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Abbreviations

Renewable energy: RE

Research and development: R&D

The multi-level perspective: MLP

small business Innovation research program: SBIR

Abstract

In this master's thesis I was interested in researching the role the state has in promoting renewable energy, and accelerating a transition to more renewable energy. Particularly I was interested in the concept of green industrial policy as a method to accomplish this. I took Norway as a case study with a focus on solar and wind power. Enova, a state-owned enterprise is used as the main case study to research the impacts of state intervention and green industrial policy. Interviews were conducted with an representative from Enova, as well as an representative from a business cluster called Solenergiklyngen to contrast the perspectives on government involvement in the relevant energy markets. I have found that government intervention, and green industrial policy in particular are very important for accelerating the renewable energy transition. Market failures are substantial barriers for the speed of diffusion of a renewable energy transition, and green industrial policy is a very potent tool to tackle these market failures (Dani Rodrik & Tilman Altenburg, 2017)- Enova has also played a very important role historically in fast tracking the wind power sector that was struggling prior to Enova support (Enova, 2014). My conclusion after conducting the research for this thesis is that it is highly unlikely that a renewable energy transition can happen fast enough to be consistent with our climate goals, and it may not have started to happen at all without public economic support for certain sectors, and some levels of green industrial policy.

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Fant ingen oppføringer i innholdsfortegnelsen.

1. Introduction

1.1 The pressing issue of climate change

One of the most important and pressing issues facing the world today is the ever so increasing threat of global climate change (IPPC, 2018) Significant changes to the global energy system needs to occur if we are going to have a chance to meet the 1.5 degrees Celsius target for global warming (IPPC, 2018). Although many countries around the world still rely heavily on conventional fossil fuel sources for their energy and electricity mix (Ritchie et al., 2020), Norway is in a bit more of a unique position in this regard as around 50% of the energy mix comes from renewable energy (RE) (*Energi Norge*, n.d.). This is even higher for the electricity mix as Norway has great hydro power capacity which accounts for 96% of the electricity mix (Nordic energy research, n.d.) Still Norway is a major oil and gas producer and exporter (*Exports of Norwegian oil and gas - Norwegianpetroleum.no*, n.d.) which can lead to conflicting priorities for policy makers. Even though a very significant portion of the electricity mix is covered by RE, the share of solar and wind energy production in Norway is still a relatively small part of the energy mix. In 2019 comparing the two, wind is the more significant one accounting for 5536.0 GWh. Solar comes quite far behind wind only

accounting for a very insignificant 13GWh (IEA, 2021). Hydropower on the other hand accounts for as much as 125796.0 GWh, which shows just how massive the electricity production from hydropower is in Norway (IEA, 2021).

The fact that hydro power was an already technological mature technology for a long period of time, and the favorable geography regarding it in Norway is an extremely important factor for the relative success of hydropower compared to solar and wind in Norway. These are also other important factors for the relative success of wind and solar power as well that is important to consider.

If Norway is to even further increase its share of RE in the total energy mix, electrification is one of the most important drivers for combating global climate change and decarbonizing the total energy mix (Electrify, Griffith, 2021), and further increasing the shares of renewable energy replacing more of the traditional fossil fuel-based energy mix is of great importance.

In this thesis I am particularly interested in the state's role in accelerating the development of renewable energy in Norway, with a focus on wind and solar power. There are many different ways the state can impact the economy and energy markets to create or accelerate the speed of a renewable energy transition, but in particular in this thesis I am the most interested in the concept of green industrial policy, and what its role is in such a transition. First however we need to understand whether or not the state can be effective in such an endeavor, or whether the state simply is a hinderance to the free market. It needs to be an effective method to restructure the economy in a more RE-oriented direction, rather than leading to ineffective results and negative economic costs for society. The urgency of the global climate crisis however should make us vary of relying too heavy on the free market, as it needs to happen within a timeframe consistent with meeting our global climate change goals, and the consequences of getting it wrong are extremely severe.

One example of a state-owned enterprise in Norway working towards achieving our climate goals by actively supporting different technology projects is Enova (Enova, n.d). In this thesis I will use Enova as my primary case study to analyze how Norway utilizes government intervention and green industrial policy to help accelerate the transition to more sustainable energy solutions. Understanding Enova's impact on the markets they operate with, what method and tools they use and how they have historically influenced the trajectory of solar and wind power in Norway will grant important insights into the effectiveness of green industrial policy

1.2 State of the art literature, and literature gap

A lot has been written on the importance for public sector intervention and green industrial policy for promoting development of renewable industries.
From Dani Rodrik & Tilman Altenburg (2017) we get many theoretical reasons for the importance of Green industrial policy. From Robinson & Mazzucato (2019) we get many insights into the importance of public sector intervention and green industrial policy when certain investments are considered very risky by private sector investors like many renewable energy technologies. From Gross et al (2012) we understand the importance of lock-in mechanisms in hampering RE technologies relative to conventional fossil fuel sources. Although much has been written on various elements on the effectiveness and importance of green industrial policy and public sector support, the question of whether or not it is necessary for a renewable energy transition to happen still remains. However just making the transition at some point is not necessarily enough, in order to meet our climate goals, the transition has to be made in a timely manner consistent with those goals. The question of whether or not a renewable energy transition can happen in a timely manner without a green industrial policy or a similar public sector support framework is one of the central research questions in this thesis, and a part of the literature gap I how to contribute too.
I have conducted Interviews with Enova, a government owned enterprise and Solenergiklyngen, a business cluster working towards promoting solar energy solutions in Norway and internationally.

The Findings in my thesis is consistent with much of the literature on public sector support and green industrial policy where Enova has played a very important role in promoting renewable energy in Norway. This especially so in the wind energy sector which would have developed a lot slower if at all with

support from Enova. The trajectory of how the policy is handled is equally important, and there is a point in time where support needs to be reduced or stopped completely depending on the context. Maybe the most important question, which is whether or not it is realistic for a RE transition to happen in a timely manner to reach our climate goals without public sector support and green industrial policy, becomes clearer the more data I gathered. From my findings and analysis, it is very unlikely that renewable energy transition can happen in a timeframe consistent with meeting our climate goals, as there are to many factors slowing it down. lock-in mechanism, low investments prior to public sector support/Green industrial policy and the general slow pace of sectors prior to more ambitious public sector initiatives are all central here.

2.3 Structure of the thesis

In the first section, section nr 2 after this Introduction, I will conduct a literature review. There I will start given some context to the success of industrial policies before venturing into green industrial policy, and the mission-oriented policy framework. I will then go on to some of the economics of green industrial policy to give some context of the opportunities and challenges related coming with green industrial policy. I will then be going on to review literature on the empirical efficacy of green industrial policy and present Theory from the Multi-level perspective on socio-technical transitions. In section nr 3, I will present the theoretical framework I will use in this master's thesis as well as present my research questions. In section nr 4, I will present the methods used for this master thesis. In section nr 5, I will start the empirical analysis part by presenting my secondary research findings and analyze them. In section nr 6 I will present my primary research findings and analyze them. In section nr 7 I will discuss my findings and analysis. Finally I will conclude

2 Literature review: Green industrial policy, mission-oriented policy and socio-technical transitions

In this section I will review literature on Industrial policy and green industrial policy to give some context to what the similarities and differences are between conventional industrial policies and green industrial policies, and why they have been, and continue to be important. The importance of Mission-oriented policy to foster a policy environment sufficient to bolster the renewable energy transition in time. The economics of green industrial policy will also be covered to give some context into the opportunities and challenges relating to such policies. The section will end with reviewing theory From the multi-level perspective on socio-technical transitions which will be further explored in the methodology section as one my theoretical concept and framework approach for structuring my thesis and discussion.

2.1 Historical examples of industrial policy and public sector intervention

Before reviewing literature specifically on the overall success of state involvement in the renewable energy industry, it can be useful to take a step back and look at the general potential of government involvement in Industry in general, as this can tell us something about whether the public sector historically has been capable of positively impacting sectors

of the economy to greater prosperity. The renewable energy industry is after all just that, an industry, and although industries to have heterogenous factors that could make government involvement different based on industries, there are still useful historical comparisons that can be made from reviewing literature on previous cases of government involvement. This can tell us if government intervention of various kinds in the private sector is useful or if it ineffective and just wasteful public spending.

(Block & Keller, 2011) analyzing who the successful actors are, in innovating In the US economy has many interesting findings. using Research and development (R&D) awards between the period 1971 to 2016, the data shows many interesting trends, such as a declining amount of awards among large firms and rising awards for newer startups. A very interesting finding for the purpose of this thesis however is the growing importance of public sector agencies as winners of these rewards. This ties in with the growing importance of public-private sector cooperation in US economy. In fact, most off the R&D awards were won by public universities, laboratories or publicly supported spin offs. It's very clear that the public sector can have substantial positive impact on innovation both through its own research and cooperation with other private sector firms. The successful role of public support or cooperation with the private sector is just as telling when we they look at the success of the small business Innovation research program (SBIR) were firms that are eligible for funding receives a grant of support off 100 000 dollars, then later if the firm seems promising, up to as much as 750 000 dollars. These firms that were granted support by the SBIR were well represented by the R&D awards.

Here we can clearly see very successful attempts in the US of various public institutions whether it be universities, public laboratories, public spin offs or government programs like the SBIR showing clear success in being able to encourage innovation in the private sector as well as being significant sources of innovation themselves (Block & Keller, 2011).

(Hartmann et al., 2021) takes this further looking at historical examples of how many successful economies developed contrary to less successful ones. They find that not only was smart industrial policy necessary for the successful economies to develop such as Iceland, Israel, Singapore and Korea among others, they were necessary to do so. A major reason for this is that without smart industrial policies, product diversification and complexity did not increase and they were stuck producing simpler products. This has interesting implications for two reasons. It may be the case that for certain economic transitions to occur, in this case from a less complex to a more complex economy, the public sector should not only play a role, but

it may “have too”. Second it proves that there are strong examples of public sector intervention and industrial policy being successful but it has to be done in the right way and this is where it can be difficult.

Overall, from both the largest economy in the world the US, and historically internationally the public sector has and continues to play and important role in supporting the private sector. However industrial policy is not enough if we are to move towards a very specific economic transition that is based on more renewable energy. It has to be with a vision and purpose of creating and steering the economy away from traditional fossil fuels as much as possible and more into renewable energy alternatives. This is where Green industrial policy comes in.

2.2 Mission oriented policy and Green industrial policy

2.2.1 Justifications for green industrial policy

We have seen that industrial policy and public-private sector cooperation can be very successful for both promoting innovation and subsequently improving the complexity of the economy leading to economic growth. But here we are not only interested in economic growth and innovation in a vacuum we are interested in a very particular type of innovation and a specific direction for industrial policy. In order to meet the climate goals RE transition needs to take place in a timely manner and Industrial policy needs to shift a focus from purely focusing on economic development and the subsequent underlying elements such as jobs, exports industrial development etc. to a focus on promoting green and renewable energy sectors. In this part of the section, we will review literature regarding what the reasons are for a green industrial policy paradigm over the more conventional industrial policy thinking. What are the differences between green industrial policy, general climate policy and conventional industrial policy? We will also review literature on the concept of mission-

oriented policies, where achieving certain societal missions and goals leads into green industrial policy.

Although we have seen success stories of industrial policy in the previous section, the question still remains why may such policy be needed regarding the renewable energy transition specifically? If public policy is to play a role in directly intervening in the economy by various means theoretical justifications for this should be understood.

From Dani Rodrik & Tilman Altenburg (2017), we find many theoretical reasons why Green industrial policy is imperative for the renewable energy transition to happen in a timely manner. Although price signals in the market in many cases may be sufficient to stimulate the necessary investments, this is not always so. When investments can grant larger scale benefits to a society, which is the case for investments in renewable energy for the positive climate change implications they bring, it becomes more complicated than letting the market follow simple price signals.

One reason for this is that private investors will only take into account private returns of said investment when making the investment decision, and not the greater public benefits of more renewable energy as well as potential subsequent knowledge spill overs from the investments. Knowledge spill overs can be hard to quantify but they can play an important role in building up capabilities overtime regarding the projects and technologies in hand. Another market failure that can occur are “Coordination failures” These are characterized by the need for similar investments in related fields. Firms are unwilling or at least hesitant to invest as they are unaware if the necessary investments in related fields that are important for the success of the industry will happen. Lower level of investments in emerging industries can also be hampered by the fact that other firms can take advantage of the early knowledge gains the pioneering firms make. This is an issue from the point of view of the pioneering firm because the cost of making the investments is born purely by that firm, yet other firms can take advantage of their discoveries and the improvements the pioneering firm have made. This of course ties in with that was discussed earlier with the private returns of investments often being lower than the public returns to investments (Dani Rodrik & Tilman Altenburg, 2017).

A paper by the imperial college of London lays further out the importance for policy to take an active approach to fostering RE deployment. Investment risks associated with RE cannot be solved simply by for example simply adding a carbon tax. Although a carbon tax can make building RE technologies and producing RE cheaper relative to more conventional fossil fuel

alternatives, there are many other considerations going into it. These include Uncertainties around with wholesale power prices, turbulence in future electricity/energy politics and carbon permit prices. These factors can all lead to investments in RE becoming riskier, and hence lead to underinvestment relative to what we would consider to be socially optimal (Gross et al., 2012) These and other considerations explain to a large degree why the renewable energy industry often prefers targeted policies such as feed-inn tariffs that deliver stable income over time, rather than more uncertain policies. Hence targeted policies would likely be more effective in incentivizing investment into the renewable energy industry. This would also drive down the cost of finance over time further increasing the relative competitiveness of RE technologies over time compared to traditional fossil fuel competitors. (Gross et al., 2012)

It is also the case that in many parts of the world, rather than carbon being taxed, it is indeed subsidized. In fact, it is more often subsidized on average than being taxed. The global politics of carbon taxes are often quite volatile and politically difficult which is important to keep in mind. (Gross et al., 2012)

Targeted support can also create very much needed early support for new RE technologies by fostering early markets. Targeted support like subsidies can help create dynamic effects were increasing returns to adoption and economics of scale come into play. Thus, over time the economic costs of newer technologies will fall, making them more competitive with more traditional fossil fuel alternatives. This also helps facilitate lock-in mechanisms for these technologies over time, which may be specifically important as they are often competing against technologies benefitting from decades off lock-in. (Gross et al., 2012)

Up until this point the market failure theory justification for green industrial policy has been the main theoretical framework to build the case for green industrial policy. However, there are also other theoretical foundations to build sound green industrial policy on that is equally as helpful

Government interventionist policies are often focused around the debate about fixing market failures. In the case of renewable energy policy, the argument would be government needs to design policy to counter the negative externalities caused by fossil fuels on the environment. Robinson & Mazzucato (2019) however, argues a focus on fixing market failures are useful when looking at policy trying to put fixes on existing trajectories that markets are taking. The RE transition however, is very much looking to radically change this trajectory, so it might

not be enough in when considering the RE transition. However, fixing “directional failures” as an alternative and complimentary standpoint and theoretical lens can be useful. Mission oriented policies should be willing to state and create a “direction” for markets. Fixing directional failures are more about shaping and creating markets using policy to achieve set environmental and RE goals. (Robinson & Mazzucato, 2019)

Taking the concept of mission-oriented policy further, the mission-oriented policy approach lays out how policy should embrace active mission-oriented policy to achieve societal goals. Mission oriented policies needs to be bold and have wide social relevance, It needs to too be targeted and measurable to ensure it can be quantified whether or not the mission oriented policies were a success or failure. The timeframe for the policy needs to however be long enough for different public and private actors to build synergies and relationships. It needs to be ambitious and involve high risk projects as well, as these are often the ones that can be the most transformative for the goal the mission-oriented policy is trying to achieve (Mazzucato, 2018)

If we take these principles as the basis for successful mission-oriented policy, green industrial policy should meet as many of the principles as possible. It needs to have wide societal impact which an energy transition to a renewable energy-based economy certainly would do. Here where we can separate green industrial policy from regular industrial policy is its mission. It needs to be targeted first and foremost towards orienting the economy and energy systems to more renewable based technologies with a long enough policy timeframe for niche markets to build relationships with different actors and technologies to mature. This will include risky public investments as there are no guarantees that these technologies will succeed but this is a necessary part of mission-oriented policy.

The market failure and directional failure theories for green industrial policy are useful starting points for some theoretical foundations for the need for green industrial policy, but what distinguishes green from conventional Industrial policy, and what are some of the important factors for its success?

2.2.2 Differences between green and conventional industrial policy

How green industrial policy differs from the more conventional industrial policy, and how green industrial policy differs from conventional environmental policy can be interesting to consider. Industrial policy in the conventional sense revolves around the need for the economy to adapt to changes in technology and market developments that are occurring.

Fundamentally the core goal is very similar, trying to make policy that nurtures and develops important industries that policy makers and other stakeholders see fit. Creating policy to ensure the development of, and the nurturing of these sectors and industries going smoothy, or even is happening at all is the key behind the argument for industrial policy (Dani Rodrik & Tilman Altenburg, 2017).

The line between green industrial policy and conventional environmental policy is also a very blurry one. Fundamentally an environmental policy like a carbon tax will likely create structural changes in the economy. Higher carbon prices will lead to the relative competitiveness of renewable energy technologies compared to conventional fossil fuels improving, hence potentially creating a structural change, where there is more renewable energy technologies at a higher capacity relative to before the carbon tax was changed policy (Dani Rodrik & Tilman Altenburg, 2017).

Going however, to the comparison between conventional industrial policy and green industrial policy, it is also different in a quite important element. With the emergence of climate change on the horizon as a global threat that needs to be handled, the importance of steering the economy towards a greener and more renewable path significantly increases in importance relative to the more conventional industrial policy. This is because were the focus from more conventional industrial policy primarily lies in trying to develop and improve industries and markets where the potential for economic growth is high, Green industrial policy intends to steer the focus towards sectors and industries with the specific purpose in mind of promoting a more sustainable and RE oriented economy (Dani Rodrik & Tilman Altenburg, 2017). Focusing industrial policy on for example developing wind energy instead of promoting the existing coal industry in a country would be an example of the focus on green industrial policy compared to more conventional industrial policy.

Dani Rodrik & Tilman Altenburg (2017) highlights some key points to focus on when considering the differences between green industrial policy and conventional industrial policy. Green industrial policy should focus on correcting market failures were there are negative environmental externalities. Were the social cost of negative environmental externalities are not taken into consideration (Or at least not too a high enough degree) by private actors. Green industrial policy needs to direct policy towards industry that helps alleviate these negative externalities like fossil fuel industries and towards renewable energy industries like Wind and solar power sectors. Market failure theory here is the main justification for their

perspective on the need for green industrial policy, but is correcting market failures enough when structuring a green industrial policy?

An important difference between Green and conventional industrial policy is that good and bad technologies can and should be identified regarding green industrial policy. As mentioned earlier, conventional industrial policy focuses on the importance of steering the economy towards the promising technological and market developments that can lead to high economic growth, and can hence be seen as value neutral. Green industrial policy however needs to take more of a targeted focus on specifying which technologies are "good" in the sense that they promote the more climate and sustainable friendly solution (Dani Rodrik & Tilman Altenburg, 2017).

Here we start getting a very noticeable distinction, if conventional industrial policy is more technology "neutral", and focuses on just the high economic impact sectors and technologies, green industrial policy is more concerned with technologies and sectors beneficial to the specific goal of orienting the economy towards a more sustainable direction, and hence less technologically neutral.

Urgency is another element that green industrial policy has to deal with to a larger extent than conventional industrial policy. Tipping points, and points of no return are important considerations to take into account when structuring green industrial policy. Time is off the essence, and policy to accomplish the energy transition needs to be ambitious enough in scope to be able to deliver results in a timely manner that ensures or increases the probability that we do not exceed the tipping points. This will almost certainly entail a certain amount of misallocation of resources and failed government subsidies and investments in risky projects. With the need to act with urgency however, this may have to be considered acceptable. Although policy needs to focus with a sense of urgency, the transition will not happen overnight, and the transition has to viewed through the lens of long-term goals, as well as shorter ones (Dani Rodrik & Tilman Altenburg, 2017).

Urgency being a central theme in my thesis, comes across as a particularly important focus for green industrial policy. Not only does the transition need to happen, but it needs to happen in a timeframe consistent with meeting our climate goals, and there is no way of ensuring this will by free market forces as we have seen due to the market failures occurring. This then, is one of the most important justifications for green industrial policy.

Another less intuitive but still important difference between conventional and green industrial policy is the importance of a global common. Generally, industrial policy is usually only interested in national consequences on industry and the potential positive externalities gained, like spill overs across firms and sectors, and avoiding negative externalities. However, in regard to global climate change, taking a more global approach to looking at positive externalities is also useful. Technological improvements made in one country will have positive externalities for the rest of the world as well, and this should be encouraged, rather than being looked upon as a net negative, as after all, the goal of green industrial policy is at its core to transition to a more sustainable economy (Dani Rodrik & Tilman Altenburg, 2017).

2.2.4 Uncertainty and coordination

Uncertainty from the private sector is another concern regarding Green industrial policy, as long-term confidence from investors in a consistent policy trajectory is important to ensure investments that may take long periods of time and rely on such a consistent policy trajectory. The government here then has an important role in trying to ensure a stable policy trajectory, and ensure that they are willing to stick to policy goals to calm potential investor fears of sudden changes in policy goals. This of course does not mean that policy does not need to be flexible, as changes in technologies and markets might open up new pathways which are important to be open too. (Dani Rodrik & Tilman Altenburg, 2017).

Policy coordination matters, the transition to a more environmentally friendly economy does encompass more than just changes to one industry or sector, several industries like transportation, energy and infrastructure for example all matter, and policy needs to understand these interrelated problems arising from different ends. Policy that changes the structure of the economy can also have significant impacts on different stakeholders. Changes in energy composition of a country can have a number of unintended consequences on elements such as land and food prices, and these potential problems should be taken into account and should arguably also be included into the policy structure (Dani Rodrik & Tilman Altenburg, 2017).

2.2.5 Conclusion

As we have seen, market failures like negative externalities are among the most important justifications for green industrial policy. Coordination failures and the gain from private

investments being lower than the gains the overall society gets from positive spillovers from renewable energy investments leads to lower levels of investments in renewable energy than are societally optimal. There are many similar elements between green and conventional industrial policy as well as environmental policy. They will all create certain structural changes to the economy, there are still important differences. Focus on environmental externalities, Urgency, choosing specific technologies that are climate friendly and a higher priority on the global common are noticeable differences between green and conventional industrial policy. A stable policy trajectory and sound policy coordination across many different industries and sectors are all crucial to a successful green industrial policy.

2.3 Economics of green industrial policy

2.3.1 Job creation and labor re allocation

In this part of the section, I will review literature on the economic implications for green industrial policy. This is important as understanding the larger macro and micro economic consequences will be necessary to keep in mind when designing the policies most fit for what are trying to achieve.

Green industrial policy as well as environmental policy in general which as we have seen, can be hard to separate or clearly distinguish as they will both have many relevant effects on labor markets. The main point of conventional industrial policy is to try to nurture and create industries with well-paying jobs for the people of said country. Workers in sectors and industries related to renewable energy is expected to rise overtime (Dani Rodrik & Tilman Altenburg, 2017). Green industrial policy here will also play an important role not just in the positive benefits it has for society regarding emission reductions, but also as a source of creating jobs within renewable energy sectors. At the same time, sectors and industries from more traditional fossil fuel sources could expect to see fewer workers over time in those sectors. The effects of Industrial policy in general, and Green industrial policy in particular in this case will often transcend just the direct effects it has on the particular sectors it targets. Spill overs from the increasing scale of the sectors targeted by industrial policy will lead to other businesses and potential industries emerging. This is because demand for inputs may lead to supply-chain businesses and sectors (Dani Rodrik & Tilman Altenburg, 2017).

From Michele Esposito et al (2017), a different chapter in the same publication as Dani Rodrik & Tilman Altenburg (2018), we can see that Similar effects can work in the opposite direction as well which is important to consider. Reduced demand from traditional fossil fuels will have similar negative spill-overs that can impact supply-chain firms to those sectors. A successful green industrial policy should then consider doing more than just implementing policies to strengthen the renewable energy sector and other important sectors for the green transition, key here is supporting labor market flexibility from traditional fossil fuel firms to renewable energy sectors. Supporting training systems to allow workers to adjust their skills to the new potential occupations as well as expanded educational opportunities regarding future green jobs are important examples (Michele Esposito et al., 2017). Avoiding potential political backlash as well as making some workers poorer as a consequence of displacement from fossil fuel jobs are hence key factors that should also go into the strategy of successful green industrial policy, and not only focusing on bolstering renewable energy sectors. The potential for green jobs certainly is there. The percentage increase in jobs categorized as Environmental goods and service sector jobs increased as much as over 50% in the EU from 2000-2012 (Michele Esposito et al., 2017). A majority of this increase came from producing renewable energy, particularly wind and solar power stations as well as installations for heat and energy savings (Michele Esposito et al., 2017). This bodes well for replacing existing fossil fuel-oriented jobs with jobs in RE as well as other green jobs.

2.3.2 conclusion

Although there are opportunities for creating many jobs in the renewable energy sector and in related spin-off sectors, there are also challenges with workers leaving sectors from traditional fossil fuels falling behind. The right labor market policies have to be thought about and implemented correctly to have as smooth of transition as possible for the people leaving these sectors to potentially move over to jobs in renewable energy or related spin-offs.

2.4 Principles and successes of green industrial policy

2.4.1 Principles

As we have seen, the role of industrial policy in general, and green industrial policy in particular when analyzing it from the viewpoint of transitioning to a greener and more renewable economy can help to alleviate some of these market failures thar arises from

coordination failures and general market failures regarding a lower level of socially optimal investment because of the returns of private investors being lower than that of the public returns (Rodrik & Altenburg, 2017). As noted by the authors, the goal of industrial policy in regulating and fixing these various market failures arising in regard to sustainability, is not to create a public planning regime were top-down decisions are made regarding production, rather the goal is to embed the market process into a general societal welfare perspective that leads to broad gains for the society as a whole, rather than just private interests.

3 principles of green industrial policy are highlighted by the authors as helpful to navigating the often-difficult process of how to engage in effective green industrial policy.

The first one being Embeddedness, which relates to the importance for the government and its agencies to create and maintain workable relationships with private industry. This is important because the government agencies that are implementing the policies need to have a strong understanding of the industry in questions, were the opportunities and challenges are, what potential bottlenecks can arrive and were the potential market failures are the most crucial. This is not a static process, but rather a continuing process of generating information about the industry and being flexible when conditions change. Collaboration here is key, not competition between the government and the private sector.

The second principle being discipline. This principle relates to the importance of maintaining a transparent and fair system. The potential problem of "regulatory capture" by the private sector should not be taken lightly, and maintaining transparency here is important. important. The focus of green industrial policy should always be to keep the general societal public interest in mind, and not particular corporate interests Consistent monitoring and evaluation criteria's here are important to make sure that for example subsidies are going to companies that can show progress in their goals. The government financial support should always be subject to re-evaluation and the potential to stop supporting companies that does not meet the benchmarks for success.

The last principle is accountability: This principle relates to the importance of the policymakers and various government agencies implementing the policies, needing to be held accountable. Auditing requirements and various reporting requirements here are important to make sure that policy implementers are held accountable.

2.4.2 Efficacy of green industrial policy

There are many strong arguments as we have seen for green industrial policy and public sector economic support to play a central role instead of leaving the transition to happen naturally to the free market, as this is unlikely to lead to the socially optimal levels of renewable energy investments needed. Whether or not Policy can speed up the transition, or if it can be effective at all is at the end of the day an empirical question, and that is where we will turn to next

A thesis Published by the university of East Anglia, investigates whether industrial policy can positively impact renewable energy innovation. It was found that RE policy and policy instruments had a positive and significant effect on RE innovation. The interactions between different instruments like demand-pull, technology push and systemic instruments were positive when they were analyzed by themselves. The coefficients for technology-pull instruments were larger than the ones for demand-pull which were again larger than the ones for systemic instruments. However, it was also found that not all instruments complement each other, and it's important for governments to design policy instruments that are synergetic with each other. (Pitelis, 2018.)

In the next chapter in the same thesis, further looking into specifically industrial policies effect on RE technologies. It finds that industrial policy instruments have a significant positive effect on RE technologies. This so especially in countries where intervention is higher in these markets. It is important to note that countries that have more experience with industrial policy and these targeted interventions show higher degrees of success in achieving its goals. Northern European countries with more experience with industrial policy than southern countries being the example here. This could have important implications insofar as the countries building up an early lead with successful industrial policy being ahead for a substantial period of time, while straggler countries with less experience and interventions potentially struggling to catch up (Pitelis, 2018). one limitation of the study as admitted by the author is using patents data as a proxy for innovation, which may only tell some of the story behind RE energy innovation.

From Niesten et al (2018), looking at the effects of RE energy policies on the Dutch wind energy sector, again finds similar positive effects from RE energy policies. Looking specifically at the effect of fixed subsidy feed-inn tariffs from 1996- 2006 we see again that this had a very positive impact on investments going into the wind energy sector. This seems to work through increased willingness to invest because of the reduced risk that comes from the government guaranteeing fixed prices over a significant period of time, hence getting rid

of the risk of potentially volatile prices that could make the investments unprofitable (Niesten et al., 2018). This policy of guaranteeing fixed prices was changed after 2006 (with lagged effects starting to show in 2008) to a tariff rate that would depend on the market price of electricity. This led to a relative fall of investments from the years prior that peaked in 2007. The reason for this fall in investments was that the change in the tariff rate to reflect changes in market prices, rather than a fixed guaranteed price set for a 10-year period led to increased risk for investors. Another important factor was a change in the subsidy scheme that led to more competition for subsidies among renewable energy technologies, favoring technologies that required lower subsidy rates.

In a paper by Mazzucato & Semieniuk (2018), they investigate different financial flows towards renewable energy between 2004-2014 to investigate which actors finance different technologies, and the risk factor of these (Which actors finances more risky/breakthrough investments). They find that the risk element to which renewable energy projects are financed differ significantly between public and private funders. Private actors tend to favor more less risky investments in general, while high risk investments tend to be favored by public financiers. This has implications in that certain technologies and markets that are underdeveloped could fail to take off if lack of public support is lacking, as these investments would often be considered riskier to make. They also find that high risk RE investments tend to be driven by very few actors, in contrast to less risky RE investments (Mazzucato & Semieniuk, 2018).

An important question often raised in regard to public investments is whether the private sector can be "crowded out" by public investments, meaning public investment soaks up funds that can be used by the private sector make investments. In a journal article by Deleidi et al (2020), analyzing data from 2004-2014 on various OECD countries looking at solar and wind RETs, they find that quite to the contrary perception that public sector investments crowd out private sector investments in renewable energy, public sector investments particular in combination with feed-inn tariffs has a positive impact on private investment. They also found that by far the contributor to increasing private investment was public investment in renewable energy, compared to any other policy. It's also interesting to consider that most of their investment data analyzed was under conditions were the RE technologies were not competitive on price with traditional fossil fuel-based energy resources, which fits well with the evolutionary economics perspective that government intervention can be effective at creating and shaping new markets (Deleidi et al., 2020). They conclude with the

importance for public investment in helping to stimulate private investment into renewable energy, and public investment in renewable energy should be seen as complimentary and helpful to private investment, rather than crowding out private investment

Time Is an important to consider. The longer the energy transition takes, more environmental damages occur, climate change may reduce the overall number of financial resources available as well as increases the amount of adaption measures needed. (Lamperti et al., 2019). Potential delays in the implementation of RE policies like subsidies, feed-inn tariffs and carbon taxes is then important to keep in mind as these will become more costly to the society to implement over time.

A journal article from MIT looking at a growth model with endogenous and technical change. They find that delays in implementation are costly. The faster and more impactful the policy response is, will reduce the overall costs by the policy implementations (Acemoglu et al., 2012). A faster and more impactful policy response should make what they refer to as the "slower growth face" shorter and less costly as well. They also find that subsidizing RE energy in combination with a carbon tax, significantly reduces the how high the carbon tax needs to be (Acemoglu et al., 2012). This is important as it has implications for the ramifications on consumers or a very high carbon tax.

2.4.3 Conclusion

Many important key takeaways from this section are worth noting. The relationship between the government agencies and the private sector needs to be strong, and checks and balances needs to be in place to ensure accountability and transparency. Overall Public policies targeted at RE and green industrial policies in particular have historically been successful at increasing the development and diffusion of RE technologies. If a transition is to be made in a time consistent manner it is important to take these lessons with us so we don't lose any time in setting up the renewable energy sectors for success.

2.5 The multi-level perspective theory on socio-technical transitions

2.5.1 Understanding socio-technical transitions

In this part I will review literature from the multi-level perspective (MLP) regarding socio-technical transitions. The MLP is a very useful analytical framework that can give a strong

foundation to understand some of the underlying mechanisms for why socio-technical transitions occur, and why they may not occur.

From Geels (2019), we get presented some useful theoretical concepts to understand socio-technical transitions. Innovation occurs differently between the existing systems and regimes which and niches. Innovation in existing systems and regimes is characterized by much more incremental progress as well as suffers from a number of different lock-in mechanisms leading to more path-dependency. Sunk costs in areas such as Infrastructure, factories and capabilities. This lock-in mechanisms creates vested interests over time that will be resistant to radical change, and hence will favor a more incremental innovation path. These however are not the only lock-in mechanisms that matter, political lock-in mechanisms are also very important. Regulations, standards and policy networks will also create an environment of lock-in mechanisms further leading to more incremental change.

Niches however are where radical innovation is more likely to occur. Niches are protected spaces where radical innovation is more sheltered from market pressures, and provides an environment where technology nurturing and learning can flourish. These niches often exist at the periphery of the existing regime, and often comprise of start-ups entrepreneurs and outside activists (Geels, 2019).

Both the niche and the existing systems and regime are influenced by the socio-technical landscape factors which encompass such developments as demographics, macro-economic growth and decline, politics and price shocks. The interplay of the niche, regime, and the socio-technical landscape factors are what leads to socio-technical transitions. Both the niche and landscape factors can put pressure on the existing regime, which can lead to a destabilization of regime elements, leading the way for niches to breakthrough.

This way of thinking about Innovation with a very sharp distinction between the niche and regime innovation however can be a bit simplistic. Does radical innovation occurring always mean that Niches must overtake the existing regime? (Geels, 2019), Addresses that this is not necessarily the case in the same article.

Geels & Schot (2007) Further elaborates on different transition pathways that can occur beyond the somewhat simplistic Niche outcompetes regime paradigm. Reconfiguration is a pathway where the relationship between niche actors and regime actors go beyond just the niche outcompeting the regime, and symbiosis can exist. On this pathway, regime actors are willing to adopt new technologies that are developed and introduced by niche level actors.

The transformation pathway can occur when landscape pressures put pressure on the regime before niche technology solutions are ready. This can lead to regime actors changing course and reorienting their innovation activities where a new regime grows out of the old one instead of being "dethroned" by a niche operating from the outside. (Geels & Schot, 2007).

2.5.2 Conclusion

Socio-technical transitions occur as a result of socio-technical landscape factors destabilizing the regime. This allows the niche that is responsible for more radical innovation, relative to the more stable innovation trajectory shown by the regime to potentially breakthrough. The niche may still not completely overtake the regime, as reconfiguration can also occur, where the regime adopts to the new landscape factors.

3 Methodology

3.1 Research questions

The main research questions I will attempt to answer in this thesis relate to the necessity, effectiveness and approach of green industrial policy and public sector intervention. This study is somewhat limited in scope by looking at Enova in Norway, a smaller rich economy that has strong institutional and economic capability to implement successful green industrial

policy over less wealthy and economically developed counties. Hence the generalizations from this study may not be applicable in every case.

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1. Is green industrial policy an effective tool to combat climate change by creating the necessary structural changes in the economy and energy markets?

2. If green industrial policy is effective, what is the trajectory of such policy?

3. Can a renewable energy transition happen without green industrial policy or state economic support in a timeframe consistent with meeting our climate goals?

3.2 Theoretical concepts

When deciding which theoretical concepts to use to structure my thesis to help me answer my research questions, there are some important factors to keep in mind. A multidisciplinary approach that can help as an analytical framework to analyze from both an economic and socio-technical transition approach is useful. The first one is a theoretical framework approach, that I will use is the multi-level perspective. The multi-level perspective utilizes elements from technology studies, evolutionary economics and neo-institutional theory among other disciplines to give a well-rounded multidisciplinary understanding of socio-technical transitions. (Geels, 2011).

The foundations of the multi-level perspective are based upon three different analytical levels, the niche, the socio-technical landscape and the socio-technical regime (Geels, 2011).

The niche

Niches can be understood as “protected spaces, where radical innovation is more enabled to succeed. Some examples of various protected spaces relating to the niche are R&D laboratories, which are often publicly funded, and certain niche small markets were the niche product offers certain qualities that consumers are willing to spend a premium on. The niche however is operating outside of the existing regime that it struggles to compete against.

Various lock-in mechanisms that the regime is characterized by, makes it more difficult for the niche to breakthrough and take over the regime, or become part of it (Geels, 2011).

The regime

The socio-technical regime can be thought off and understood, as the semi coherent rules that guides and coordinates various activities by the actors in the socio-technical system, that help reproduce the existing rules and structures that are present in the socio-technical system. These rules and structures fundamentally serve as a stability mechanism to these existing structures. Some examples are shared rules and beliefs among the actors, as well as existing capabilities, all acting as lock-in mechanisms creating the stable trajectory of the existing socio-technical system. Under these conditions innovation tend to occur more incrementally that in niches, hence regime level innovation have a far more stable trajectory compared to the more radical innovation that can occur from niches (Geels, 2011)

The socio-technical landscape

The socio-technical landscape we can understand as the broader context that will influence the socio-technical system, and hence the niche and regime levels within. Population growth, macroeconomic developments, political factors and economic growth are all examples of various landscape developments that the niche and regime are impacted by. These landscape factors are considered to be out of the control of niche and regime actors, at least in the short run. These landscape conditions among others can have major transformative impact on the socio-technical system by potentially putting pressure on the existing socio-technical regime. If the socio-technical regime fell under enough pressure from landscape factors, the niche could eventually breakthrough assuming the right conditions (Geels, 2011).

Economic concepts

Various concepts from economics covered in the literature review will be useful to guide me as a focus for analyzing the data gathered and try to answer the research questions. Market failure, covered in relation to climate change and green industrial policy by Dani Rodrik & Tilman Altenburg (2017) will be helpful to understand as one of the central justifications for green industrial policy. Mission-oriented policy by Mazzucato (2018) as the basis for how

such a policy should be envisioned. “Patient capital” as laid out by Mazzucato & Semieniuk (2018) to understand how public investments differ from private investments in terms of which projects gets financed. The concept of public investments “crowding out” private investments dealt with by Deleidi et al (2020). Finally, the concept of “market making” or “directional failure” as opposed to just fixing markets as a result of market failures by Mazzucato (2018).

In this thesis I will use the MLP theory and the economic concepts covered in this methodology part as loose theoretical concept and framework approach to put into context the importance of public involvement and green industrial policy in the economy and energy markets, rather than using them as an all-encompassing theory.

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4. Methods

4.1 Quantitative and qualitative methods

4.1.1 Quantitative methods

One of the common regarded significant distinctions between qualitative and quantitative methods are that quantitative methods are more concerned with counting and measuring the various different aspects relating to social phenomena (Blaikie & Priest, 2019). Some researchers however regard this distinction as not very useful (Norman Blaikie & Jan Priest, 2019). There are various different types of quantitative methods that can be used, some of these include questionnaires, structured observations, structured interviews and content analysis of documents. Structured interviews and questionnaires however are the research instruments most commonly used (Blaikie & Priest, 2019). Structured interviews and questionnaires have many commonalities between them, but there is still a very important difference between them, which is how they are prepared. In contrast to structured interviews, a questionnaire should be prepared in a way where the respondents should not need any outside help or assistance, only the built-in instructions should be enough. Structured interviews however work differently, as the interviewer will provide more clear direct instructions towards the respondents (Blaikie & Priest, 2019).

Qualitative methods 4.1.2

Data in qualitative methods is often regarded and characterized by generated and collected (Blaikie & Priest, 2019) One of the most common qualitative methods used by researchers is the participant observation method. This is often regarded as the standard regarding qualitative methods, and is commonly referred to as field research. Semi structured interviews as well as unstructured interviews are methods used often to gather data in qualitative methods. Observations are also usually done in group settings rather than just on an individual participant (Blaikie & Priest, 2019). Group observations are not the only way however to study groups. Group interviews as well as discussions commonly referred to as focus groups are becoming an increasingly popular data collection method in qualitative methods (Blaikie & Priest, 2019)

Case study on Enova 4.1.3

Case study in this thesis I will take Wind and solar power in Norway as the standpoint, and research specifically what Enova, a public enterprise working to reduce GHG emission In Norway has done and continues to do, to promote Wind and solar. The reason I choose Enova

as a case study is that they were crucial to fast tracking the Norwegian wind energy sector In the early 2000s (Enova, 2014), and are also trying to promote both solar and wind power In Norway. As my main research question revolves around what the government can do to speed up the renewable energy transition, what tools are most useful and what is the trajectory of such green industrial policy/public intervention. Enova serve as a very interesting case for my thesis for their central role in promoting renewable energy solutions in Norway as a public sector enterprise. Semi Structured interviews will be conducted with Enova as well as with another central actor within solar, to try to gain further insight into their history with Renewable energy policy, success and failures, what specific tools they consider to be more effective as well as further plans for RE development.

4.2 Data collection

From Blaikie & Priest (2019), we have three different forms of data. Primary data, which is data generated form the researcher, secondary data, which is generated by another researcher and tertiary data, which is analyzed by a different researcher than yourself. In this thesis I will be relying on all of these different data forms. Primary data will be generated threw semi-structured interviews from representatives from Enova and Energiklyngen. Secondary and tertiary data will generated from analyzing reports and publications as well as some published literature. The interviews lasted from 40-50 minutes each and were not recorded, I instead relied on carefully writing down notes for each of the questions and topics that were covered. (Blaikie & Priest, 2019)

4.3 Respondent selection

When deciding which respondents, I were going to reach out too for interviews I had to consider carefully who too reach out too, as I was trying to achieve more in-depth interviews with a few respondents in a semi-structured interview setting, rather than send out a survey to a large number of respondents. This is because to try to answer my research questions talking to a few key actors would be more informative for me. As my focus is on Enova's role in promoting solar and wind energy in Norway, reaching out to a representative from them was the most important one. I also wanted to contrast their perspective with a more business-oriented cluster that cooperated with them to get their perspective as well. This ended up being Solenergiklyngen, as they are very central for promoting solar energy solutions In Norway, where I was able to schedule an interview with a key spokesperson.

4.4 Interview guide

In preparation for the interviews conducted I made an interview guide to assist me with the topics and sub topics that I was planning to cover in the interview. As my interview style was of the semi-structured nature, the goal was not to have very rigid questions that I was going to get very straightforward answers from, rather to create a discussion around the questions and get as much depth out of every question as possible. I purposefully did not have too many questions in the interview guide as I figured it would be more useful to spend more time on each question to fully delve into the details of the different topics, rather than to ask a very high quantity of question with less depth. In other words, quality discussion around the questions rather than a high quantity of questions. The purpose of the interview guide was also not for the questions I had planned to be very rigid in getting very specific answers to the questions, but rather as a guide to the different topics.

4.5 Document analysis

In order to contrast the perspectives given by Enova and Solenergiklyngen it is important to conduct a document analysis from reports, publications and press-statements regarding Enova's role in promoting the renewable energy transition and green industrial policy. Yearly reports from Enova that are available to the public were used. Other relevant publications on the subject published by Enova's as well as press statements from Enova and others are also used for document analysis. Especially the yearly reports and press statements by Enova on projects such as Hywind Tampen have been of particular importance.

4.6.1 Reliability

Reliability is the possibility of a research instrument to consistently measure the different constructs or variables (Haber & Wood, 2016). The reliability of a research instrument is then the ability of the research instrument to yield the same results consistently with repeated measures. Accuracy, stability, homogeneity, precision, Equivalence and consistency are of central concerns to the concept of reliability. By using the same or similar instruments on several different occasions we should see similar results if the instrument is reliable.

4.6.2 Validity

The concept of validity encompasses the extent to which an instrument can properly measure different attributes of a concept accurately (Haber & Wood, 2016). A valid research instrument will accurately reflect the concept that is being measured. A measure can be reliable yet still not valid, however a valid instrument is always reliable. As an example, if a researcher wanted to measure anxiety in patients by measuring the body temperature of different patients, highly accurate, precise and consistent temperature measurements, but that does not guarantee that temperature is valid indicator of anxiety. The reason however that a valid instrument must always be reliable is that an instrument cannot validly measure the different attributes or a a singular attribute if it is not consistent and accurate (Haber & Wood, 2016).

5. Empirical analysis: Document analysis

Findings from document analysis

In this section I will look into the history, success future projects from Enova in their role to speed up the renewable energy transition. I will also analyze some tertiary data on Norway and Sweden's contrasting path, as this is a very interesting case on how policy impacted two very similar countries in their respective renewable energy trajectory.

5.1 Context of Enova

Enova is a state-owned enterprise that where the responsibility lies under the climate and environmental department. Earlier it was under the Oil and energy department (Energifaktanorge.no, 2018). Enova is responsible for both economic support as well as counselling and guidance to private market actors to help facilitate projects that are environmentally beneficial (Enova, 2021). The main goal for Enova is to contribute to reduce climate emissions as well as strengthen the Norwegian energy supply (Energifaktanorge.no, 2018). In order to achieve this Enova, uses and develops tools and methods to create long lasting and meaningful structural change in the markets of relevance. A major focus is on increasing the innovative capacity of climate friendly technologies to achieve the necessary structural changes. (Energifaktanorge.no, 2018). Enova has great flexibility in achieving this, being able to use budgets in different time periods in order to maximize the potential of the projects (Enova, 2019).

Enova Focuses specifically on the early-phase technological development stage, and late-stage technological development stage (Enova, 2021). Different programs are used to help these technologies at the different stages, as what is important at various stages differ. Early on its important reduce costs for the technology and reduce the risk factor, as these are major bottlenecks early on. As the technology matures, and costs improve as well as the risk associated with the technology, increasing the market share of the technology and diffusion become the important next step. Here Enova also plays an important role in developing solutions to the barriers to entry for these technologies to diffuse into the market, and hence create the structural change needed to contribute to reducing the climate emissions. Piloting projects, demonstration projects and full-scale introduction of climate and sustainable energy technologies are examples of methods used by Enova (Energifaktanorge.no, 2018)

5.2 Policy tools and their purpose by Enova

The primary economic tools utilized by Enova in trying to achieve their goals for reducing greenhouse emissions by helping to create structural changes in the economy and energy system is direct financing and in some circumstances loans (Enova, 2021). By doing this, Enova will help reduce the uncertainty and risk associated with costs from both the demand and supply side (Enova, 2021). The financial support from Enova will also reduce the cost of the investments. By reducing the risk and lowering the costs of potential promising energy and climate technologies, these technologies have a greater chance to get out of the early-stage development stage, and mature into viable solutions on the market stage (Enova, 2021).

Sometimes barriers may not be cost related and other tools may be more useful than strictly economic ones. Information barriers are an example of that, and information and advising are another tool utilized by Enova. Enova extensive knowledge they have built up of the different markets gives them strong competence in being able to give advice and guidance for different projects. This can either as simple as answer phone call questions if dealing with a smaller company on a smaller project, or working tighter with the market actors when dealing with a more substantial project, with a larger company (Enova, 2021).

5.3 A Brief history of Enova's role in promoting wind energy in Norway

As of early 2022, there are 64 wind farms operating in Norway. The current installed capacity is 4650 MW as of early 2022, Which roughly equals 15.4 TWh in 1 year (Energifaktanorge.no, 2022). Wind energy of course greatly depends on weather conditions, with quite significant fluctuations leading to significant changes in output. Although the Norwegian available wind resources are quite significant in terms of potential, the industry still had a slow start picking up, only really around 2010 starting to show real signs of maturing (Enova, 2014. As the realization that hydropower, that has been an incredibly important renewable energy resource for Norway was not unlimited, other considerations for renewable energy had to be considered. Wind energy was at the top of the list as it was the RE with the largest capacity potential for Norway, as well as the notable promising technological improvements in wind energy. Significant improvements in wind technology made in larger industrialized countries like Germany, the US, UK and Spain was critical to stimulate

technological development in the wind industry which Norway and other latecomers could take benefit from. Developing the supplier industry was also something these countries focused on to develop a well-rounded industry (Enova, 2014). All thought this high demand globally for more wind energy leading up to 2008 led improvements in technological innovation for the industry, it also created upward pressure on prices. This in combination with other factors like limited public support and increasing prices for material inputs, led to relatively few wind power projects between the period 1999-2005 (Enova, 2014). From 2008 onwards, Enova, a state-owned enterprise started expanding support to the wind energy in Norway by launching a new wind power support program. Enova was not new to assisting the wind energy economically, the first sizable wind development in Norway in 2002 in Smøla and Havøygalven was granted economic support from Enova, but further expansions of support was needed for the wind energy sector to help it reach its potential. Between the years of 2008-2010 the public support granted by Enova led to an expansion in wind power by just under 1TWh. (Enova, 2014). Although the ambitious target of 3TWh was not reached, this support was crucial in kicking off the start of the Norwegian wind energy sector. By helping to finance the wind energy sector, considerable progress was now in reach. Learning by doing and improved experiences in the sector to a significant extent by the economic help granted by Enova would set the sector off for future success. A sign of this was the considerable better progress that was able to be made later on in terms of reaching their desired targets for wind development. (Enova, 2014)

Whether or not the wind sector would eventually have taken off without the help of Enova is impossible to know for sure as there is no alternative timeline where this did not happen, however looking at the steady progress that started to significantly pick up with Enova's involvement it would be safe to say it helped speed up the development of the Norwegian wind energy sector quite significantly. Not only has learning by doing helped significantly the wind developers themselves by improving and learning over time, but financial institutions have learned over time to understand the risk of projects. Public officials dealing with concessions have also build up competence (Enova, 2014). Here the key is that it takes time for an industry or sector to build up capability over time. In the crucial early days of a sectors lifespan public support that helps stabilize it and slowly improve and learn over time can have significant long-term implications. An important notable change for the Norwegian wind energy market was the introduction of El certificates. This was Introduced in 2011 and had noticeable impact on how the process for future wind development would occur. El

certificates are what we would consider a “technology neutral” solution to reducing emissions. The certificates are meant as a support scheme for RE development. The RE power producers supplying RE puts this certificate into the price of electricity, basically making the consumers financing the RE Producers. (Elsertifikater - NVE, n.d.). The key here is that after the introduction of the El certificates, there were no longer any official specific goals related only to win development in Norway. The goal became a broader focus on developing RE resources in general. This of course is by no means a bad thing in the sense that a broader focus on RE technologies can lead to more pathways to success. However as pointed out by Enova, the future of the Norwegian wind energy sector could become more hinged on the framework conditions of the certificate market (Enova ,2014).

5.4 Floating wind power

Floating wind power is a promising renewable energy technology as identified by Enova. There are several circumstances that need to be taken into account when understanding the complications of floating wind power. Components delivered by different suppliers needs to be compatible with each other and consistent with different place dependent conditions (Enova, 2021). Other conditions that go beyond wind conditions that is always relevant forregular wind power are factors like wave height, depth and bottom conditions (Enova, 2021). Major cost reductions to make this technology competitive are still necessary moving forward. The floating foundations, operational and maintenance and flexibility are important areas where major cost reductions are possible. The good news for Norway in this regard, is that Norwegian suppliers and the Norwegian oil and gas sector are world leading in many of these areas setting it up as a very strong foundation for success in floating wind power. Even though there are still many cost barriers present for this technology, improving cost conditions are expected to potentially be quite fast as demonstrations and improved scaling will significantly help here (Enova, 2021).

Identifying floating wind power as a promising renewable energy technology for the renewable energy transition is not the only positive impact however. Because Norway already has such a strong foundation in this area relating to the supplier industry as well as the oil and gas sector, many potential opportunities for market expansion and economic growth are also apparent. Potential for exports and further expansion in the supplier industry are other positive ramification of aiming for this technology for Norway. In fact, assuming the best-case

scenario for Norway in this regard, it could potentially capture as much as 20% of the global market share in the building of floating wind energy (Enova, 2021).

A technology like this however is a good example of a niche technology that on its own even with potential may not be able to fully mature and reach the market relevancy ideal for a renewable energy transition without public sector support. Economic and policy tools here will be crucial to make increase the likelihood this technology matures. One could argue of course that it would develop naturally given enough time, but we are interested here in making the renewable energy transition in a timely manner consistent with our climate goals, and that's where green industrial policy and public sector support is so important. We will now take a look at the specific cases of Hywind demo and Hywind tampen where Enova where important in making sure these projects could materialize.

5.4.1 Hywind-demo

Around 2005, new sources of electricity production became a contested topic in Stortinget (The Norwegian parliament) (Normann, 2015). Wind energy was a potential solution to this problem. Many significant energy companies like Lyse, Statkraft and shell, combined with the research council of Norway invested 1.4 million Euros in a research project to help further develop off-shore wind technology (Normann, 2015). Statoil (Today Equinor) also at the same time was working on its own floating turbine which was named Hywind. Here Enova was quite important in their support for Statoils efforts to conduct the world's first demonstration of the full-scale floating turbine. In 2007 Enova supported Statoil with 7.5 million euros.

The importance of the early-stage economic support for projects with low technological maturity can be crucial for these technologies to be able to mature and take off as we have seen from the literature review. Although there was some private capital interest in floating off-shore wind technology, private capital often isn't enough and tends to be more risk averse as we saw from Mazzucato & Semieniuk (2018 to an optimal levels of investments from a societal perspective. Here Enova played an important role in the early-stage demonstration phase to facilitate this to happen. If Economic support by public actors is not given, like in this scenario, the risk for promising future RE technologies not fully maturing will lead to us having less pathways to a renewable energy transition, and by granting uncertain technology projects economic support the chance of success will be higher.

5.4.2 Hywind tampen

Hywind Tampen is a project that encompasses the establishment of a floating offshore wind farm. 11 floating wind turbines each with off 8 MW. The purpose of the project is to replace parts of the existing power generation on Gullfaks A and Snorre A (Enova, 2019). Floating offshore wind as it stands currently is still in a niche state of technology development and lacks technological maturity and cost competitiveness. It is a however a very promising technological solution to climate change. Off shore wind energy in Norway has enormous potential, and Enova has chosen to support Hywind Tampen with very substantial economic support. Enova has chosen to grant 2.3 billion NOK to this project, which is the highest amount they have supported any project with in history. The reason for this is that Enova views floating offshore wind as a promising niche that can help with the transition to a more renewable and clean energy-based economy (Enova, 2019) It's interesting to note that here Enova's views their reason for supporting the project not too directly reduce greenhouse emissions but to help commercialize this technology. Enova is being supporting the transition of the energy systems and economy to a more renewable and clean energy future which is consistent with the interview I conducted with an Enova representative where he stated they view the role of Enova as more of supporter of structural changes and transitioning the economy and energy systems in a renewable and clean direction.

As an emerging technology, the importance of economic support as we have seen previously can be very important for making breakthroughs in time. Enova's conclusion after reviewing the economics of the project is that without Enova support, the project would not simply not be realized. Over time this might change without public or Enova support, but time is off the essence for the energy transition, and here Enova plays an important role in making sure this project goes through, hence capability, knowledge and experience can be built for future similar projects. Cost-competitiveness as we have seen is one of the major barriers to technology deployment and diffusion and supporting projects of this magnitude is crucial if this technology is to mature in a timely manner. Pål Eitrheim, the executive vice president of the new energy solutions for Equinor mentions in this Enova press statement that here the public authorities show a willingness to support Norwegian floating offshore wind

development, and as a result, they have decided to move further with realizing this project (Enova, 2019).

The Hywind Tampen project is a great example of the role and purpose green industrial policy and government intervention. It is an emerging technology niche that still struggles with economic cost and technology maturity barriers holding it back currently. Without Enova's help as we saw from the press statement, this project most likely would not have been set in the works, meaning Norway would have lost out on a very significant opportunity to build up capabilities and the subsequent learning by doing effects leading to improving cost structures for the technology. To fully realize the wind power potential of Norway floating off shore wind can play a major role and if this project would not take place a very promising solution to help speed up the renewable energy transition could be set back a very long time. With Enova however willing to take a substantial risk and give very substantial (as we saw their largest ever economic support) economic support this project will now take place hopefully leading to the technology maturing, falling costs and increasing economics of scale. There is very little time to wait if we want to reach the climate goals and hoping that the technology takes off by itself overtime, which is certainly no guarantee is not a luxury we have.

5.5 Success stories from Enova

District heating is a promising part of the future energy infrastructure that allows for both production distribution and storage of from several different sources effectively (Enova 2019). It has the potential to cover as much as 40% of the demand for heating on the coldest days of the year, this of course is when the demand for heating is the most significant. District heating can use several different sources of energy, the most relevant for this thesis is solar energy. District heating is characterized by having very high establishment investment costs with fairly low marginal costs. For a private district heating company these risks and high costs associating with developing district can make it very difficult to start such an endeavor. As we have also seen from the literature review on patient capital, private investors can often shy away from projects that are riskier and may have longer time horizons. Enova here played an important role since 2001 to help finance the establishments over district heating systems. From 2002 Enova has contributed with 3.73 billion NOK to 566 district heating projects. Over time as district heating became more cost competitive the trend is that more and more

district heating projects happen without any state support and Enova no longer considers it necessary to support further expansions of the district heating distribution systems.

Solar power initiatives

Solar energy is the fastest growing renewable energy technology today globally, seeing rapid cost declines the last few years (Enova, 2021). As this occurs, the focus is also starting to shift towards a more sustainable production of solar panels, rather than just a focus on the prize. The process industry in Norway for solar panels has strong potential and is growing more ambitious, especially regarding components and materials used in solar panels (Enova, 2021). Here Enova has played an important role in helping this sector with their emerging technologies. Between the period 2013-2019, as much as 489 million NOK has been granted to the industry, this comes both from loans helping mitigate risks and higher financial costs from having to take out loans in the financial markets or from banks, as well as direct financial funding (Enova, 2021).

Examples of successful business in the industry that are developing cutting edge solutions are REC solar energy, Norsun and Norwegian cystals. These companies, among others in Norway are technologically world leading, leading to a great amount of potential for Norwegian companies to make a strong impact regarding cost competitiveness and sustainable processes for the component and material part of solar panels.

Here we can see Enova recognizing the potential of a sector with great potential for both reducing emissions by increasing the capacity of solar energy components, and focusing on the projects where the technologies are trying to produce the components and materials at the lower emissions than other projects. The word that keeps repeating in this part of the yearly report is “risk”. Enova clearly recognizes that this is a technology that is still maturing, and hence will be viewed as riskier by other investors. Enova plays a very important role here in speeding up the advancement of these technologies by providing economic support both thew loans and direct financing leading to these technologies potentially maturing faster, as riskier and longer term investments as we have seen from the work from Mazzucato & Semieinuk (2018) often is shied away from by private investors.

5.6 The role of public sector support for the divergence between Norway and Sweden in the trajectory of renewable energy

Even thou as we have seen there are many success stories from Enova regarding their economic support for renewable energy initiatives, an interesting question and relevant comparison can be made between Norway and its neighbor Sweden, two fairly equal countries in many ways. Yet, quite divergent pathways regarding their respective trajectories when it comes to the development and diffusion of various renewable energy technologies. The reason I have included this comparison is to try to illustrate how impactful public support and the necessary political willingness for that too occur are.

From (Ydersbond, 2020), we can see an interesting comparison with Sweden how renewable energy resource development and diffusion has developed from 1960-2015. As Norway has historically had great access to hydropower as a renewable energy resource, the political will to press for more bold initiatives for renewable energy expansion outside of hydropower were significantly more limited that in their neighbor country Sweden. Sweden did not have quite the same hydropower resource potential as Norway and hence the political will to increase public support schemes and strategies for renewable energy development were much higher. It's important to note as laid out in the report, Sweden did not have superior foundations for many of these renewable energy technologies like wind energy, Quite the contrary, conditions for wind energy development are generally more favorable in Norway than they are in Sweden (Ydersbond, 2020). The main defining factors were a stronger political will and effort into R&D, public support schemes and more friendly regulatory environment for renewable energy technologies like wind and solar. This is interesting as it highlights the fact that even with better overall wind conditions in Norway, public policy, both from a more green industrial policy framework, and a regulatory framework in Sweden, were more important for the wind energy sector.

Another important element is the various lock-in mechanisms that also hampered a more diversified renewable energy mix in Norway contra Sweden. Physical infrastructure, intellectual capacity and investments into the fossil fuel industry act as lock-in mechanisms that can stop political willingness to support economic initiatives to support renewable energy solutions. This was significantly less the case in Sweden (Ydersbond, 2020). As we have seen from MLP theory, these lock-in mechanisms will favor the existing regime and system in

place making it difficult for newer niche renewable energy technologies to mature to the extent they need.

6. Empirical analysis: Interview section

6.1.1 Market failure and Enova's role and impacts on the markets.

Through my Interview with an representative from Enova, I was able to gather a lot of interesting information relating to my research questions. This part of the section I will present and analyze my findings from the interview regarding Enova's justification for its role in the market and the impacts on the markets it has had

As expected for reasons explored in the literature review, Enova regards itself to have a justifiable and important role to correct many market failures. Lacking incentives for businesses to internalize their costs internally, the value of R&D being greater for society as a whole than for the enterprise conducting the research and development. The building up of local value chains could be significantly improved and accelerated with Enova's Help. The importance of public "niche" support early on to help the technology or project mature past the early stage also is an important driver for Enova's existence. Market failures although not the only reason for Enova's existence, is the most important, and market failure theory of course is central to the need for government intervention and industrial policy supporting the Idea that the markets cannot simply be left to themselves especially when dealing with something as important as climate change, and the need to combat this with a renewable energy transition.

The interviewee also mentioned that although such measures as carbon taxes and quotas can be important means to achieve a renewable energy transition, they will not be enough and have their own problems. Carbon taxes can have substantial economic negative costs to society and quotas by themselves will not be enough to stimulate the necessary investments and structural change to achieve the renewable energy transition in a timely manner. Here we can see the major reason for the purpose of public and state agencies like Enova actively intervening in markets with financial support, in order to foster a transition to a more renewable energy economy, correcting market failures and early niche support is vital for achieving this in a timely manner. We saw from Gross et al (2012) that the RE industry prefers targeted policies, especially early on over policies like carbon taxes, as risk is a substantial bottleneck for them.

Enova's role in supporting the early wind power markets were substantial as showcased by the backstory to this section. Problems relating to price developments early on where major reasons for the slow take off of this sector even with Norway's substantial wind resources prior to Enova support. It was noted in the interview that beyond early support there was also important reasons to continue this support beyond the early stages to ensure economics of scale effects could take place to impact the economics of wind energy positively. Here we can see Enova following through with long patient capital support for the sector ensuring it would not only take off, but also mature into an economically competitive sector. Eventually as the sector developed green certificates, that did become the standard as a policy tool for the sector.

We can clearly here see the effect of Enova's role starting to support the wind energy sector in the early stage to ensure it was capable of taking off, and developing economies of scale, then later on phasing out a bit as the sector was more mature in Norway, and another policy tool could take its place at the later stage of development. Enova was also important in funding Hywind demo an offshore wind energy project and later Hywind Tampen, which was mentioned in more detail in the document analysis part. It is very clear that Enova's impact on the markets have been quite substantial in Norway and continue to demonstrate the effectiveness of public economic support as an effective tool for green industrial policy.

Regarding The specific policy or economic tools that Enova considers to be the most effective, the interviewee was very clear are very contextual and depends on what the bottlenecks and barriers are. Investment support and subsidies are effective tools if cost barriers are the major barrier but problems can also be related to lack of information and here support for mapping out areas for example will be the better solution. This may be obvious but it has important implications for how to do effective green industrial policy. The important of policy and economic tool flexibility to deal with different bottlenecks will be crucial to deal with different barriers regarding supporting the niches and technology projects needed to ensure the renewable energy transition happens in a timely manner.

One of the things that I was most interested about when starting the research for this thesis was how would an alternative timeline looked for wind energy In Norway if Enova or other means of public support had not been available to the sector? Here of course the interviewee has a hard time answering the question as there is obviously no way of knowing exactly how an alternative timeline would have looked, but what is for sure it would have been a lot more uncertain, as the sector did not take off until Enova did support it, it may have developed

eventually anyway but there is simply no way of knowing this for sure. What can at least be said with some certainty is that a central concern of this thesis is the need for urgency in the energy transition, and without Enova or other means Green industrial policy, the wind energy sector would not have matured as fast as it did and may not have developed at all.

6.1.2 Policy tools, bottlenecks and conflict with the market

Potential problems and bottlenecks for green industrial policy when dealing with market actors has to be of similar concern as too which economic and policy tools are most effective at dealing with different problems. Enova in general does not encounter a lot of problems when working with actors in the early and late stage of project development, however a common problem is the dilemma that applicants want as much economic support as possible while Enova ideally will want to spend as little as needed for the project to be successful. This also ties into the problem of how long Enova should support the project. We have seen in the literature review that public support should be something that helps a technology or project niche early and throughout the development until the technology can become mature. However, after this the technology has to be able to stand on its own feet and here it is a concern for Enova when exactly this is, and the need to stop support when the technology is mature. If economic support still continues after this this could simply lead to rising prices for consumers which is of course not what green industrial policy is trying to achieve. At this stage of technology development other policy tools like green certificates, taxes and fees may become more effective at reducing greenhouse emissions as the structural changes and technological developments in niche markets already occurred.

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6.1.3 Green industrial policy, directional failure and patient capital

In this part I will present my findings from the interview and analyze whether Enova is and considers itself a part of a Norwegian green industrial policy, as well whether or not Enova plays a role in fixing directional failures. Enova's part in being a source of patient capital for renewable energy sectors that needs it will also be covered.

Enova certainly considers itself as part of a Norwegian green industrial policy as the goal and main vision of Enova as mentioned earlier is to create structural changes in the economy leading to a more renewable energy mix and greener economy. There are some important caveats of course, Political decisions do not lay with Enova and need to be taken by the politicians themselves on sound scientific ground. The difference between climate policy and green industrial policy can be cloudy, as we saw in the literature review, although Enova certainly fits both, the main focus Enova has on creating structural changes in the economy through targeted financial support certainly places it very firmly in the industrial policy category, and as these structural changes are related to moving towards a greener more renewable economy we can definitely say it puts It into the category of green industrial policy. Some aspects of industrial policy like exports however are not of significant concern for Enova.

Going beyond the market failure theory into the idea of "steering" markets as we have seen in the literature review, in order to make the renewable energy transition in a timely manner. The interviewee had not necessarily thought about Enova's role in this way, but concluded that as Enova's role is to create solutions and help actors move in a certain direction that favors structural change in the energy markets and systems to a more renewable friendly direction, this could certainly be considered part of Enova's role

Enova also serves an important role in signaling to the market that they are willing to support projects economically to mobilize the market when the market is ready to make the investments. Here Enova serves as an important risk mitigating actor, as with Enova's support many projects. Here Enova acts as an instrument of "patient capital" being willing to support potentially risky projects with long term horizons as we have seen from the theory and empirical evidence by Mazzucato & Semieniuk (2018),that private investors often are more hesitant to make.

Regarding whether or not Enova considers itself part of a green industrial policy strategy, the interviewee noted that Enova certainly is part of a Norwegian green industrial policy actor. It

is a central actor that promotes structural change in the economy and energy mix towards a greener and more renewable energy solutions. By utilizing various economic tools depending on the specific context Enova can impact this structural change and help speed up the renewable energy transition. By taking this role as a central actor helping to create structural change in the energy mix, It will steer markets in a certain direction that is positive for the wider societal goals and resembles an example of a clear mission-oriented policy as laid out by Robinson & Mazzucato (2018) in the literature review.

6.1.4 Lessons and future outlook for Enova

One of the major things Enova has come to realize over the years is that the main thing they are responsible for and can meaningfully contribute too are the Structural changes that the projects financed by Enova are contributing too. Enova cannot by themselves create massive reductions in emissions, but its role is through supporting projects in renewable energy and other clean energy technologies and projects changing the energy markets and systems. Another key focus that Enova has found over the years too be very crucial the cost structures. In order for these structural changes in the Energy system to not have very high economic costs to society, costs have to fall considerably, and supporting projects and technologies that are promising in this aspect is crucial. This realization is interesting as it strikes at the core of the importance of green industrial policy, targeted support and intervention too allow niche renewable energy technologies and projects to develop and mature being the way they can indirectly contribute to reducing emissions.

Finally, Enova is looking to continue in the future economically supporting projects and technologies in the early and late phase developments. They are always open for new policy tools if there are promising ones available. Focus on more digitization and automation is also a major focus for Enova moving forward as these can improve the effectiveness and speed of the procedures for Enova going forward.

The next part of the interview section is the empirical analysis part of my Interview an representative from Solenergiklyngen. Here I focused on questions related to Solenergiklyngens role in promoting Solar energy in Norway as well as their role with Enova and their general view on the importance for public sector support for solar energy.

6.2. Interview with Solenergiklyngen

In this part I will present and analyze my findings from an interview with an representative from Solenergiklyngen. Solenergiklyngen is a business cluster encompassing many different partners with the main purpose and vision to promote solar power solutions in Norway and Internationally. Solenergiklygen also gets financial support from the Norwegian state. In the first part of this section, I will present a little bit of information about Solenergiklygens recent endeavors to give some context about them. Then I will present and analyze what some of the major bottlenecks are regarding speeding up solar energy deployment in Norway from their perspective. Then I will present and analyze their view on their relationship with Enova and their thoughts on public support for solar energy. Finally, I will present and analyze Solenergiklyngens views on the importance of patient capital and how an alternative timeline where public support for solar energy in Norway did not exist.

6.2.1 Solenergiklygen recent endeavors and successes

A recent promising niche showing signs of success is floating solar energy. The early positioning projects were helped significantly financially by Innovasjon Norge, which is a state agent working to improve the business environment in the Norway. On the area of floating solar Norway had strong comparative advantages and high competence and capabilities. The technology is still in an early and pilot stage but has shown promise already.

Solenergiklyngen also traveled to Jordan responsible for the renewable program, as Jordan as been interested in utilizing more of their renewable energy resources. However, they were

working within fairly strict limits here as Jordan has long term contracts with other fossil fuel energy providers complicating any immediate plans, however several companies were able to establish some Jordanian customers including the refugee help according to the interviewee.

6.2.2 Bottlenecks for solar energy in Norway

It was clear from the interview, that one of the major problems is related to lack of knowledge about solar energy in Norway. It is often viewed as less important that it is, as well as having less potential that it has. The interviewee went as far as saying this lack of knowledge is the most important bottleneck holding solar energy back, as significantly more research as well as economic support could significantly improve the situation. The fact that solar has difference in distribution (often more decentralized) is a contributing factor to this. If solar in Norway is not taken as seriously as other renewable energy alternatives, especially if this is based on unfounded misconceptions on the potential for solar energy in Norway, it is difficult to see how solar could ever get enough public support to truly realize its potential. We saw from Ydersbond (2020) that political willingness along with the necessary policies were the defining factors for Sweden's success relative to Norway in developing non hydro power RE technologies, and with lack of knowledge around the potential of solar, that political willingness may not be there. Even though solar could overtime still become a more significant part of the Norwegian energy mix, this is as we have seen earlier unlikely to happen in a timeframe that is consistent with transitioning to a more renewable based energy mix in a timely manner to reach our climate goals.

Parts of the solar power market is also very sensitive to regulations and incentives. This is especially true for the solar panel market where price signals and lack of information can be substantial barriers. For larger customers this is less of a problem but consistent regulations and structures are still important here the interviewee noted. We saw from the comparison from Sweden and Norway that friendly regulatory environment was one of the many deciding factors for the comparative success of Sweden's success of speeding up the renewable energy development. This is an aspect where Norway certainly could improve and it would help speed up the RE transition.

6.2.3 Solenergiklyngen, Enova and public support

The relationship between Enova and Solenergiklyngen is good and cooperative. The increased support recently Solenergiklyngen are happy with. It was noted however that the support

Solenergiklyngen had gotten was very insignificant compared to the economic support Swedish solar power had gotten over time. This is almost certainly the major reason Swedish solar energy is as far ahead its Norwegian counterpart today regarding solar power development the interviewee noted. This is consistent with the findings from Ydersbond (2018) aswell. Innovasjon Norge has also been an important public economic support factor for Solenergiklyngen which they have a good relationship with as well according to the interviewee.

Overall Solenergiklyngen views the role of the Norwegian state actors in supporting Solar power in Norway as crucial if Solar power is to become a bigger part of the Norwegian energy mix. The support it gets is good but much more can be done. Export credits from banks as well as other state institutions needs to be expanded and support in general should increase. Especially important for solar for home owners as prices are still high here, especially in this area Enova could do more. Communication between the different actors can also be a challenge and can slow down the effectiveness of the initiatives as well.

6.2.4 Solenergiklyngens views on patient capital and an alternative timeline

The importance of the Norwegian state as a source for long term stable patient capital could not be more important for the long-term success of solar, according to the interviewee. This especially so for long-term capital-intensive businesses producing inputs for production. This is a segment of the value chain where Norway already has a lot of competence, and to further expand on this competence, long term patient capital can be extremely helpful as there are enormous potential to increase scale and production the interviewee noted. As we saw in the literature review from Mazzucato & Semieniuk (2018), Patient capital is important because in the early parts of the development cycle, long term patient capital is needed to allow a technology to mature. This patient capital often comes from state actors as private investors often are risk averse, and prefer shorter term less risky investments over longer term riskier ones.

In an alternative timeline where there was no support for solar in Norway there would have been a much slower growth of solar in Norway, if at all according to the interviewee. The state acting as a buyer has also been important here as patient stable demand is important for niche markets to be able to make investments with the insurance that there will be demand ready when the investments are made. This is also consistent with MLP theory, were having a

protected niche market that has safe and steady demand, where you don't have to survive purely on market forces are important for the survivability of the niche.

Here we can see similar remarks from both the interview with solenergiklyngen and the interview with Enova, where the narrative is clearly that Enova and general public support from state actors have been very important to grow both the demand and diffusion of solar and wind energy. This also is supported by secondary data from an Enova publication regarding the development off wind energy historically in Norway featured in the document analysis section.

7. Discussion

7.1 Importance of Enova and green industrial policy

It can be difficult to know whether or not wind and solar energy in Norway would have developed with or without Enova and public sector what is very clear from both the document analysis and the interviews conducted is that it would have happened significantly slower if at all. Time is of the essence if the renewable energy transition is to happen within a timeframe fitting to meet the threat of global climate change.

The question is whether or not green industrial policy conducted has been enough and effective.

The case for wind energy in Norway historically we can see clearly that wind energy did not start to pick up until economic support from Enova really started to accelerate in 2008. This is consistent with the market failure theory justifications by Rodrik and Altenburg where the larger societal benefits off diversifying the Norwegian renewable energy mix and moving more away from traditional fossil fuels is not taken into account by the private sector and hence investments are below the societally optimal level of investments. Although other policy tools can also help like carbon taxes and fees, they are not sufficient to change the economy structurally to meet the energy demands of the future with more renewable energy and can come at a high economic cost to society.

For solar we could also see how significant green industrial policy is to realize the potential of the market. This so particularly when the interviewee from Solenergiklyngen compared the success of Norway and Sweden where Sweden got substantially more economic support from the public sector. As we have seen from both the interview with solenergiklyngen and the

secondary research data on Norway and Sweden's different renewable energy trajectories, political will and public support as the major contributing factors as to why Norway lags as far behind Sweden as it does. Sweden in this case can be thought of using Mazzucatos principles for mission-oriented policy as having a significantly bolder and mission-oriented policy approach with greater risks, but also significantly higher rewards as witnessed by the different outcomes for Norway and Sweden.

Enova however especially with their recent major economic contribution to Hywind tampen the Floating off shore wind project, is nonetheless an excellent case of such mission-oriented approach, accepting to finance a project with high risk that would otherwise not go through but can have substantial implications for the wind energy sector if the technology can continue to see positive cost reductions and technology maturity.

The importance of green industrial policy becomes even more noticeable when we consider just how many market failures hampers the transition to a renewable energy transition. Pollution costs not being internalized by the firms polluting, sub optimal levels of private investments because the gain to the investor is significantly smaller than the gain to society from the investments made in renewable and sustainable energy technologies. Potential promising projects not going through, or technologies not being financed as they are perceived by private investors as too risky. Coordination failures, where uncertainty about necessary investments being made in other related fields that is needed for the project or technology to reach market maturity. The sheer amount of market failures that potentially can slow down or completely hinder the transition makes the case for green industrial policy to be a vital part of any national or even international strategy to combat global climate change. Leaving the trajectory of our energy system into purely the hands of free market, considering the urgent need to tackle global climate change seems hard to support considering the market situation at hand.

The strong case for green industrial policy to be a vital part of the strategy to tackle global climate change, and increase the speed of the renewable energy transition has a lot of support. However the question still remains around how this policy should be structured, and what is its trajectory? Getting the green industrial policy right is not only important for its effectiveness, but also to build long term credibility and consistency around it. If it comes with unintended negative consequences like higher prices for consumers, it could suffer in popularity and political will to support it could fade. Making green industrial policy right then

is a central concern. This leads us to the second research question of my thesis which is what is the trajectory of green industrial policy, which we will discuss next.

7.2 The trajectory of green industrial policy

Although the importance of green industrial policy for meeting the climate goals are fairly straight forward, the trajectory of this is equally important to get right. We saw from the interview with Enova that one of their concerns were that although support was crucial early and later on in the technology trajectory when the technology is going from a niche state to more mature, there does come a time where it needs to be scaled back. This was a concern as economic support beyond the stage where technology is fully matured would unlikely lead to faster diffusion but rather higher prices for consumers. The underlying market failures by Altenburg & Rodrik (2017) as well as directional failures described by Mazzucato (2018), should be the basis for starting the targeted support for sectors with promise for renewable energy development. When many of these failures are resolved support needs to be decreased or ended completely. We can see an interesting case from Enova reducing support for the district heating market as good example of this. Early on high risks for private developers to make the necessary investments as well as high initial costs made these projects problematic to start, but with targeted Enova support since 2001 these district heating systems have increased substantially in quantity and are now by Enova's impression mostly self-sufficient with more public sector support as more and more projects are now being started without any support from Enova or other public sector entities. Enova as a result of this have decided to ramp down their support of the district heating sector. There are of course sometimes exceptions to this principle as mentioned in the interview with the Enova representative where certain sections of a market may still need support despite of the general maturity of the technology or market so this should also be taken into account. The principles of successful industrial policies by Altenburg & Rodrik (2017), where avoiding regulatory capture is off crucial importance is also well covered by this policy trajectory. That is because by stopping or slowing down economic support when the technologies become more mature, you avoid the regulatory capture situation where you are financing these projects long term, beyond the point where they need to be. The embeddedness principle is also very well covered, as Enova stated that they generally have a good working relationship with the market.

Another interesting case is from the section about the history of wind energy in Norway and Enova's role in it. We saw that early Enova initiatives were crucial to get the sector moving after a slow start prior to this support, and the results were noticeable and impactful. However, overtime the policy structure changed over time to green certificates being the main way of intervening in the industry, green certificates being a more neutral instrument than directly supporting wind energy in the same capacity as earlier. Questions can certainly be asked whether this was a bit early for green certificates to become the dominant policy solution, but it is nonetheless an interesting case of more direct economic support early on leading later to a more neutral policy solution. We saw both from the interview with Enova and from the literature review by Gross et al (2012) that early on more neutral instruments like carbon taxes often are not enough to create the structural changes needed in the markets and energy system we need to see for the renewable energy transition to occur in a timely manner. Lack of potential to create structural changes, uncertainty around many factors in the renewable energy industry were key reasons why the renewable energy industry favored targeted policies over more uncertain neutral ones.

Carbon taxes, quotas, green certificates and other conventional climate policies however still can play an important role, especially after the time when its time to scale down more direct economic support. If we accept that early on, Green industrial policy needs to be more focused on direct measures like economic financing, later on in the policy trajectory, carbon taxes and quotas should play a more substantial role.

7.3 Could a renewable energy transition occur In Norway without public support?

This is probably the most difficult research question to answer as we don't have two alternate timelines to compare. However, from both the primary, secondary and tertiary data a few things are quite clear. Both the representative from Solenergiklyngen and Enova where quite clear that the advancement seen regarding solar and wind in Norway would not have moved as fast without public support in the early niche phase of the technology and sector phase, and it may not have happened at all. Getting the perspective from the representative from solenergiklyngen as well as the tertiary data on the Sweden and Norway comparison, public support for niche renewable energy technologies plays a massive role in speeding up the development and diffusion of said technologies.

Whether or not a renewable energy transition can happen or not without public support does not however answer the most important question. The more pressing and relevant question however in regards to this thesis is not only if it would have happened, but it needs to happen in a timely manner consistent with meeting our climate goals.

The fact that wind energy development in Norway struggled to gain momentum until more targeted Enova support in the 2000s is a strong indication that without such economic support from Enova or other public actors, the sector would not have moved as quickly. Regarding the Hywind Tampen floating off-shore wind project, we also saw from a press statement from Enova that their own analysis they had conducted concluded that the project simply would not have occurred without the economic support from Enova. Considering not only the promising potential on reducing emissions from such a technology maturing and becoming a viable part of the energy mix, we also saw from Enova the potential economic benefits this could bring as Norwegian suppliers are very strong in this area, and could potentially take up a substantial amount of the market share. Green industrial policy here as well gives us more control over exactly how we want to steer the transition, as focusing on certain technologies and sectors over others could bring other potential benefits like economic growth and job creation. We saw from Michele Esposito et al (2017) that with lower demand for conventional fossil fuel resources, the side effects are potential job losses in these sectors. A successful green industrial policy with popular support should take this into account as well, this is especially interesting for Norway as Hywind Tampen is a floating off-shore wind project, which has many similarities to more conventional oil and gas off shore activities. This could potentially mean there could be potential for workers that could lose their job if there was less activity in the oil and gas sector to move over to off-shore floating wind projects. Taken into account the job labor market impacts from green industrial policy will be an important factor for the long-term success and popularity of it.

The comparison between Norway and Sweden also illustrates this nicely as Sweden was getting to a point where it could not rely as much on hydropower as Norway did, it needed to make bolder more mission-oriented policies for other renewable energy technologies leading to significantly higher development and diffusion rates of non-hydropower renewable energy.

The data I have analyzed does not support the idea that a renewable energy transition is likely to happen in a timely manner without public economic support for early niche renewable energy sectors allowing them time to build up knowledge, capabilities and economic of scale. Over time as these technologies become cost competitive, support should be reduced or

removed as we saw in the trajectory of green industrial policy, but without early support for these sectors a renewable energy transition is unlikely to occur.

7.4 Green industrial policy in an MLP perspective

How can we understand the role of green industrial policy in relations to what we know are the perquisitions for a socio-technical transition to happen? We can identify emerging renewable energy technologies as a niche relative to the more established technologies like hydropower and fossil fuels. Wind and solar power both somewhat are in this niche state right now in Norway, all thought wind power admittedly significantly less so now. This however as we saw from the section on Enova's role in helping to develop the wind sector early, only because the wind energy sector was able to be economically supported by Enova, and where not forced to only survive purely in the free market. It was able to operate in somewhat of a protected space by receiving this economic support, where it was able to slowly work itself more into the regime level over time. Solar power in Norway is even more of a niche, and still as we saw is a very insignificant part of the Norwegian electricity mix. We saw from the the interview from the representative from Solenergiklyngen that public support for solar were regarded by the interviewee as crucial for the progress seen in solar. All though there is still much work to be done to increase solar power in Norway, we can see that what is happening is significantly helped by state involvement.

We saw from the section on Enova's role helping to accelerate wind power in Norway that socio-landscape factors did play a role in wanting to expand other renewable energy technologies beyond hydropower. The political understanding that hydropower was not unlimited in Norway played a role in spurring political interest in expanding beyond hydropower into other RE technologies. Political realignment was also a factor in the Norway Sweden comparison where the political reality became that they could not only rely on hydro, and needed to focus political will and public economic support towards other RE technologies. Climate change of course is a very strong underlying landscape factor that spurs the will to move towards a more RE based economy and move away from more traditional fossil fuels. It is still very early in the life cycle of wind and solar

It is still too early to say with certainty how the socio-technical regime will respond to these landscape factors, and if solar and wind will eventually become part of the regime, but some interesting points are worth noting. The Hywind Tampen project, which was analyzed in the secondary data section is a project by Equinor which has substantial experience with off-shore

projects. If floating off-shore wind, and off-shore wind in general becomes a major contributor to the Norwegian energy mix, we could see a scenario where the existing regime adapts to the landscape factors mentioned earlier and incorporates those some of the niche wind power technology into. This would not be a case of a niche replacing the existing regime, but rather the regime incorporating the niche into it.

If the goal is for the niche to mature and eventually become part of the regime or replace it, green industrial policy should be a vital part of that strategy. We have already seen that from the press statement from Enova that their own analysis concluded that the Hywind-Tampen project would not happen without Enova support. The fact that the existing socio-technical system is characterized by several lock-in mechanisms as well, which is something one of the justifications for green industrial policy in general further highlights its importance.

8. Conclusion

Climate change is an urgent issue that needs to be addressed, and we have to to be willing to use bold active measures to resolve it. A green industrial policy should be an important part of a strategy mix to solve this problem. Industrial policy as a historic policy tool to move the economy towards economic growth has proven to be successful, and green industrial policy is a way to utilize this tool to the specific goals that needs to be addressed regarding the economy, markets and energy systems to make sure the renewable energy transition can occur in a timeframe consistent with meeting our climate goals. The early sluggish start in the Norwegian wind energy sector prior to Enova support and Sweden's comparative success in non-hydro renewable energy development over Norway among other cases are all examples of how important economic policy support can be to speeding up the renewable energy transition. The data analyzed in this thesis shows a very clear picture that active green industrial policy matters tremendously and has been successful in kickstarting technologies that had potential but were not getting the necessary investments from private financiers to create enough technology development and market diffusion

Due to the many market failures present that will slow down, or potentially stop the renewable energy transition from happening, leaving the trajectory of renewable energy development and diffusion up to the free market is not realistically a viable option. There is simply to much risk associated with this strategy, both regarding whether the transition will happen at all, as well as how fast it can realistically occur without a green industrial policy. The question then should not be about whether there should be a green industrial policy or not, but rather the design of the policies. What technologies and sectors should be focused on? When can economic support by state actors be rolled back, and more conventional environmental policies like carbon taxes and quotas become the main drivers a climate strategy? In the early-phase of development, when the technology and project is still in a niche state, there needs to be more targeted support for the technology project from public actors as this stage where risk around the technology is high, and private investors as we have seen often tend to more risk averse. There is also an important role for green industrial policy in the late-stage of the technology project phase, as making sure the technology can reach the market and diffuse quickly is crucial for making the renewable energy transition happen in a timely manner. Over time however, as the technology reaches market maturity, economic

support should be scaled back, or stopped completely depending on the context to avoid negative consequences like rises in consumer prizes and higher costs to society from taxes spend on green industrial policy that is needed to achieve the climate goals.

Although answering whether or not a renewable energy transition could or was likely to occur without public support was difficult as there is no alternative timeline to directly compare it too, the data analyzed strongly suggests that suggest a transition is very unlikely to occur without public economic support. This becomes even more clear when we put it into the proper context of time. We simply don't have the luxury to wait until the free market can solve this problem, as urgency is key. The fact that green industrial policy gives us a plan and the necessary proven policy tools, to help nurture niche renewable energy technologies and speed up their diffusion makes it a vital part of any national or international strategy to combat global climate change. Just the fact that it is a threat to the global commons, and not just to any individual country makes the international benefits of countries all over the world of running a coherent successful green industrial policy even more important because of the positive spillovers everyone benefits from.

In this master's thesis I have tried to contribute to the research on the impacts of government intervention in the economy and markets in order to achieve a specific societal goal, in this case increasing the speed of the renewable energy transition. Particularly I have focused on the concept of green industrial policy as a very potent part of a strategy to tackle global climate change, as it has a lot of potential to create the necessary structural changes in the economy needed to combat global climate change by favoring certain technologies and projects that can achieve this, and supporting them via various economic methods too grow out of the niche state and into market maturity. I have particularly tried to contribute by focusing specifically on the questions regarding whether or not such a renewable energy transition can occur, or can occur fast enough to meet our climate goals without green industrial policy or similar forms of public economic support. For future research purposes more focus could be on how to increase both the political popularity and the general information in the public about the potential for green industrial policy. More research could also focus specifically about the details of how to design such policy in a inclusive way to make sure that workers that may be left behind from previous sectors such as traditional oil and gas sectors do not suffer unnecessary heavy economic losses, and may be able to migrate over to the expanding renewable energy sector, as well as various spin-off sectors that may emerge as suppliers for these sectors.

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