate policy does not challenge the core interests of the carbon complex. Norwegian climate policy has primarily focused its efforts on cost-effective global measures like carbon trading, and on funding emission reductions in developing countries (Boasson & Lahn, 2017). Although the Norwegian petroleum sector is subject to CO_2 tax since 1991 and since 2008 part of the EU ETS, these measures have to a little extent restricted the activity of the petroleum sector in Norway. The sector was responsible for more than ¼ of Norwegian CO_2-emissions in 2015, and has increased its emissions since 1990 by 83%, mainly due to increased activity (SSB, 2016b). Although further study is needed to conclude on this issue, these examples indicate that climate policy in Norway can be studied within the same type of analytical framework as used in this thesis.

It may thus seem that Norway is both hydro- and carbon locked-in. The Norwegian case therefore rises (at least) two important questions regarding the carbon lock-in theory. The first question is whether there should be made a distinction between different types of carbon lock-in, rather than an overall societal carbon lock-in. In a recent article, Unruh and colleagues (Seto et al., 2016) review the literature on carbon lock-in and propose to categorize three "types" of carbon lock-in: technological, institutional and behavioral. However, it may seem somewhat contra-intuitive to distinguish these three as the argument in earlier works (Unruh, 2000, 2002) has been that it is exactly the co-evolution of increasing returns mechanisms in technological, institutional and behavioral patterns that create a TIC and the carbon lock-in.

Further, these "types" of carbon lock-in are very inclusive and broad, which this description of institutional lock-in, from the above-mentioned article, illustrates:

> Although institutional lock-in is a characteristic of institutions, it arises through the coevolution of multiple systems or spheres (8, 9, 52). Technological, economic, scientific, political, social, institutional, and environmental spheres coevolve, with changes in each being both responses to and causes of changes in other spheres (53). Coevolution involves iterative dynamics that strongly favor lock-in, with each sphere's norms, rules, actors, processes, and logic increasingly coming to favor reproductive over disruptive changes. Disruptive changes that do emerge in one sphere tend to be tamped down by status quo pressures from within that sphere and from other spheres. These dynamics generate a mutually reinforcing consistency, with each sphere and the system as a whole becoming increasingly resistant to change (Seto et al., 2016, p. 434).

This all-encompassing understanding of carbon lock-in in institutions does not necessarily improve the explanatory strength to the theory, especially when we try to understand what consequences such lock-in can have for policies trying to "lock-out". Furthermore, sources of lock-in seem to be "everywhere", which may in fact lead our attention away from what may be the actual and most important drivers of lock-in. Therefore, although there may exist different types of carbon lock-in, I argue that the differentiation between such types must be more specific than what the current literature suggests (see below).

The second question raised in the wake of the Norwegian case is whether one can claim, as Unruh does, that carbon lock-in is in fact something strictly carbon-related, or whether lock-in can happen regardless of the carbon element in the technological system. Some former studies point in the direction that similar lock-ins also develop for renewable energy technologies.

Klitkou et al. (2015) study transition towards sustainable technologies in the transport sector in the Scandinavian countries. They observe that dominant renewables technologies seem to create lock-in in the same manner as fossil fuels - wind power in Denmark, hydropower in Norway, and in Sweden, first generation biofuels. According to the authors these RE lock-ins create barriers to the diffusion of other renewable energy technologies. They therefore suggest to "distinguish between lock-in mechanisms which favor, respectively, the old fossil-based regime, well established (mature) renewable technological trajectories, and new technological trajectories" (Klitkou et al., 2015, p. 35).

Nordensvärd and Urban (2015) make a similar observation in an article studying the feed in-tariff for wind power in Germany. They claim that the wind power development has created a lock-in similar to a fossil fuel lock-in, and that this wind power lock-in may be a barrier to further energy transition in Germany (Nordensvärd & Urban, 2015, p. 164).

For analytical purposes it seems that a fruitful first step is to distinguish between energy related lock-ins by type of technological system (i.e. transport or electricity) and type of energy source (i.e. wind power or coal).

The above examples lead to a third, and maybe more problematic question regarding the theory of carbon lock-in: Is there then an added value of talking about a particular carbon lock-in compared to technological lock-ins, like Arthur (1989) already described a few decades back?

I argue that although the mechanisms and processes of lock-in may be the same, there are two reasons why paying attention to the carbon aspect of lock-in may be important. The first reason relates to the dispersed use of fossil fuels in several technological systems crucial for modern societies, like electricity systems and transportation. As these are important societal functions, there are not only economic, but also political vested interests in keeping them up and running. This makes the transition away from them more complex. Also, replacing fossil fuels in one system will not achieve a complete "lock-out" as related systems may still be locked-in.

Second, the carbon aspect of these technological systems also contributes to make them more politically controversial. As we have seen, renewable energy has been way more controversial in Poland and Australia, than in Norway. In Norway, hydropower is not as controversial since it is a clean source of electricity. From a climate perspective, there is no need to transition away from hydropower. On the other hand, in Poland and Australia the need to transition, from a climate perspective, is urgent. For the fossil fuel industry therefore, the stakes are high as the ultimate consequence is the full transition away from them. Further, as argued in

Chapter 2, the sector is capital intensive and thus the industries and policymakers that invest in and potentially benefit from fossil related incomes are likely to be more reluctant to change. This political-economic aspect of carbon-based technological systems should therefore not be neglected, and it highlights how studying interest structures and who benefit from lock-in is particularly important in a carbon-related lock-in context.

How can carbon lock-in then be useful for the study of energy and climate policy and politics? We can use the three case studies in this thesis to illustrate how different types of both carbon and renewable energy lock-in may exist in these countries, even alongside each other. By making the distinction between the consumption and the production of fossil fuels, as well as taking into account the purpose of the consumption and/or producction, we see that the three country cases in fact portray a variety of lock-ins (Figure 10).

Figure 10: Varieties of lock-in in the three country cases

	Consumption lock-in	**Production lock-in**
Purpose	*Electricity generation*	*Export*
Australia	Coal lock-in	Coal and gas lock-in
Poland	Coal lock-in	–
Norway	Hydropower lock-in	Oil and gas lock-in

The distinction between consumption and production illustrates that although the domestic technological system may not be carbon locked-in, being a carbon producer can also create lock-ins. Although not studied in detail in this thesis, it is reason to believe that such lock-ins may as well influence policy development in climate and energy politics.

I therefore argue that taking into account the potential variety of energy related lock-ins and the particular political and economic interests of the actors that may benefit from sustaining such lock-ins, can provide us with a better understanding of the development of climate and energy policy requiered for energy transition. This may help us take a step beyond the quite generic explanation that carbon lock-in produce resistance to change.

6 Conclusion

This thesis has sought to understand to what degree and in what ways fossil fuel dependency, conceptualized as carbon lock-in, may influence renewable energy policy. I have assumed that the mechanisms leading to carbon lock-in create mutual dependencies between fossil fuel industries and policymakers that result in a change-resistant fossil fuel industry-policymaker complex. Further, I expected that under such conditions only renewable energy policies that do not challenge the core interests of this complex will develop.

I have found support for this expectation when studying the development of renewable energy policies in Poland and Australia, where coal dominate the electricity generation. For Norway, on the other hand, the findings are slightly different. Although Norway portrays important characteristics of a carbon locked-in country due to its high economic dependency on the petroleum sector, the electricity sector is almost carbon free. However, electricity generation is dominated by hydropower and similar mechanisms as in the coal dependent countries are observed here. I have therefore argued that there may in fact be two distinct industry-policymaker complexes in Norway that may produce two distinct types of lock-in – one carbon lock-in and one hydropower lock-in.

These findings illustrated the need to distinguish between different types of energy related lock-ins, rather than assuming an overall carbon lock-in. I argued that taking into account the potential variety of energy related lock-ins, and the political and economic interests that may benefit from these, can provide us with better insights about the development of climate and energy policy necessary for energy transition. This may help us take a step beyond the generic conclusion that carbon lock-in produces resistance to energy transition, and improve our understanding of why resistance to change persists in some country contexts and not in others.

However, a better both empirical and theoretical understanding of how an incumbent industry-policymaker complex functions is needed. Furthermore, studying how the growing renewable energy industry challenge the incumbent industry-policymaker complex is important in order to understand how "lock-out" may be possible. From a comparative perspective, the political intuitions through which interests are channeled, is also an interesting factor that may lay the foundations for "lock-out". Needless to say, much more research is needed in order to fully understand the processes of lock-in and "lock-out".

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Appendix 1: Carbon lock-in index

Index ranking	Country	Energy system: Fossil fuel energy consumption	Energy system: Electricity production from oil, gas and coal sources	Economy: Added value energy-producing activities	Economy: Fuel exports	Index score
1	Australia	94	90	X	24	**208**
2	Poland	95	96	5	6	**202**
3	Israel	97	100	2	1	**200**
4	Greece	93	88	2	16	**199**
5	Netherlands	94	89	4	9	**196**
6	Mexico	89	78	8	14	**189**
7	Ireland	89	90	1	1	**181**
8	Denmark	85	77	4	6	**172**
9	UK	87	72	3	9	**171**
10	Italy	89	77	2	3	**171**
11	Luxembourg	87	80	1	1	**169**
12	US	85	70	4	4	**163**
13	Czech	85	69	5	3	**162**
14	Japan	84	67	2	1	**154**
15	Korea	84	62	2	5	**153**
16	Germany	83	63	2	2	**150**
17	Portugal	80	64	2	4	**150**
18	Estonia	28	97	5	9	**139**
19	Hungary	78	54	4	3	**139**
20	Spain	79	52	3	4	**138**
21	Norway	56	1	21	59	**137**
22	Chile	73	47	3	1	**124**
23	Belgium	75	39	2	6	**122**
24	Canada	74	23	7	17	**121**
25	Slovakia	73	32	5	5	**115**
26	Slovenia	69	36	3	3	**111**
27	Austria	75	29	3	2	**109**
28	Latvia	66	36	3	4	**109**
29	New Zealand	67	27	X	3	**97**
30	Finland	50	36	2	5	**93**
31	France	52	9	2	3	**66**
32	Switzerland	54	2	2	1	**59**
33	Sweden	34	4	3	4	**45**
34	Iceland	21	0	4	1	**26**
Average:		**74,2**	**21**	**3**	**4**	**139**

X= Missing data.

Index description

The index is additive. All indicators are given as a percentage share of total, based on a calculated average over the period 1990–2015. Where some country-year data have been missing, the available country years are used for calculations. Australia and New Zealand have not provided data on energy producing activities. Turkey is not in the index due to missing data. Further, Australia and New Zealand do not provide data for energy-producing activities.

Indicators

Indicator	Description	Source
Fossil fuel energy consumption	% of total energy consumption. Fossil fuel comprises coal, oil, petroleum, and natural gas products.	World Bank
Fossil fuel electricity production	% of total electricity production. Fossil fuel comprises coal, oil, petroleum, and natural gas products.	World Bank
Added value energy-producing activities	Energy producing activities as a share of total GVA. Energy-producing activities are defined in the OECD STAN Database as the categories: Mining and quarrying of energy producing materials; Coke and refined petroleum products; Electricity, gas, steam and air conditioning supply. It does not distinguish between renewable and fossil energy sources for electricity.	OECD Structural Analysis Database
Fuel exports	% of total merchandise exports. Fuels comprise mineral fuels, lubricants and related materials.	World Bank

Appendix 2: List of renewable energy policies

Australia

Policy name	Policy type	Status	Start	End	Technology
Green Power Scheme	Voluntary Approaches	In force	1997	t.d.	Multiple
Renewable Energy Industry Programme (REIP)	Economic Instruments	Superseded	1998	2007	Multiple
Renewable Energy Commercialisation Programme	Economic Instruments	Superseded	1999	2007	Multiple
Renewable Energy Equity Fund	Economic Instruments	Ended	1999	2012	Multiple
Renewable Energy Action Agenda	Voluntary Approaches	Ended	2000	2007	Multiple
Renewable Remote Power Generation Programme	Economic Instruments	Ended	2000	2009	Multiple
Solar Homes and Communities Plan (formerly Photovoltaic Rebate Program)	Economic Instruments	Superseded	2000	2009	Solar
Mandatory Renewable Energy Target	Regulatory Instruments	Superseded	2001	2009	Multiple
Renewable Energy Industry Development (REID)	Economic Instruments	Superseded	2003	2007	Multiple
"Securing Australias Energy Future" - White Paper on Energy	Policy support	Ended	2004	?	Multiple
Renewable Energy Development Initiative	RD&D	Ended	2004	2008	Multiple
Low Emissions Technology Demonstration Fund	RD&D	Ended	2004	2008	Multiple
Solar Cities	Economic Instruments	Ended	2004	2013	Solar
Advanced Electricity Storage Technologies Program	RD&D	Ended	2004	2012	Multiple
Improving Grid Accessibility	Regulatory Instruments	Ended	2004	2014	Multiple
Wind Energy Forecasting Capability	RD&D	Ended	2004	2009	Wind
Funding for Low Emissions Technology and Abatement	RD&D	Ended	2005	2009	Multiple
National Code for Wind Farm Construction	Regulatory Instruments	Ended	2006	2010	Wind
Clean Business Australia	Economic Instruments	Ended	2008	2012	Multiple
Green Precincts Fund	Economic Instruments	Ended	2008	2012	Multiple
National Solar Schools Program	Economic Instruments	Ended	2008	2013	Solar

Clean Energy Initiative	RD&D	Ended	2009	2011	Multiple
Solar Flagships Program	Economic Instruments	Ended	2009	2012	Solar
The Australian Centre for Renewable Energy	RD&D	Superseded	2009	2012	Multiple
Renewable Energy Demonstration Program (REDP)	Economic Instruments	Ended	2009	2012	Multiple
Australian Solar Institute	RD&D	Ended	2009	2013	Solar
Renewable Energy Future Fund					
Green Loans Programme for Households	Economic Instruments	Ended	2009	2011	Solar
Solar Credits	Economic Instruments	Ended	2009	2014	Multiple
Enterprise Connect	RD&D	Ended	2009	2014	Multiple
Renewable Energy Target	Regulatory Instruments	In force	2009	2030	Multiple
Clean Energy Future Plan	Policy support	Ended	2012	2014	Multiple
Renewable Energy Venture Capital Fund	Voluntary Approaches	In force	2011	t.d.	Multiple
Clean Technology Innovation Programme	RD&D	Ended	2012	?	Multiple
Australian Renewable Energy Agency (ARENA)	RD&D	In force	2012	t.d.	Multiple
Remote Indigenous Energy Program	Economic Instruments	Ended	2011	?	Multiple
Research and Development (R&D) Program	RD&D	In force	2012	2022	Solar
Regional Australia's Renewables (RAR)	RD&D	Ended	2013	2015	Multiple
Accelerated Step Change Initiative (ASCI)	RD&D	In force	2013	t.d.	Multiple
Clean Energy Finance Corporation (CEFC)	Economic Instruments	In force	2015	t.d.	Multiple
National Wind Farm Commissioner and Independent Scientific Committee on Wind Turbines	Regulatory Instruments	In force	2015	t.d.	Wind

Poland

Policy name	Policy type	Status	Start	End	Technology
Support for the development of energy from renewable sources	Policy support	In force	1991	t.d.	Multiple
Feed in Tariff	Economic instrument	Ended	1993	1999	Multiple
RE purchase obligation	Regulatory instrument	Ended	1999	2005	Multiple
Energy Law Act	Regulatory instrument	In force	1997	t.d.	Multiple
Development Strategy for the Renewable Energy Sector	Policy support	Superseded	2001	2010	Multiple
Renewable Energy Tax Excise	Economic instrument	In force	2002	t.d.	Multiple
Obligation for Power Purchase from Renewable Sources	Regulatory instrument	In force	2005	t.d.	Multiple
Energy Policy of Poland Until 2025	Policy support	Superseded	2005	2009	Multiple
Red Certificate System	Economic instrument	In force	2008	2018	CPH
Programme for RE and high efficiency cogeneration projects	Economic instrument	Ended	2009	2012	Multiple
Polish Energy Policy until 2030	Policy support	In force	2009	t.d.	Multiple
Green Investment Scheme (GIS)	Economic instrument	In force	2009	t.d.	Multiple
National Renewable Energy Action Plan (NREAP) of Poland	Policy support	In force	2010	t.d.	Multiple
Elimination of low emission sources through support of energy efficiency and development of dispersed renewable energy sources.	Economic instrument	in force	2013	2018	Multiple
PROSUMER - programme supporting deployment of RES microinstallation	Economic instrument	In force	2014	t.d.	Multiple
BOCIAN - support for distributed renewable energy sources	Economic instrument	In force	2014	t.d.	Multiple
Loans from the National Fund for Environmental Protection and Water Management	Economic instrument	In force	2015	t.d.	Multiple

Norway

Policy name	Policy type	Status	Start	End	Technology
NYTEK R&D Programme	R&D	Ended	1995	?	multiple
Wind Power Production Support	Economic instrument	Ended	1999	2003	Wind
White Paper on Energy Policy	Policy support	Superseded	1999	-	multiple
Subsidy Scheme - Energy Use and Production	Economic instrument	Superseded	2000	2002	multiple
Enova	Institutional capacity	In force	2001	t.d	multiple
Investment aid and conditional loans to support development and deployment of energy and climate efficient technologies and measures through Enova SF	Economic instrument	in force	2002	t.d	multiple
Strategy for Small-scale Hydropower	tax relief	in force	2003	t.d	Hydro power
White Paper on Energy Supply	Policy support	in force	2003	t.d	multiple
Clean Energy for the Future (RENERGI) Programme	R&D	Superseded	2004	2012	multiple
Environmental Technology Scheme (Miljøteknologiordningen)	Economic instrument	in force	2004	t.d	multiple
Klimaforliket I: White Paper on National Climate Policy	Policy support	Superseded	2007	2012	multiple
Energi21 - National Strategy for Research, Development, Demonstration and Commercialisation of New Energy Technology	Policy support	in force	2008	t.d	multiple
Centres for Environmentally-friendly Energy Research	R&D	in force	2008	t.d.	multiple
Act on Offshore Renewable Energy Production	Economic instrument	in force	2010	t.d.	wind/ocean
Klimaforliket II: Report to the Storting Norwegian Climate Policy and political climate agreement in the Parliament from 2012 (Innst. 390 S (2011-2012)	Policy support	In force	2012	t.d	multiple
Investment aid and conditional loans to innovative energy and climate technology though Enova SF	Financial support	In force	2012	t.d	multiple
Norway-Sweden Green Certificate Scheme for electricity production	Economic instrument	in force	2012	2022	multiple
ENERGIX Programme	R&D	in force	2012	2022	multiple
National Renewable Energy Action Plan (NREAP)	Policy support	in force	2012	t.d	multiple
Investment aid for Energy measures in households though Enova SF	Financial support	in force	2013	t.d	multiple