Dutch Wind Energy: Assessing Upscaling Potential

Masters Thesis

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Executive summary

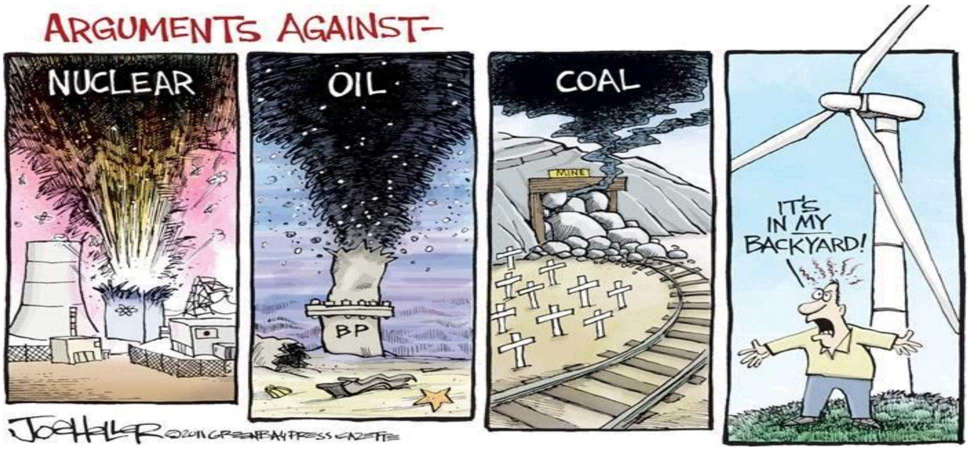
The wind energy system in The Netherlands is still underdeveloped, and is on the verge of the process of tremendous upscaling. Although this upscaling undertaking has already commenced, the dynamics that govern this process are not thoroughly addressed in the current body of literature and are hence still unclear. This study addresses this knowledge gap by identifying and measuring the factors that affect the upscaling potential of wind energy in The Netherlands. This resulted in the following research question: *What barriers and stimuli influence upscaling potential of wind energy in The Netherlands, what is the respective weight of these factor?*

By amending the Functions of Innovation Systems Framework as such that it is applicable to this case, novel insight into the factors that influence the upscaling potential have been revealed in study. According to this framework, there are seven processes that need to be sufficiently present for the innovation system to function. The following processes, which are coined as 'functions', are proposed by the framework: *Entrepreneurial activities (1)*; *knowledge development (2)*; *knowledge diffusion through networks (3)*; *guidance of the search (4)*; *market formation (5)*; *resource mobilisation (6)*; *creation of legitimacy/counteract resistance to change (7)*

By engaging active and knowledgeable actors in the innovation system in which wind energy in embedded, potential barriers and stimuli were measured for their relevance to the upscaling process. The results of this study have revealed there is a wide range of factors that influence the upscaling potential of wind energy. Moreover, a hierarchy between the involved processes and factors was established, providing researchers and policy-makers detailed insight into the upscaling potential of wind energy in the Netherlands. Although wind energy has great potential for upscaling, it is currently not realised. The results point towards two major issues that hinder the upscaling process. Firstly, there is severe lack of legitimacy of wind energy technology, and efforts to remedy this have been unsuccessful. Secondly, the lack of long-term government vision and adhering institutionalisation specific to wind energy is a significant barrier for the creation of legitimacy and for upscaling of wind energy in the Netherlands entirely.

Preface

When writing the research proposal for this project, people warned me on several occasions that I would engage in a highly controversial topic. A highly polarised opinion domain, to which wind energy is subject, is a challenging arena to enter. It is difficult to ensure that the conclusions that are drawn from the results of this study do not drown in an endless sea of scientific, social and political debate. Moreover, more often than not, the debate on wind power is rather considered social and political, than it is considered scientific.



Yet, the level of controversy is not a reason to avoid the topic. Rather, it provides motivation to get out there and not only join in the discussion, but to rise above it. It is the ultimate challenge of the researcher to address any problem from an objective stance. For a highly debated topic such as wind energy, this is extremely difficult. I do feel however that I managed to do so relatively successful. I did not research the normative question of whether wind power should be scaled-up. Rather, I responded to the political ambitions to make wind energy a major part of the energy grid in the future. Assuming that the national government will indeed scale up wind power, it makes an interesting research topic as to how this can be done most effectively and efficiently.

I have greatly enjoyed researching this topic. By interviewing all these people that have been active in the discussion for years, and some even decades, I received a wide range of insights into the dynamics of wind energy and the debate that spawns from it. Although I have not researched the economic or ecological merit of wind energy technology, I am quite certain that wind energy will be a part of our lives for decades to come. Since the birth of the idea of using wind power for our benefits, it has been an interesting research topic. It still is, and will be for years to come.

Acknowledgements

First and foremost I am grateful to all respondents that were willing to participate in this research project. Without their honest and insightful input the project would not have been possible. In addition, I want to thank those who, by means of referencing, have helped me to get in contact with all the involved people. Furthermore, I am very grateful to my supervisor, Prof. Dr. Peter Driessen, who has been a tremendous source of intellectual reflection and support. I also want to thank those in my social circles that have supported me throughout the project. My friends and family have greatly contributed to this project by means of emotional support and intellectual inspiration. Finally, I want to thank my girlfriend. Her unwavering support has helped me through the most difficult and taxing stages of the project.

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1. Introduction

1.1 Problem statement

In the last decades, it has been increasingly recognised that climate change is a pressing issue (IPCC, 2007; Johns et al., 2003; Meehl et al., 2007; Rosenzweig et al., 2008). However, studies have shown that many people do not realise the severity of the consequences of a change in our climate (Capstick et al., 2015; Lorenzoni et al., 2006; Poortinga et al., 2011). A rise in global temperature would result in the melting of the polar ice caps, a rise in sea level and ultimately major floods all around the globe (Johns et al., 2003). Moreover, rise in temperature has a negative impact on agriculture and would irreversibly affect our food supply (Wreford et al., 2010). The climate change process is not an entirely natural one. Anthropogenic activities have significant influence on the pace in which our climate is changing. Many scholars have recognised that greenhouse gas emissions from anthropogenic sources have at least some influence on the process of global warming (Adger et al., 2005; IPCC, 2014, 2015; Johns et al., 2003; Rosenzweig et al., 2008; Wreford et al., 2010). As a response to the latter, the number and intensity of climate change mitigation and adaptation policies is increasing as well (Adger et al., 2005; Hoppe et al., 2014, IPCC, 2015). Among these policies is the promotion of energy from clean and sustainable sources. The EU has formalised these green energy goals in the Europe 2020 Strategy, in which emission reduction and green energy targets are laid down (europa.eu, 2015). Current numbers show, as depicted in figure 1.1, that the actual share of renewable energy in Europe exceeded expectations.

EU-28 actual and approximated progress to interim and 2020 targets

EU-28	Actual contribution			Expected NREAP trajectory			RED
	RES	RES denominator	RES share	RES	RES denominator	RES share	Indicative trajectory
	Mtoe	Mtoe	-	Mtoe	Mtoe	-	-
2005	102.9 (106.5)	1 221	8.7 %				8.7 %
2006	106.8 (112.9)	1 221	9.2 %				
2007	111.7 (119.9)	1 203	10.0 %				
2008	116.2 (126.7)	1 209	10.5 %				
2009	122.9 (135.6)	1 143	11.9 %				
2010	134.9 (149.0)	1 196	12.5 %	138.4	1 191	11.6 %	
2011	147.5 (152.9)	1 141	12.9 %	147.6	1 190	12.4 %	11.0 %
2012	163.0 (166.1)	1 144	14.3 %	156.0	1 191	13.1 %	
2013	171.0 (172.4)	1 143	15.0 %	164.3	1 192	13.8 %	12.1 %
2014	167.2 (168.6)	1 102	15.2 %	173.2	1 192	14.5 %	
2015				182.4	1 191	15.3 %	13.8 %
2016				192.8	1 190	16.2 %	
2017				205.1	1 190	17.2 %	16.0 %
2018				217.0	1 189	18.2 %	
2019				229.6	1 188	19.3 %	
2020				244.9	1 187	20.6 %	20.0 %

Source: EEA (based on data from Eurostat, NREAP reports using GFEC after adjusting for aviation in the energy efficiency scenario and the Renewable Energy Directive (2009/28/EC)). The second column shows the consumption of RES accounting only for biofuels complying with RED sustainability criteria. RES consumption accounting for all biofuels is shown in parentheses. Hydropower and wind power are normalised.

Figure 1.1 Actual and approximated progress to renewable energy targets of 2020

Still, despite the established targets and the relative success in Europe as a whole, in many countries, such as the UK and The Netherlands, the transition towards a greener economy and more specifically to a sustainable energy sector is proceeding at a slower pace than desirable (Conti et al., 2016; Loorbach, 2007). Figure 1.2 shows the share of renewable energy per country in 2005 and 2013. As can be observed here, many countries are not on the right trajectory to meet the 2020 targets, and need to strengthen policy to realise a more rapid transition.

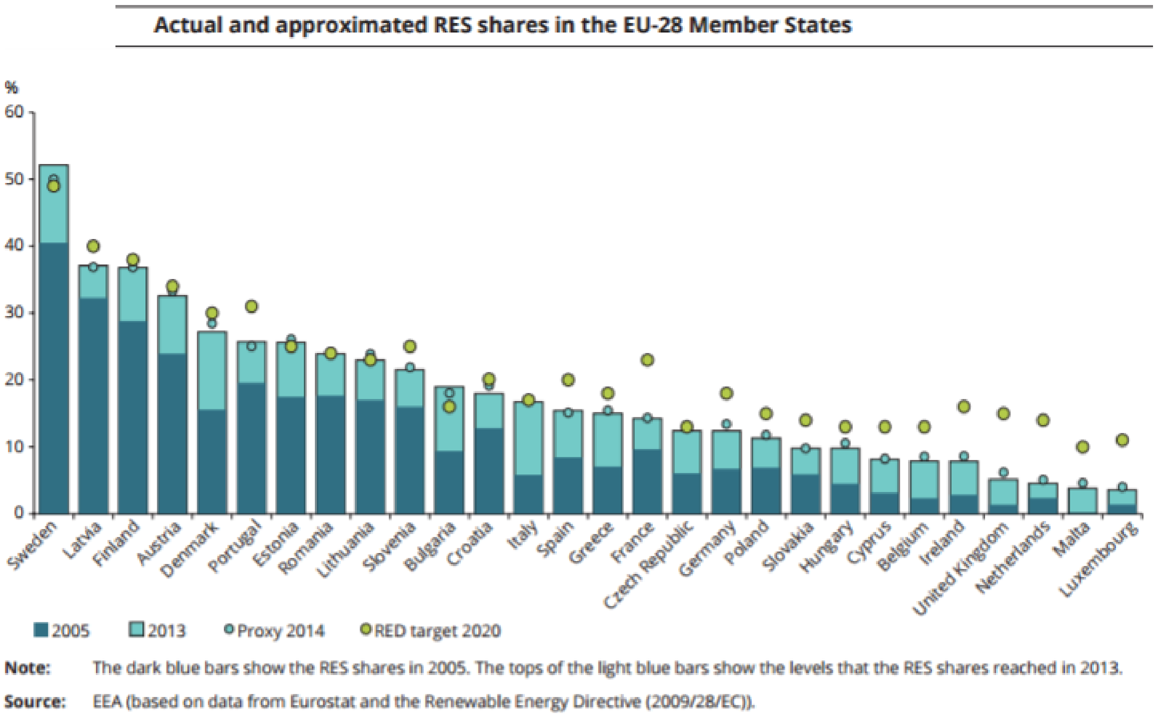


Figure 1.2 Actual and approximated share of renewable energy per country in 2005 and 2013

One of the processes of such a transition is diffusion of energy technologies and upscaling of green energy projects. The concept of upscaling in this particular context refers to the process of achieving broad implementation of an innovation, such as energy technologies. Upscaling constitutes the process of transition from niche projects all the way to regime changes (Coenen et al., 2010; Sandick, 2010; Roy et al., 2013). In this context, niche projects refer to innovations that are not yet mainstream, but are still undeveloped and immature. When these innovations move up in society and become more mainstream, it can have implications for the dynamics of the dominant structure and dynamic of the societal system, hence regime changes. Furthermore, besides the extent to which energy sources are potentially lucrative, numerous factors influence its potential for upscaling.The incumbent regime comprises infrastructure, institutionalisation and rationalisation which all support the current unsustainable energy system (Smith et al., 2004). Consequently, compatibility with the current regime is highly determinant for upscaling potential of energy innovations.

One source of renewable energy that is in the process of being up-scaled in many European countries is wind energy. The significant increase in wind energy investments is mainly due to improvements in efficiency (Blanco 2009; EWEA, 2009; Manwell et al., 2010; Devine-Wright, 2005). Although wind energy in itself is not a recent development, with the relatively recent advances in efficiency wind energy can be seen as an innovation. Wind farms are expected to play a significant role in future energy supply in Europe (Blanco, 2009). In 2006, the European Commission (2006) and the European Wind Energy Association (EWEA) (2006) estimated that the wind energy contribution to the entire European energy grid will be between 10 and 15% in 2020. In 2015, the reality already exceeded these estimates with 15.6% of the entire energy grid coming from wind (EWEA, 2015). Although to harvest the power of the wind is not a young notion, it is only since the 1990s that breakthroughs in efficiency technologies allowed for the wind energy industry to experience a resurgence (Manwell et al., 2010). The main critique to which wind energy has been subject regards the expensive nature of wind energy in comparison with other energy technologies such as coal and gas (Blanco, 2009). However, increased efficiency has made the technology cost-effective since the turn of the century (Johnson et al., 2006). This trend has been increasing over the last decade as well. According to Blanco (2009), modern wind turbines produce 180 times more electricity than wind turbines from 20 years before. Moreover, higher level of efficiency has led to lower operating costs, making wind energy increasingly more attractive for investors (Chehouri et al., 2015). As a result of these developments, the interest in wind energy has been growing steadily over the last decade as well and is expected to continue to do so in the years to come (Blanco, 2009). In the last 15 years wind power generation capacity in Europe has grown from a mere 2.3% of the total energy grid to the previously mentioned 15.6% at the end of 2015 (EWEA, 2015). Although wind energy has been subject to sceptics that argue wind energy will never be able to compete with the far more efficient fossil fuel industry, it is widely recognised that wind energy will play a significant role in our future energy supply, mainly due to innovations that enhance efficiency (Blanco, 2009; EWEA, 2009; Manwell et al., 2010; Devine-Wright, 2005). Still, like many renewable energy technologies, smooth and rapid diffusion of such innovations (more efficient wind turbines) is stagnating due to many factors like the lock-in mechanisms of the incumbent regime (Kemp et al., 1998; Loorbach, 2007). Diffusion of wind energy innovations are stagnating in The Netherlands as well.

In terms of renewable energy contribution to the entire national energy grid in 2014, The Netherlands was still 8.5 percentage points below the national target of 14% for 2020, (CBS, 2016). These national targets were established in accordance with the EU Renewable Energy Directive (Eickhout et al., 2008). In comparison to the leading European countries of Sweden (53%) and Latvia (39%), and also when compared to the EU average (16%), the Dutch renewable energy figures are staggeringly low. Wind energy as part of the entire energy mix, relative to other European countries, is also low in The Netherlands (EWEA, 2015). Although there is relatively much wind in The Netherlands, only 3.4 % of total European wind energy is generated by Dutch wind turbines (Ibid). The low levels of wind energy in the Netherlands, relative to other European countries, suggests that wind energy in the Netherlands is still underdeveloped. Despite the trend of increasing efficiency technologies, which can be considered to be innovations, the underdeveloped wind energy market in The Netherlands can be regarded as a minor niche (Verbong et al., 2008), since it is not yet fully accepted as mainstream technology. To meet the 2020 targets and the Intended Nationally Determined Contributions (INDCs) established with the Paris Agreements, the Dutch government, among others, needs to boost the transition to a more carbon neutral energy system (Rogelj et al., 2016). There is no lack of effort to upscale wind energy in the Netherlands (Ibid). In order to increase the share of renewable energies such as wind farms, the Dutch government will be investing approximately 8 billion euro in renewable energies in the form of subsidies for private investors (RVO, 2016). One of the aims of this investment is upscaling of Dutch wind energy projects. However, the share of wind energy in the Dutch energy grid reveals that Dutch wind energy is currently far from desirable levels. From the perspective of the *Innovation Systems* approach, these developments suggest that the innovation system in which wind energy is embedded in The Netherlands has a low level of functionality (Walz, 2007; Wieczorek et al., 2013).

For policy makers that deal with energy transition, it is essential to be able to assess the potential for upscaling of particular innovative renewable energies, such as these wind energy projects. It is widely recognised that if policy decisions are to be effective, they need to be knowledge-based, and sufficiently informed of the processes that will supposedly lead to the desired policy outcome (Almeida & Báscolo 2006; Boaz et al., 2009; McKenzie et al., 2014). Current policy decisions regarding wind energy projects do not fully adhere to this particular requirement due to the lack of assessment tools. In order to further upscale wind energy in the Netherlands, it is essential that policy-makers, on (inter)national, regional or community level, have access to policy recommendations that are based on in-depth knowledge of the dynamics of wind energy upscaling. In order to reach the desired policy outcome, it is pivotal to know which policy instruments can be used in which instances (McKenzie et al. 2014). More specifically, more insights into the level of influence of these barriers and stimuli, relative to different system aspects and to each other, would certainly contribute to formulating effective policy. Policy recommendations that provide insight into the existence and the nature of these barriers and stimuli would hence contribute to reaching the desired policy outcomes. Currently, the weight of the factors that influence widespread diffusion and upscaling of wind energy technology in The Netherlands is unclear. This provides a knowledge gap and a unique opportunity to investigate these factors for their influence. Although there is much research on the performance of innovation systems (Edquist, 1997; Kemp et al., 1998; Hekkert et al., 2007; Walrave & Raven, 2016), the nature and level of the independent variables that affect such performance are insufficiently known in order to formulate effective policy.

1.2 Theoretical perspective

The analysis conducted in this study draws on the FIS framework by Hekkert et al. (2007). It is argued here that the stagnation of wind energy technology diffusion can be explained by a poor functioning innovation system in which wind energy is embedded. This study is not concerned with measuring the level of performance of this innovation system. Rather, it assumes a low level of performance as evidence of stagnating diffusion and implementation, and addresses the factors that cause or may remedy this stagnation. The FIS framework suggests that a number of processes need to occur within an innovation system for it to function well. Hence, the authors refer to these prerequisite processes as ‘functions’. The following functions are adopted in this analytical framework: *Entrepreneurial activities (1)*; *knowledge development (2)*; *knowledge diffusion through networks (3)*; *guidance of the search (4)*; *market formation (5)*; *resource mobilisation (6)*; *creation of legitimacy/counteract resistance to change (7).* Now, since the facts and figures that were presented in the previous section clearly show that wind energy in The Netherlands is still underdeveloped, it can be assumed that one or several of these functions are not fulfilled. In this study, the barriers and stimuli that affect these functions are identified by means of literature review, and interview data is used to address the respective weight of these factors. By analysing the fulfilment and relevance of the functions, and establishing a hierarchy between the factors affecting these functions, a clear overview can be established that helps to understand the dynamics of the functioning of the innovation system. Since these functions and factors determine upscaling potential, this overview can thus provide insight into the upscaling potential of wind energy in The Netherlands. The theoretical underpinning for this study will be discussed in detail in chapter 2 of this report.

1.3 The Dutch wind energy system

In order to provide a better contextual understanding of the problem at hand, this section provides a brief typology of the current Dutch wind energy system, on the basis of the FIS framework. A preliminary analysis of the fulfilment of each of the functions sheds light on the extent to which the current innovation system in which wind energy is embedded is dysfunctional. Each of the functions will be addressed in more detail in chapter 2 of this report.

Entrepreneurial Activity

According to Wieczorek et al. (2013), the offshore wind energy innovation system functions relatively well in terms of entrepreneurial activity, as evidence of the involvement of Dutch private entities in wind energy projects. Onshore wind energy is less efficient than offshore wind energy, making onshore wind energy less attractive for investment (Bilgili et al., 2011). This suggest that onshore wind energy enjoys entrepreneurial activity to a lesser extent than offshore wind energy. Still, as evidence of the data put forward by the Wind Energy Market Intelligence (WEMI) (2016), the Dutch wind energy innovation system in its entirety does not suffer a lack of entrepreneurial activities.

Knowledge Development

Knowledge development in the wind energy innovation system in The Netherlands, assuming research publications as an indicator for this function, is relatively high (Wieczorek et al., 2013). The high number of publications on wind energy per research institute indicate that knowledge development in this field occurs sufficiently. The latter claim is corroborated by interviews with stakeholders in the field, reported in the study of Wieczorek et al. (2013). The increase in the amount of patents and RD&D projects that relate to wind energy in The Netherlands can also give an indication of the extent to which knowledge is developed in this particular innovation system. According to the Benelux Patent Platform (BPP) (2016), there were 158 patents relating to wind energy filed in The Netherlands since 2010. This is a relatively large amount of patents when compared to other European countries. On the basis of the above mentioned considerations, preliminary analysis suggests that the function of knowledge development is sufficiently fulfilled in the Netherlands, in order for the innovation system to function.

Knowledge Diffusion through Networks

In the Netherlands, learning networks that facilitate exchange of knowledge regarding wind energy certainly seem to be strongly present, as transnational collaboration of multiple sectors is common across wind energy projects in The Netherlands (Wieczorek et al., 2013). Although the networks seem to be far reaching, it is relatively difficult to measure the intensity of such networks. Mainly due to the fact that knowledge exchange is more than occasionally not registered. Another way to measure the functioning of 'learning networks' is to analyse the outcome. As wind turbines are becoming increasingly more efficient and reliable, one could argue that the learning process, which is facilitated by 'learning networks', is well established (Verbong et al., 2008). This is however not exclusive to The Netherlands, which strengthens the argument that these networks are sizeable and have a relatively high level of inclusiveness. Again, preliminary analysis suggests that this function is relatively well fulfilled in the Dutch wind energy innovation system.

Guidance of the Search

With regard to wind energy, the *guidance of the search* has been subject to a wide range of environmental concerns (Premalatha et al., 2014). Academic articles that regard wind energy and that are published in professional journals are predominantly concerning the economic and environmental drawbacks of wind power. The wind energy innovation system in the Netherlands is no exception to these concerns. Although there is a strong influence of industrial actors on the direction of the search, there seems to be a severe lack of *guidance of the search* by the Dutch government. Despite subsidising efforts, existing government vision and policy targets do not provide a stable framework for renewable energy activities such as wind power (Wieczorek et al., 2013). Preliminary analysis suggests that the fulfilment of the function of *guidance of the search* is inadequate in the Dutch wind energy innovation system.

Market Formation

According to Wieczorek et al.(2013), market formation in The Netherlands regarding offshore wind energy is weak. This claim is based on analysis of the size of the market and supporting incentives. In The Netherlands, onshore as well as offshore wind energy projects compete for the same government subsidies as other renewable energies. In that respect, *market formation* is inadequately fulfilled, as other cheaper forms of renewable energies are often more attractive for investment and subsidy. In terms of market size, the Dutch innovation system might score better in terms of market formation when onshore wind farms are taken into account, for the fact this market is relatively large in comparison to offshore wind energy (Biligi et al., 2010). Another consideration that leads to the claim of a weak Dutch wind energy market, is the amount of windfarms that are planned to be built. The current Dutch wind power capacity, as well as the target wind power capacity for the future, suggests that *market formation* is inadequately fulfilled.

Resource Mobilisation

The extent to which resources are accessible by niche actors in The Netherlands can give an indication of the fulfilment of this function. Access to resources is however not easily measured, as ‘access’ is a rather subjective concept. The question of what level of resource availability is regarded as adequate access renders this indicator somewhat intangible. As measured in access to financial and human capital, the function of resource mobilisation in The Netherlands is according to literature only moderately fulfilled when compared to wind energy innovation systems of other European countries (Wieczorek et al., 2013). Financial capital is not well supported by government investment, as prices are still considerably higher than is desirable (Ibid.). Human capital is somewhat better, as there are numerous educational programs that are relevant to wind energy (Wieczorek et al., 2015). Further increase in availability of human capital is however partially dependent on the availability of financial capital (Mansfield, 1991).

Creation of Legitimacy

As mentioned before, preliminary analysis suggests that the Dutch government lacks vision with regard to wind energy specifically. Although there are several wind farms under construction, there are no concrete programmes that envisage the construction of many new wind farms in the future. Moreover, the lack of such vision, together with the fact that renewable energy projects have to compete for a limited sum of subsidy indicates that wind power is currently perceived as only weakly legitimate (Wieczorek et al., 2013). Creation of legitimacy is therefore highly essential for the functioning of the innovation system. Preliminary analysis however suggests that this is currently insufficiently accomplished in the Dutch wind energy innovation system.

1.4 Research objective and research question

Besides the extent to which particular renewable energy sources are effective and efficient relative to other forms of energy, there are numerous other factors that influence the success of upscaling such technologies (Kemp et al., 1998). When formulating policy regarding wind energy, it is essential for policy makers to have in-depth knowledge of all relevant aspects that may influence the dynamics of upscaling processes. The aim of this study is to assess the wind energy innovation system in The Netherlands in terms of upscaling potential. In this respect, upscaling potential refers to the extent to which it is possible and feasible to increase wind energy production in the Netherlands. Moreover, such upscaling not only includes the replication or expansion of windfarms, but also constitutes the establishment of legitimacy and institutionalisation for wind energy. The analytical framework that was developed for this study draws on the Functions of Innovation Systems (FIS) framework by Hekkert et al. (2007). Literature review of theories regarding transition and upscaling was used to complement and complete the development of the analytical framework. The functions, as described in the previous section of this report, and the factors affecting these are used to assess the upscaling potential of wind energy. This means that these variables determine the extent to which the barriers can potentially be overcome and the stimuli can be realised. The level of influence these factor have on the function performances of an innovation system is measured by means of interviews with innovation system actors. It is thus assumed that these factors affect upscaling potential of wind energy through their influence on function performance. In that respect, the extent to which the level of function performance is influenced determines upscaling potential, the dependent variable in this study. Ultimately, this study aims to contribute to the current body of literature by providing a better understanding of why the innovation system in which wind energy is embedded is functioning poorly in the Netherlands, and how this can be addressed.

The explanatory and evaluative nature of the project results in the following research question: *What barriers and stimuli influence upscaling potential of wind energy in The Netherlands, what is the respective weight of these factor?* In order to answer this question, several sub-question are formulated: *What does the concept of upscaling imply is the context of the wind energy system?(1); How do the different functions of innovation explain upscaling potential?(2); What policy lessons can be drawn from analysing the upscaling potential of wind energy by means of the functions of innovation?(3).* The first sub-question (1) is formulated in order to come to an operational definition of the concept of upscaling, and is descriptive in nature. Besides the notion of upscaling, there is another undefined concept in this sub-question that needs elaboration. In this context, the wind energy system refers to the sum of all processes that directly affect the delivery of energy from wind turbines that are located within the geographical border of The Netherlands, including the Dutch part of the North Sea. The second sub-question (2) aims to address upscaling potential in relation to the functions of innovation. Since the theoretical framework applied in this study was initially developed in order to explain the diffusion of innovative technologies, and it is used here to address the potential for upscaling, it is essential that this link be thoroughly explicated before answering the main research question. The third sub-question (3) allows for the formulation of policy recommendation regarding upscaling of wind energy in The Netherlands. When a hierarchy between the influential factors has been determined, the next step is to establish who can do what in order to realise the upscaling potential for wind energy.

1.5 Methodological approach

The framework enabled the assessment of wind energy upscaling potential in the Netherlands by interviewing stakeholders in the wind energy innovation system. Interviews with stakeholders within the Dutch wind energy innovation system, spawned data that addresses the functions of this innovation system. Ultimately, the application of the developed framework to the empirical data provided novel insight into the dynamics of upscaling processes of wind energy in The Netherlands. Literature review and analysis of these interviews results revealed the existence of barriers and stimuli that influence the functioning of the innovation system and hence the potential for upscaling wind energy in The

Netherlands. Besides the identification of these barriers and stimuli, the interviews have shed light on the respective weight of these factors. In that respect, the barriers and stimuli can be considered the units of analysis for this study, as these are the units that are analysed for their relevance. Ultimately, policy recommendations were formulated that adhere to the relevance of these particular barriers and stimuli. Moreover, it allowed for critical analysis of previous attempts at upscaling, and it provided insights into what pitfalls and challenges policy-makers face when formulating future policy regarding upscaling of innovative renewable energy technologies such as wind turbines.

As the interviews are the main source of data on which the analysis is based, the selection criteria are highly relevant for the validity of the study. A set of criteria that are based on involvement and knowledgeability within a certain dimension of the wind energy innovation system resulted in 15 interviewees (N=15). Furthermore, the study is designed as such that the policy recommendations can address the most relevant function(s), and the most important barriers and stimuli that affect that function, individually. The research design of this study is discussed more elaborately in chapter 3 of this paper.

In sum, barriers and stimuli that affect the Dutch wind energy innovation system were identified on the basis of the FIS framework and literature review. Next, the perceived weight of these factors is measured by means of interviews with innovation system actors. When this analysis has revealed which barriers and stimuli are most influential with regard to the functions, these can be analysed again for potentially suitable policy measures. A more elaborate explanation of the methodology can be found in chapter 3 of this report.

1.6 Set-up of this report

The second chapter of this report comprises a detailed review of literature relevant to the scope of this paper. Moreover, the chapter lays out the analytical framework by drawing on the analysed literature. Thus, the first section (2.1) embeds key concepts in literature, and establishes an operational definition. The second section (2.2) analyses relevant literature to ultimately arrive at the analytical framework which is thoroughly addressed in the third and last section (2.3) of this chapter 2. The methodology is laid out in detail in chapter 3 of this report. Firstly, the design of this research project is elaborated on in the first section (3.1), including a schematic representation of the project. The second section (3.2) addresses the means by which data was collected, including selection criteria. The last section (3.3) explains how the collected data is analysed. Then, the results of the research project can be found in chapter 4. It is structured as such that each of the functions of the analytical framework is addressed in a separate section, each containing three sub-sections. The first function for example is, like all other functions, analysed quantitatively (4.1.1) and qualitatively (4.1.2). A brief function-related conclusion and an integration of the quantitative and qualitative analysis is also included in a separate sub-section (4.1.3). The final section (4.8) of chapter 4 provides an overall integration of the results, including some tables and figures that give an overview of the results. Chapter 5, in which the conclusions are adopted, consists of three sections. The first, and most important section (5.1) aims to answer the research question. The second section (5.2) provides a critical reflection of the existing body of literature in retrospect of this study, and explains what this study contributes to this literature. The third section (5.3) of chapter 5 critically reflects on the methodology that is adopted for this study. Recommendations for further research are then addressed in the final section chapter 5. The final chapter of this report comprises recommendations for policy practice, and is structured on the basis of the respondent categories.

2. Functions of upscaling potential

2.1 Conceptualization of relevant concepts: Upscaling and diffusion of innovation

The concept of technological change within societies has been subject to wide range of approaches that attempt to explain the dynamics and processes of such transition (Edquist, 1997; Geels, 2010; Hekkert et al., 2007; Kemp et al., 1998; Loorbach, 2007). One of these approaches, on which many recent theories are build, is the *Innovation Systems* (IS) approach. As a product of integration of institutional and evolutionary theories, IS views technological change has being driven by all institutional and economic structures within a certain innovation system (Hekkert et al., 2007). In that respect, innovations are generated by the interaction between all entities/actors within an innovation system (Saviotti, 1997). Diffusion of innovations is also regarded to be part of the innovation system. According to Rogers (1983), diffusion of an innovation refers to the process in which a particular innovation is communicated and implemented across a societal system.

In this study, it is argued that the notion of upscaling similarly constitutes this particular process. The concept of upscaling in the context of innovation refers to the process of achieving broad implementation, or diffusion, of an innovation, such as i.e. energy technologies. Upscaling refers to the process of transition from niche projects all the way to regime changes (Coenen et al., 2010; Sandick, 2010; Roy et al., 2013; Van Doren et al., 2016). A niche project refers to an innovations that is immature and undeveloped, and is thus still in the 'niche'. The process of becoming mainstream, bringing about changes on a societal level, is regarded as upscaling (Van Doren et al., 2016) Moreover, the notion of upscaling allows for the distinction between horizontal and vertical upscaling. Horizontal upscaling refers to the replication of innovations or technologies in the same fashion in different geographical and temporal settings. Whereas vertical upscaling regards the diffusion of innovative technologies across multiple system levels, ultimately leading to rationalisation and institutionalisation supporting that particular technology (Van den Bosch & Rotmans, 2008). The wide scope of such a process means that, in order to reach the end-goal, all the involved parties have to accept the technology as a main-stream solution (Sandick, 2010). For the purpose of this study, it is assumed that upscaling or diffusion of innovations are an intricate part of any innovation system. In order to clarify the relevant variables and their interrelations, figure 2.1 shows a conceptual framework that will guide the analysis conducted in this study. The operationalisation of the concepts in this framework is schematically represented in the research framework and the analytical framework. The latter of which contains different factors that affect the concepts depicted in figure 2.1.

Figure 2.1 Conceptual framework

The dependent variable in this study is the upscaling potential of wind energy in The Netherlands. As was established above, upscaling and diffusion of technology constitute a similar process. As these are closely related or even similar concepts, when this study refers to upscaling, it simultaneously refers to diffusion. Hence, the first connection in the conceptual framework in figure 2.1. The latter assumption is a prerequisite for the correlation that follows. The FIS framework is developed to explain the functioning of an innovation system, which in turn serves to diffuse technology. As upscaling and diffusion are assumed to be one and the same in this study, it can be argued that the FIS framework similarly explains upscaling potential. Now, the aim of this study is to measure the influence of the barriers and stimuli on the functions of innovations in this particular system. Thus, the barriers and stimuli can be considered to be the dependent variables influencing the independent variable of upscaling potential, through the innovation system functions that explain the diffusion, or upscaling, of technology. For this rationale to be valid, it is prudent that the technology in question in **not** fully embedded in the system already and is still considered to exists, at least partially, in a niche.

2.2 Theories in Transit

Now that the conceptualisation of the relevant concepts has revealed that upscaling of niche innovations is a concept that is interchangeable with the notion of technology diffusion, such upscaling can be embedded in literature by examining theories that attempt to explain the development and diffusion of technologies. As mentioned before, there are many theories on socio-technical systems and transition that aim to explain the dynamics of technology diffusion and societal transitions (Edquist 1997, Geels 2010, Hekkert et al. 2007, Kemp et al. 1998, Loorbach 2007). Theoretical understanding of the systematic nature of society and technological transition is continuously scrutinised and improved upon, each theory building on the cumulative knowledge of previously established theories. One might thus say, these theories are continuously in transit. Some of these theories, such as the IS approach, focus on macro-level changes that alter the settings of a regime entirely (Edquist, 1997). These approaches consider transition to ultimately occur on a societal scale. It may prove difficult to use such theories to explain the micro-level processes separately, which is essential for in-depth understanding the dynamics of upscaling potential. The compatibility of renewable energy innovations with the existing regime and hence the potential for upscaling may however yet be explained by integrating existing theories on socio-technical systems and transition that lay emphasis on the micro-level processes that accumulate to societal transition. Theories such as *Strategic Niche Management*, *Transition Theory*, and *Functions of Innovation Systems*, that focus on micro-level dynamics, provide insight into what barriers and stimuli innovation upscaling may encounter (Hekkert et al. 2007, Kemp et al. 1998, Loorbach 2007). Hence, understanding the dynamics of these theories can contribute to identifying barriers and stimuli that potentially have an impact on the upscaling potential of a technology. Studies that opt for the discussed theories were thus consulted for the identification of additional barriers and stimuli that affect the functions of innovation.

2.2.1 Strategic Niche Management

A very prominent theory on socio-technical systems is Strategic Niche Management (SNM) as proposed by Kemp et al. (1998). SNM is put forward under the premise that a transition towards a 'greener' society is desirable and possible, but evidently not achieved. The theory proposes a mode of governance with which technical transitional processes can be facilitated by creating or managing niches for promising technologies. SNM is a perspective that proposes an approach on how to transit a dominant technical regime into a new, more sustainable one (Kemp et al. 1998; Geels & Raven 2006). Scholars that opt for the SNM approach argue that sustainable development is not realised by pushing radical technologies, but rather it is the result of interrelations and interaction between social and technical features of society (Kemp et al., 2001; Schot & Geels, 2008; Van der Laak et al., 2007). Social and technical change are in that sense the cornerstone of sustainable development. Such change can, according to the SNM approach, be stimulated and manipulated by creating and managing niche spaces, in which novel technologies can be developed and matured (Van der Laak et al., 2007). Diffusion and upscaling of these niche technologies is considered to be the end-goal of SNM.

In an attempt to explain diffusion and upscaling of niche technologies, SNM has been applied to a wide range of cases that deal with sustainable technologies such as wind turbines (Kemp et al., 2001), battery powered vehicles (Kemp et al. 1998, Truffer et al. 2002), biogas plants (Geels & Raven 2006), biomass (Raven, 2005), and biofuels (Van der Laak et al., 2007). The application of SNM to these cases has revealed that niche technologies are subject to a wide range of factors, both internally and externally, that affect its potential for successful diffusion and upscaling (Geels & Raven, 2006; Kemp et al. 1998; Kemp et al., 2001; Raven, 2005; Truffer et al., 2002; Van der Laak et al., 2007). As wind energy in the Netherlands can still be considered to be a minor niche, SNM contributes to explaining the dynamics of successful diffusion and upscaling of such technologies. In the very least it provides basis for identification of additional influential factors.

2.2.2 Transition Theory from Multi-Level Perspective

Another theoretical perspective that builds on the latter theories is Transition Theory (TT). According to Loorbach (2007), societal change or transition can be viewed as transformation processes in which existing structures, institutions, culture and practices are broken down and new ones are established. In order to escape the lock-in mechanisms in which our society is embedded, structural changes are needed. These societal alteration processes are, from this theoretical perspective, considered transitions. As TT addresses the dynamics that govern societal transformation processes, it can contribute to the identification of obstacles that may hinder upscaling of innovation technologies, such as wind energy. There are multiple perspectives of TT, one of which is widely recognised. The Multi-Level Perspective (MLP), that builds on SNM as well as TT, distinguishes between several system levels which interact in order to facilitate technical change: *regime*; *niche*; *landscape* (Avelino & Rotmans 2009, Markard & Truffer 2008, Smith et al. 2010). The *regime* level refers to the mechanisms of the incumbent regime, whereas the *niche* level refers to the area in which experimentation and innovation is allowed to occur, excluded from the current regime. Additionally, the incumbent regime is also pressured by external factors, of which the *landscape* is comprised (Verbong & Geels, 2008) . These system levels interact on a multitude of dimensions (e.g. social, technical, institutional, political), leading to transition (Geels, 2010). For each of these levels, certain obstacles or stimuli for upscaling exist. Analysis of these factors provides insight into which variables influence upscaling potential. Moreover, upscaling can be achieved across vertical or horizontal levels, making the MLP all the more relevant.

In order to explain transition dynamics, the MLP approach to transition has been applied to several societal sectors, such as agriculture (Wilson, 2007), the food market (Smith, 2006) and electricity systems (Verbong & Geels, 2007). Still, the macro-scale and theoretical nature of MLP results in a relatively low level of applicability to micro-level processes. For this reason, it is argued here that MLP alone is not well suited to explain upscaling dynamics of wind energy in The Netherlands. However, the literature on the MLP approach has supported the existence of certain barriers and stimuli that affect diffusion of technology, hence upscaling.

2.2.3 Functions of Innovation Systems Framework (FIS)

As a response to the accumulation of theories on IS, Hekkert et al. (2007) developed the Functions of Innovation Systems framework (FIS) which provides critique on the existing theories on IS: that it is too static, and that it lacks focus on the micro-level. Although the IS theories attempt to explain societal changes by focussing on (mirco-level) sub-systems within society, the variables within these sub-systems are relatively unaddressed in current literature on IS. The FIS perspective focusses more on the individual processes within the innovation system and attempts to map them. Hence, there is more emphasis on the micro-level than in previous IS approaches. According to Hekkert et al. (2007), the interaction between activities within innovation systems explain the extent to which a technology is developed and diffused. In order to map these activities they are categorised under *functions* that facilitate transition. In their FIS framework, Hekkert et al. (2007) propose 7 functions of innovation: *Entrepreneurial activities (1)*; *knowledge development (2)*; *knowledge diffusion through networks (3)*; *guidance of the search (4)*; *market formation (5)*; *resource mobilisation (6)*; *creation of legitimacy/counteract resistance to change (7).*

Bergek et al. (2008) build on the FIS framework by addressing inducement and blocking mechanisms that stimulate or hinder the fulfilment of the functions of an innovation system. They argue that the identification of these mechanisms will aid policy-makers and entrepreneurial firms in determining which inducement or blocking factors to focus on. Now that is was previously established that upscaling refers to widespread diffusion of niche technologies and that the FIS framework is a tool to explain this process, these inducement and blocking mechanisms to the fulfilment of the functions can be deemed barriers and stimuli for upscaling of niche technologies. Consequently, many of the barriers and stimuli identified for this study are derived from these inducement or blocking mechanisms. The literature review that was reported in the previous section allowed for the identification of additional barriers and stimuli. Moreover, each function in itself is in some cases identified to be a barrier or stimuli for another.

The fulfilment of one particular function may be influenced by the extent to which another function is fulfilled (Hekkert et al., 2007). Hence, the absence of one function may be a barrier for another. Visa versa, the fulfilment of one function may stimulate the fulfilment of other functions. Hekkert and Negro (2008) argue that the interaction between the different functions serves as a catalyst for growing innovation systems, hence speeding up diffusion of technology. The authors conducted a cross-case analysis in order to test the latter claim. Case-studies where system functions are highly interactive and case-studies where interaction between the functions was negligible were used for comparative analysis. The results of the study confirmed the above mentioned claim, suggesting that it is relevant to adopt certain functions as barriers or stimuli for another.

2.3 Analytical framework

As previously established, theories on IS attempt to explain technological transition by categorising sub-systems within society. However, in order to explain upscaling potential of one particular technology, it is essential to understand the individual processes that occur within each sub-system. Hence, the extent to which the explained theories focus on the individual micro-processes determines its applicability to one particular technology.
Now that a literature review has revealed the characteristics and features of several prominent theories that may explain upscaling potential, it has become clear that the FIS framework, complemented by Bergek et al. (2008), is most suitable for this analysis. Because this framework enables the user to assess the innovation system of one particular technology by sub-dividing the system processes into ‘functions’, it is ideally suited to explain why a technology may or may not diffuse, and what its potential for upscaling is. In order to develop the analytical framework, the next step is to identify barriers and stimuli that affect the fulfillment of the proposed functions, so that even more emphasis can be laid on the micro-level. In this section of this study, each of the functions as proposed by Hekkert et al. (2007) will be explained, followed by the identification of barriers and stimuli from the reviewed literature on innovation systems, socio-technical systems and transition. Since wind energy in the Netherlands is not entirely new, and is hence only in particular respects considered to be a

niche technology, the functions are in some cases modified as such that they are more suited to explain the case study at hand. The section will conclude by presenting a table that summarizes the identified barriers and stimuli, and categorizes them by function.

2.3.1 Entrepreneurial activities

According to Hekkert et al. (2007), the presence of entrepreneurs and their activities is a prerequisite for the existence of an innovation system and the associated technological diffusion. In that respect, entrepreneurs are deemed agents of change (Acs & Varga, 2005) The potential for new knowledge and networks is utilised by entrepreneurs to generate and diffuse technological developments, creating new markets for these technologies in the process. Experimentations within niches is an essential part of an innovation system, and is closely related to the functions of knowledge development and knowledge diffusion. As such, this concept will be more thoroughly explained in following sections of this papers. For this particular function, experimentation is crucial for the fact that entrepreneurs are the agents that facilitate and realise these experiments (Bergek et al., 2008). The set of entrepreneurs within an innovation system comprises firms in the incumbent regime that attempt to diversify their business strategies in order to benefit from novel developments, and new entrants that have innovative perspectives on market opportunities (Hekkert et al., 2007). Subsequently, the level of fulfilment of this function can be measured by the number diversification activities of actors of the dominant regime and by mapping the number of new entrants. Another indicator is the number of experiments conducted with the resulting technological innovation (Ibid.).

Barriers

A barrier that exists for many of the proposed functions, including this one, is the lock-in to established technologies (Ibid). The incumbent regime harbours infrastructure, institutionalisation, and rationalisation that all support established technologies (Kemp et al. 1998, Smith et al. 2010). Naturally, the regime in place uses systemic power in order to sustain its dominance (Avelino & Rotmans, 2009). As a result, these processes that sustain current system dynamics serve as blocking mechanisms for drivers of change. Niche technologies have to compete with highly organised incumbents that ensure that institutions are aligned to the dominant technologies (Hekkert & Negro, 2008). *Entrepreneurial activities* can be severely hindered by the lock-in to embedded technologies, put in place by incumbent entities.

Another barrier to flourishing *entrepreneurial activities* is a lack of long-term government vision. Although long-term government objectives may not directly influence the extent to which entrepreneurial activities are blooming, lack of such goals will allow for the dominant regime to sustain itself indefinitely due to a lack of fair competition. In order to facilitate sustainable *entrepreneurial activities*, long term government vision should reflect the need for assistance for niche innovations to compete with dominant technologies (Bergek et al., 2008). Long term targets set by the governments provide guidance for knowledge development in certain fields of interest, in turn leading to entrepreneurs making use of the opportunity to benefit from this new knowledge (Hekkert & Negro., 2008). A lack of such vision can make it difficult for these entrepreneurs to determine which technologies are lucrative, and therefore reducing the level of sustainable entrepreneurial activity.

Stimuli

One way to assist niche technologies in their diffusion is to create protective niche spaces (Smith & Raven, 2012). Normally, prevailing selection pressures will disallow innovations to develop and diffuse as desired. Smith and Raven (2012) have identified three main properties of protection of niche spaces: shielding, nurturing, and empowerment. Shielding refers to the protection from prevailing selection pressures. Nurturing regards the opportunity for niche actors to develop and nurse niche innovations into more robust technologies that are better supported in socio-technical networks. Empowerment enables the niche innovation to compete in a relatively unchanged external environment. The technology needs to be nurtured in such a way that is becomes compatible with the dominant regime, hence empowering it in terms of fittingness and conformity (Ibid). Now, the creation of such niches, including the associated internal processes, gives novel entrepreneurs a better change to further develop their innovative product and service. Therefore, these niche spaces stimulate entrepreneurial activity for innovation oriented enterprising. The creation of these pocket markets is closely related to the fifth function of market formation, which may have a stimulated effect on *entrepreneurial activities* (Hekkert & Negro., 2008).

Additional instruments that may contribute to increasing the chances of niche innovations when competing with dominant technologies are measures affected relative prices (Hekkert & Negro, 2008). Either the prices of the niche-technology may be artificially lowered (by i.e. subsidies or tax exemptions) or prices of embedded technologies may be artificially increased (by i.e. eco-tax) (Van der Laak et al., 2007). This will protect innovative entrants from market pressures, thus stimulating entrepreneurial activity regarding particular innovative technologies. Furthermore, the main method by which entrepreneurial activities result in innovations is experimentation. Government or other agent strategies that are aimed to encourage experimentation can therefore have impact on the fulfilment of the function of *entrepreneurial activities*. R&D funded and facilitated by the government, and corporate experimentation can have a stimulating effect, it is however important to differentiate between public and private experimentation spheres.

2.3.2 Knowledge Development

An obvious prerequisite for flourishing innovation systems is the *development of knowledge* (Hekkert et al., 2007). Any innovation that is developed is based on novel insight and knowledge that is utilised by niche actors in order to create new technologies. In the niche, knowledge is developed by experimentation of niche actors, as was mentioned above. Besides academic and firm-level research and development, a continuous process of failure and improvement spawns novel insight and knowledge, giving birth to innovations. Hence, the concept of ‘learning by doing’ is central to experimentation and *knowledge development* (Bergek et al., 2008). Although the abstract nature of the concept of knowledge development makes it difficult to measure, there are several indicators that measure the effort put into the development of knowledge: RD&D projects; amount of patents; investment in RD&D (Hekkert et al., 2007). In addition, 'learning curves' can be used to map any increase in technological performance (Ibid.). Academic publications can be utilised to analyse such 'learning curves'. Moreover, publication from academic institutions, as well as from industrial parties, can be considered as an indicator in itself for the fulfilment of this function (Wieczorek et al., 2013).

Barriers

The barrier of weak network failure refers to a lack of tight networks that stimulate 'learning by doing'. Experimentation is less likely to provide innovative results, or to occur at all, when there is no network in place that interconnects the entities within an innovation system. As *knowledge development* and *diffusion* are highly interdependent functions, this particular barrier will be explained more thoroughly in the section on knowledge diffusion through networks.

As was mentioned before, *entrepreneurial activities* and experimentation are highly essential for the functioning of an innovation system. Without *entrepreneurial activity*, experimentation would not occur. Without experimentation, knowledge would not be developed. Since the birth of science as we know it, trial and error has been the main method of determining what is truth and what is not. According to Shapin and Schaffer (1985), since Boyles experiments with the air-pump, experimentation is the pinnacle of knowledge development. It is therefore crucial that *entrepreneurial activity* flourishes in order for knowledge to develop (Hekkert & Negro, 2008).

Stimuli

Research and development is also based on trial and error, and is another cornerstone of *knowledge development* (Hekkert et al., 2007). Governments can either fund or facilitate research, development and demonstration programs (RD&R). This will stimulate experimentation and hence the development of knowledge. Moreover, the concept of 'learning by doing' can be encouraged by stimulating experimentation. As was previously established, *entrepreneurial activity* will also stimulate experimentation, and vice-a-versa. Therefore, measures that *increase entrepreneurial activities* as was put forward in one of the previous sections, are likely to encourage *knowledge development* as well. Once again it is important to recognise that private and public research or experimentation activities may have a different level of impact on particular function.

2.3.3 Knowledge Diffusion Though Networks

As mentioned before, *knowledge development* and *knowledge diffusion through networks* are interdependent functions. These functions are mutually stimulating in the sense that knowledge can only be diffused when it is adequately development. In turn, *knowledge development* and 'learning by doing' is stimulated through interaction. Hence, increased *knowledge development* due to knowledge diffusion is driven by 'learning by interacting'.

(Hekkert & Negro, 2008). These ‘learning network’ are essential for the smooth *diffusion of knowledge*. The amount of conferences, workshops, panels, platforms etc. can be considered as a measure for the diffusion of knowledge. The size and intensity of networks in which an innovation system is embedded is another means of analysing the fulfilment of this particular function (Hekker et al., 2007).

Barriers
Knowledge development and diffusion often takes place in learning network. ‘Learning by interacting’ is crucial for smooth development and *diffusion of knowledge* (Bergek et al., 2008). A lack of such networks may therefore severely hinder the fulfilment of this function. When the connectivity of a particular network is weak, exchange of information cannot adequately take place.

Stimuli
In order to contribute to the fulfilment of the function of *knowledge diffusion through networks*, it is essential to recognise the importance of network connectedness. Stimulation of interaction between entities in the innovation system positively influences the extent to which ‘learning by interacting’ occurs (Lundvall, 2010, p.40). Organisation of workshops, conferences, forums, panels etc. may increase the connectedness of a particular network, hence stimulating *diffusion of knowledge*. These can serve as modes for the transfer of information and knowledge (Bergek et al., 2008).

2.3.4 Guidance of the search

As *knowledge development* is regarded as the creation of technological variety, the function of *guidance of the search* entails the selection process (Hekkert et al., 2007). Societal preferences are central to this particular function, as it may influence the direction in which ‘learning’ processes take place. Changing norms and values within a society may change *the direction of the search*. This function entails the factors that motivate entrepreneurial actors or other entities within the innovation system to ‘search’ for innovation in a certain direction. The *guidance of the search* is the cumulative result of a multitude of factors, ranging from technology specifics to prevailing external pressures such as climate change (Bergek et al., 2008). This makes it difficult to measure in absolute values. However, the direction of the search can be expressed in more subjective terms. Government policy or industry targets give an indication as to which technologies receive more attention. Furthermore, academic articles published in professional journals can also indicate which technologies are at the forefront of public debate. Moreover, the content of the discussion regarding certain technologies is another measurement of the guidance of the search. Whether positive features of particular technologies are commonly discussed or, alternatively, the shortcomings, is highly determinant for the guidance of the search (Hekkert et al., 2007).

Barriers
Although there are many barriers to the fulfilment of this function, only the most prominent as identified from the literature, are addressed here. A reoccurring barrier that is also of

influence for this function is the lock-in to established technologies. Technologies that are embedded in the incumbent regime may influence the direction of further development and innovations. The priorities of RD&D programs can be significantly influenced by entities of the dominant regime that will attempt to sustain their dominance, hindering innovation in the desired direction in the process (Hekkert et al., 2007).

The characteristics of new technology may also be of great relevance for the *guidance of the search*. Logically, technologies that are expensive and unreliable are not likely to gain support (Hekkert & Negro, 2008). Technologies in a certain direction that were deemed inefficient or ineffective in the past will most likely not be a priority on the RD&D agenda. The *guidance of the search* is in that respect also influenced by the function of *knowledge development*, as this determines the characteristics of the technology. Furthermore, there is a clear distinction between societal characteristics and techno-economic characteristics of a technology. The social implications that a technology may have for any layer of society may be of entirely different calibre than the implications of the technological characteristics, which refer mostly to the cost-effectiveness and implementation complexity of a technology. In essence, technologies that either have negative societal implications or are not cost-effective are less likely to gain support. Hence, these factors can be a barrier for the function of *guidance of the search.*

Weak organisational power may lead to an uncoordinated search for innovation (Bergek et al., 2008). Although this may not prevent innovations from being developed entirely, it does directly influence the functioning of the innovation system. To determine the trajectory of technological innovation is much more effective and efficient when it is well coordinated Geels & Schot, 2007).

Stimuli

Funding or coordination of RD&D programmes can significantly contribute the influencing the direction of the search. If it is deemed desirable to develop certain technological areas further, governments can either set up RD&D programmes in that particular field, or fund existing programs (Hall & Lemer, 2010). This will directly guide the search for innovation, thus stimulating the functioning of an innovation system.

In many cases governments have influenced the *guidance of the search* by the formulation of long term goals (Hekkert et al., 2007). Articulate formulation of long-term objectives (i.e. renewable energy targets) may give entrepreneurs incentives to direct their attention to a certain technological field. Moreover, it will increase the *legitimacy* of certain technologies and justify the mobilisation of resources in that particular direction (Ibid). The functions of *mobilisation of resources* and *creation of legitimacy* are therefore also affected by this particular stimulant (Bergek et al., 2008) .

2.3.5 Market formation

The concept of market formation was already discussed as a stimulus for *entrepreneurial activity*. For innovations, markets may be underdeveloped or may not exists at all yet. Moreover, price/performance is often poor for newly born technologies (Bergek et al., 2008). For this reason, *market formation* is adopted as a function of an innovation system. It is prudent for markets to form, likely with the assistance from government or other system agents, in order for innovations to adequately diffuse (Hekkert et al., 2007). As mentioned before, these market can be artificially formed, sustained, and nurtured by agents in the innovation system. This will create a protective space, where the innovation is allowed to further develop and mature (Smith & Raven, 2012). The number of niche markets within an innovation system can give an indication as to the fulfilment of this function. Furthermore, government measures, such as tax benefits or environmental standards, that provide a competitive advantage to certain innovative technologies are also indicators of *market formation* (Hekkert et al., 2007).

Barriers

Without assistance, some innovations may not be able to enter the market due to the lock-in to established technologies (Kemp et al., 1998). Fully embedded technologies are often much more efficient than innovations, making it difficult for these innovations to compete with dominant regime technology (Bergek et al., 2008). The characteristics of niche technologies can in that respect also be seen as a barrier *to market formation*. Both the societal and techno-economic characteristics of a technology can form barriers for the formation and development of a market. The features of these barriers were already discussed in section 2.3.4 of this report. These features can also be of influence on this function. If the level of performance of niche technologies is not high enough, *market formation* is obviously difficult. Not only do niche innovations have to compete with dominant technologies, but also with other niche technologies that may have more attractive characteristics.

Another barrier to fulfilling the function of *market formation* is a lack of customer competence to articulate their demand. Potential end-users may not have the opportunity to express their preferences, suggesting that there is a need for intermediaries that formulate public demand (Negro et al., 2012).

Furthermore, when government lack a long term vision, *market formation* may prove difficult. Protective market spaces are often created for a specific application of a particular technology, with an overarching purpose at the basis of the rationale. Lack of government vision points to the absence of such purpose, consequently giving the government no incentive to create these protective spaces (Bergek et al., 2008). Although a lack of *entrepreneurial activity* would certainly hinder market formation, as it is a prerequisite for any innovation system in general, it is not adopted as a barrier to *market formation* alone.

Stimuli

There are several ways to create protected niche spaces. By identifying certain actors in market segments where the benefits of the technology are deemed to be higher than its costs, it is possible to create a protected space for innovation with a specific application (Ibid.).

Another option is to create competitive advantages for the niche technology. Government instruments to facilitate this include investment subsidies or measures affecting relative prices (e.g. tax exemption) (Smith & Raven, 2012).

Turnover that a niche technology can potentially generate is another key concept for the fulfilment of this function. Demand for that particular innovation is highly determinant for the rate of diffusion and the extent to which markets can be formed (Negro et al., 2012). Public entities can make up a large part of the purchasing share. Therefore, another stimulant for market formation is a competent municipal buyer, that ensures a large share of the turnover.

Increase concern for the environment may also stimulate *market formation* of environmentally benign technologies (Shrivastava, 1995). Public concern for the environment legitimises research into this particular field. Moreover, it justifies the *mobilisation of resources* towards this purpose, which brings us to the next function, *resource mobilisation*.

2.3.6 Resource mobilisation

Production of knowledge requires the *mobilisation of resources* in the form of human capital, financial capital, and complementary assets (Bergek et al. 2008, Hekkert et al. 2007). The fulfilment of this function is contingent on the extent to which actors within an innovation system have access to resources. If innovations are considered as the outcome of innovation systems, than resources are the input. A basic example of financial capital resources is funds for RD&D programs that aim to gain innovative knowledge and technologies. The extent to which this function is fulfilled is difficult to measure, for it is determined by the level of access to resources as perceived by agents within an innovation system (Hekkert et al., 2007). In that respect, interviews with these actors can give an indication of level of access. Access to such resources can be expressed in volume of capital, human resources and complementary assets (Bergek et al., 2008).

Barriers

Again, the lock-in to established technologies is considered to be a barrier for the fulfilment of this function. Agents that develop innovative technologies have to compete for resources in society (Hekkert et al., 2007). Actors of the dominant regime mobilise resources that are aimed to sustain the current system, disallowing niche actors to utilise these resources for the purpose of innovation. Moreover, technologies that are embedded in the incumbent regime are likely more efficient that niche technologies (Hekkert & Negro, 2008), making it more attractive for investors or other actors to put resources into those particular technologies.

The last function discussed in this chapter, *creation of legitimacy*, is also highly determinant for the *mobilisation of resources* (Bergek et al., 2008). Lack of legitimacy of innovative technology are severe obstacles for adequate *mobilisation of resources* to that particular innovation.

Stimuli

As was mentioned above, an example of *resource mobilisation* is funds for RD&D programs that aim to develop innovative technologies. In that respect, allocating more funds to such programs will contribute to the fulfilment of this function. Moreover, the mobilisation of financial capital may stimulate the mobilisation of human capital and complementary assets, as educational programs and scientific inquiry often require financial resources in order to produce desirable outcomes (Mansfield, 1991).

As was mentioned before, long-term government vision is considered to be a stimulant for the *mobilisation of resources*. Long-term goals of governmental institutions provide a certain level of justification for the *mobilisation of resources* into a certain direction (Hekkert & Negro, 2008). It increases the legitimacy of a particular kind of innovation, giving investors incentive to mobilise resources for the purpose of gaining knowledge in that particular field.

2.3.7 Creation of legitimacy

The seventh function proposed by Hekkert et al. (2007) is considered to be of utmost importance (Bergek et al. 2008, Hekkert & Negro 2008). Legitimacy is deemed to be a prerequisite for the functioning of any innovation system. Walrave and Raven (2016), distinguish between technological legitimacy and market legitimacy. These authors argue that when technological knowledge is well developed and diffused this increases the technological legitimacy of an innovation. Market legitimacy is determined by the extent to which institutionalisation regarding an innovation is established. This study adopts a more general definition of legitimacy, in order to capture the entire ontological domain. The extent to which a technology is perceived to be desirable, appropriate and socially accepted can, according to Rao et al. (2008) and Kishna et al. (2016), be generally referred to as legitimacy. This will thus be the operational definition of legitimacy is this report.

Practicality has shown that emerging innovation systems with a low level of legitimacy often function poorly, and that incumbent institutions are in such a case not well aligned with the needs of the niche agents of that particular innovation system (Hekkert & Negro, 2008). The function of *creation of legitimacy* is crucial for emerging innovation systems, as they have to compete with dominant technologies that already have a high level of legitimacy due to their embeddedness in the incumbent regime. Although these indicators are not always quantitatively expressible, the rise of interest groups and lobby activities can map the extent to which this function is fulfilled (Hekkert et al., 2007).

Barriers
First and foremost, lock-in to established technologies is again considered to be a barriers to the fulfilment of this function. As mentioned above, technologies embedded in the dominant regime are often fully legitimised (Bergek et al., 2008). Agent of the incumbent regime will defend the legitimacy of such technologies and will mobilise their resources to sustain current system dynamics. For niche innovations it is difficult compete with technologies that have such a high level of legitimacy, especially when these innovations are still in the process of *creating legitimacy* and *counteracting resistance* to these changes. Additionally, competition

with other innovations can also be a barriers for the *creation of legitimacy* of a particular innovative technology.

The characteristics of innovative technologies are another determinant for the potential to create legitimacy. Obviously, technologies that are reliable and efficient are more likely to gain legitimacy than innovations that are not. Therefore, it is pivotal for entrepreneurial actors to present the technology as featuring these particular attributes. From the perspective of the end-user, an innovation is considered legitimised when it fully adheres to their expectations (Bogers et al., 2010). As such, it is essential for entrepreneurial actors to gauge the specific preferences of the end-users. The previously explained distinction between societal and techno-economic characteristics is also applicable here. Moreover, technologies that have environmentally damaging characteristics are unlikely to gain legitimacy as it concern for the environment is a common occurrence. In terms of windmills, an example of a societal characteristic that may hinder legitimisation is the visual presence of windmills on the landscape, which can be perceived as visual pollution (Wolsink, 2000).

Another crucial factor for the *creation of legitimacy* is the extent of organisational power of agents in emerging innovations systems. According to Hekkert and Negro (2008), agent of emerging innovation systems do not easily form well organised coalitions that represent common interests. Rather, they observed that the perceptions on ideal technologies and strategies to promote them differ greatly among agent within emerging innovation systems.

Stimuli

An important catalyst for the *creation of legitimacy* is the formulation of advocacy coalitions (Bergek et al., 2008). Agents within an innovation system that act in a coordinated manner to represent common interests have significant influence on the legitimisation of innovative technologies. As actors of the incumbent regime will also defend embedded technologies by means of well organised action strategies, the only way to compete with these forces is to create opposing advocacy coalitions that unite in common interests (Hekkert et al., 2007).

Agent of emerging innovation system, ideally united as advocacy coalitions, can stimulate the creation of legitimacy of innovations by lobby activities. The technical, institutional and financial conditions for particular innovative technologies can be influenced by agents lobbying for that innovation (Hekkert & Negro, 2008). Lobby activities can take the form of awareness campaigns, workshops, conferences, web-tools etc..

External factors can also influence the legitimacy of certain technologies. Concern for the environment legitimises innovation in the field of renewable energy, or other environmentally friendly technologies (Bergek et al., 2008). For example, innovations that are aimed to decrease carbon output of regime embedded technologies are fully legitimised, even by the incumbent regime, as it does not threaten the incumbent regime, and is considered compatible with dominant actor interests.

Lastly, long-term government goals can justify the *guidance of the search* in a particular direction, and incentivise entrepreneurs to *mobilise resources* for one particular purpose (Hekkert & Negro, 2008). In that sense, long term objectives of governmental institutions legitimise innovations in a certain field, stimulating the fulfilment of the function of creation of legitimacy. Moreover, government agents may also be involved in lobbying activities in order to contribute to reaching long-term government objectives.

2.3.8 Overview of barriers and stimuli

This section of the paper provides an overview of all the barriers and stimuli that affect the fulfilment of the proposed functions of innovation systems, as identified in the literature. Theory analysis reveals that the functions are relevant to several dimensions. Table 2.1 reflects this, not only by categorizing the barriers and stimuli by functions, but also by showing the frequency of dimension(s) for each function. The purpose of the dimensional distinction is to serve as an interview candidate selection criterion. The analysis revealed that the barriers and stimuli that influence the functions of innovation systems are relevant to five different dimensions: technical (Kemp & Rotmans 2005, Hekkert et al. 2007); social (Ibid); economic (Blanco 2009, Hekkert et al. 2007); institutional (Edquist 1997, Geels 2004, Hekkert & Negro 2008); political (Hekkert et al. 2007, Smith & Sterling 2010). Bearing in mind the goal of the dimensional distinction, identification of the dimensional nature of a particular barrier or stimuli does not mean that it cannot be classified as constituting other dimensions. Rather, the table shows the most prominent dimension in which a certain barrier or stimuli is of influence, as identified from the existing body of literature. The identification of the relevant dimensions thus guides the selection of interviewees. As interview candidates are selected on the basis of their knowledgeability within a certain dimension, selecting them on the basis of these dimensions ensures that all relevant aspects are addressed by experts in the field. Furthermore, when it is identified that certain barriers or stimuli of one particular function are mostly (not exclusively) e.g. economic in nature, policy recommendations can be calibrated more specifically to focus on that particular aspect of the function. The nature of each barrier and stimuli is determined by analysing literature on the FIS framework.

Functions of innovation systems	Barriers	Stimuli	Relevant dimensions
Entrepreneurial activity	Lock-in to established technologies Lack of long-term government vision	Protected niche spaces (nursing markets) Measures affected relative prices (e.g. tax exemption) Encouraging experimentation (learning by doing)	Technical (1/5) Economic (2/5) Institutional (2/5)

Knowledge development	Weak network failure Lack of entrepreneurial activities (F1)	Government RD&D programmes Encouraging experimentation (private sector) (learning by doing)	Technical (2/5) Economic (2/5) Institutional (1/5)
Knowledge diffusion through networks	Weak network failure	Stimulate interaction (learning by interacting) in the form of workshops, conferences, forums	Institutional (2/2)
Guidance of the search	Lock-in to established technologies Societal characteristics of technology Techno-economic characteristics of technology Weak organisational power	Formulation of long term goals (i.e.renewable energy) Government RD&D programmes Increasing legitimacy (F7)	Technical (2/7) Institutional (3/7) Political (1/7) Social (1/7)
Market formation	Lock-in to established technologies Societal characteristics of technology Techno-economic characteristics of technology	Protected niche spaces (nursing markets) Investment subsidies Measures affected relative prices (e.g. tax exemption) Competent municipal buyer	Technical (1/9) Institutional (2/9) Economic (3/9) Social (3/9)

	Lack of customer competence Lack of long-term government vision	Increase concern for the environment	
Resource mobilisation	Lock-in to established technologies Lack of legitimacy of innovations (F7)	Government RD&D programmes	Technical (1/3) Institutional (1/3) Political (1/3)
Creation of legitimacy/counteract resistance to change	Lock-in to established technologies Societal characteristics of technology Techno-economic characteristics of technology Opposing advocacy coalitions of incumbent regime	Formulation of advocacy coalitions Awareness campaigns Lobby activities, including workshops, conferences, web-tools Increase concern for the environment	Technical (1/8) Institutional (1/8) Political (4/8) Social (2/8)

Table 2.1 List of all identified potential factors

The development of the analytical framework has revealed that all the proposed functions of innovations systems are highly interconnected and interactive. The weight of the barriers and stimuli (including the effect the functions may have on one another) are not explicit in the existing body of literature. This may also differ greatly across cases and geographical setting. Interviews with stakeholder in the wind energy sector in the Netherlands, selected on the basis of the relevant dimensions, will provide insight into which of these barriers and stimuli are most relevant, and would benefit from intervention by government or other actors.

Literature review has revealed that each function is influenced by multiple barriers and stimuli. As was established in the beginning of this chapter, a well-functioning innovation system is able to facilitate rapid diffusion of technology. This concept, in turn, is interchangeable with the concept of upscaling. Hence, upscaling potential can be determined by examining the barriers and stimuli that affect innovation system performance. This makes the FIS framework ideally suited to systematically analyse upscaling potential. Figure 2.2 depicts this line of argumentation in a schematic framework. This alternative conceptual framework works its way back from the independent variables (barrier and stimuli) to the dependent variables (upscaling potential).

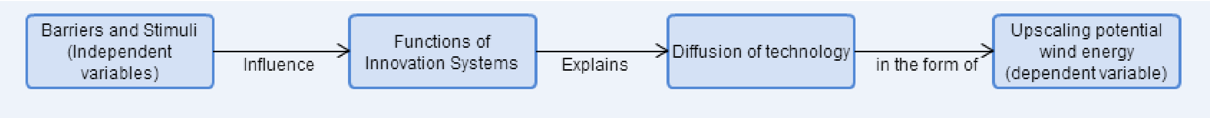


Figure 2.2 Alternative conceptual framework (reverse)

Although the existence of these independent variables has become apparent from the literature, the level of influence is still unclear. Interviews with actors within the innovation system will shed light on this knowledge gap.

3. Methodology

The third chapter of this report entails a detailed explanation of the methodology that is used to achieve the research objective. The first section explains the design of the project on a step-by-step basis. The structure of this section adheres to the research framework depicted in figure 3.1. The methodology used for data collection and data analysis is explained is the section that follows. The selection criteria for interviewees, and the structure for the policy formulations are described here as well.

3.1 Research Design

Figure 3.1 illustrates the research framework in several steps. The operationalisation of each of these steps will be briefly explained in this section of the paper. The first step is to review existing literature on transition and upscaling in order to identify functions of transition, and their respective barriers and stimuli. The literature on the FIS framework is the main source from which the functions, and the associated barriers and stimuli, are derived. The theoretical perspectives of SNM and TT embed the framework in additional literature on transition. Moreover, these theories have contributed to the identification of barriers and stimuli, once the functions were established.

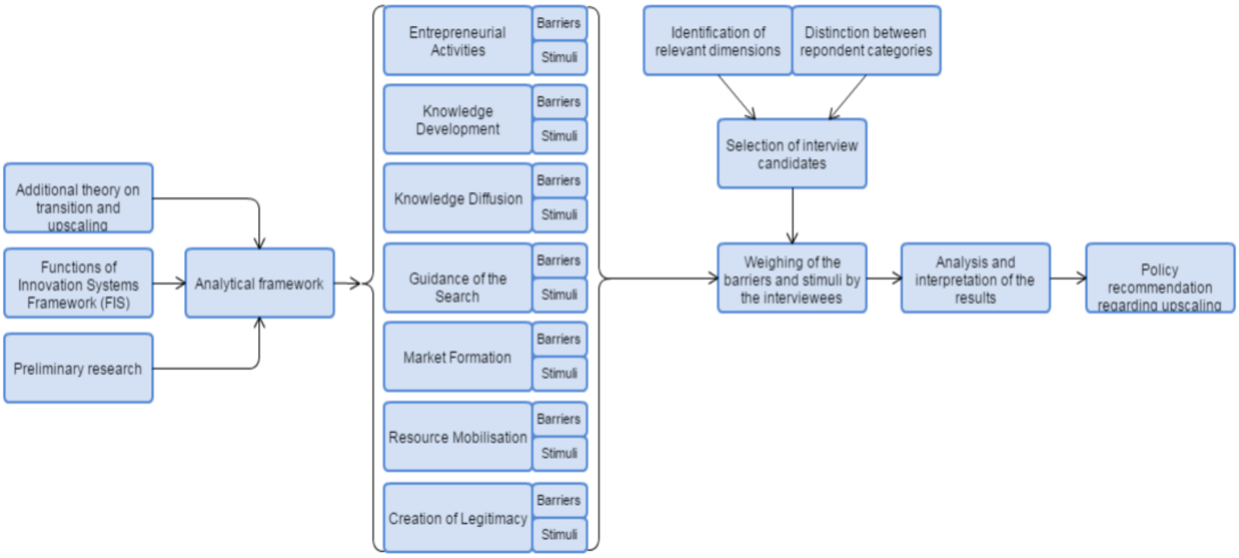


Figure. 3.1 Research framework (Verschuren & Doorewaard, 2010)

The second step regards the development of an analytical framework on the basis of the functions. Analysis of the literature on socio-technical systems, transition, and innovation points towards the existence of several system levels that interact in different dimensions. The analytical framework is structured by the identified functions and the nature of the barriers and stimuli that were identified within the existing body of literature on transition and wind energy. The analysis revealed factors that constitute five different dimensions: technical (Kemp & Rotmans 2005, Hekkert et al. 2007); social (Ibid); economic (Blanco 2009, Hekkert et al. 2007); institutional (Edquist 1997, Geels 2004); political (Hekkert et al. 2007, Smith & Sterling 2010).

The following step regards the empirical application of the analytical framework to the wind energy sector in the Netherlands. As the literature has revealed which barriers and stimuli potentially influence the fulfilment of the functions, and hence upscaling, the actual existence and weight of these factors was determined by empirical data derived from interviews with stakeholders. The interviews are structured as such, that the respondents directly respond to the proposed barriers and stimuli. The interview candidates were asked to weigh all the potential barriers and stimuli, as identified in the literature, according to their own experience in the field. In the interviews, each function was addressed separately. For each function, the interviewees were asked about the extent to which they perceive the associated barriers and stimuli affect the fulfilment of that function with regard to wind energy in The Netherlands. In order to quantify the weight of the different factors, the respondents gave each barrier and stimuli a score from 1 to 5, where 1 indicates the lowest level of influence on the fulfilment of the function in question and 5 indicates the highest level of influence. Consequently, the mean score of each barrier or stimuli suggests a certain level of influence on the fulfilment of particular functions. After weighing each barrier and stimuli of a particular function, the interviewees were asked to give a score to the fulfilment of that function, as well as their impression of the Dutch wind energy innovation system in its entirety. This provided additional insight into the real-time dynamics of wind energy upscaling in The Netherlands.

3.2 Data Collection

The main source of information for the theory analysis was academic literature. This literature was searched for by using academic search engines such as Google Scholar and Scopus. The main selection criteria for the relevant literature is the extent to which it deals with transition, innovation, wind energy, upscaling, or socio-technical systems, using these concepts as key search words. Background information on the wind energy sector in The Netherlands was obtained using official government documents, public databases and academic literature. These sources have also pointed out which policy-makers were involved in the wind energy sector in The Netherlands.

In order to fully encompass all relevant factors in the results, stakeholders were also selected on the basis of the dimensions. As it would not be relevant to i.e. interview an environmentalist regarding the technical specification of a project, the interviewees were selected on the basis of their relative knowledgeability within a certain dimension, as evidence of their position in the wind energy sector in The Netherlands. A number of stakeholders of the largest wind energy projects, either operational or under construction, on-shore or off-shore, were selected for the interviews. In addition, stakeholders that are involved in the innovation system in some other manner (e.g. government policymakers) were selected as well. The barriers and stimuli to the fulfilment of the functions that are of influence on wind energy are presumably different for on-shore wind projects than for off-shore wind projects. Off-shore windfarm are for example considered to be more efficient (more wind), but have more environmental impact (Bilgili et al., 2011). Although the upscaling dynamics may be similar, the possible difference in upscaling potential between on-shore and off-shore wind energy justifies the selection of interview candidates that are involved in off-shore wind energy projects as well as on-shore projects.

In order to capture the political and institutional dimensions, policy-makers were the most suited candidates. Operators and developers of the particular wind energy projects are appropriate to cover the technical and economic dimensions. Opposing parties often call upon environmental and socio-cultural objections in their argumentation (Devine-Wright 2005, Oosterlaken 2015). In that respect, environmentalists and residencies that are opposed to wind farms may offer novel insight with regard to the social dimension. In addition, there are some pragmatic issues that need to be considered, such as availability and willingness of the interviewees or any monetary costs that may be involved. The above mentioned considerations initially lead to the following selection criteria: Involvement in the wind energy innovation system in the Netherlands (1); perceived knowledgeability within a certain dimension with regard to wind energy in the Netherlands (2); availability of the interview candidate (3); willingness to participate of the interview candidate (4); feasibility in terms of time and money (5). The first two criteria are most important for the sake of external validity of the results. In order to identify potential candidates, the first step was to dissect the Dutch wind energy innovation system, so that the different structural components reveal which actors are involved in this system. The structural dimension that revolves around system actors can, according to Wieczorek and Hekkert (2012) be divided into subcategories: Civil society; companies (start-ups, SMEs, large firms, multinational companies); knowledge institutes (universities, technology institutes, research centres, schools); government; non-governmental organisations (NGOs). The categorisation of potential respondents leads to the adoption of an additional selection criterion. In order to ensure a high level of inclusiveness, three interview candidates from each of these subcategories were selected for analysis, each addressing one or more dimensions of the innovation system. The selection of the interviewees was done as such, that each of the identified dimensions is addressed by the expertise of at least 6 candidates. Note that some candidates can address the problem from multiple dimensional perspectives. The selection criteria resulted in 15 interviewees (N=15), three from each category. The interviews are semi-structured on the basis of the analytical framework in order for the factors identified from the literature to be directly addressed by the respondents. Appendix I presents the interview design that was used to conduct the interviews. Appendix II comprises a list of the involved respondents.

3.3 Data Analysis

The final two steps entail the analysis and interpretation of the empirical findings, and the formulation of policy recommendations. Each of the functions was addressed separately in the interviews, allowing for the formulation of policy recommendations that are specific to one particular function. Although this may not be reflected in accumulative scores per function, barriers or stimuli that were revealed to exists for multiple functions require more attention than others. The policy recommendations hence adhere to the accumulative score given by the respondents and frequency of reoccurrence of a particular barrier or stimuli. In order to ensure more consistency throughout the paper, the policy recommendations were structured according to the respondent categories discussed in the previous section.

3.3.1 Descriptive Statistics

The results of the interviews allowed for a quantification of the relevance the function, and the influential factor. Since the functions have no absolute value, statistical analysis is unpractical. However, descriptive statistics has revealed some interesting observations. As each of the functions was addressed separately in the interviews, each of the individual functions spawned a sample that allows for statistical description. Therefore, each function was addressed separately in Microsoft Excel as well, so that each function can be quantitatively assessed individually. In essence, the mean relevance score for each function and each factor provides an hierarchical picture of the relation between these variables and their level of impact on upscaling potential of wind energy. In that way, all the variables adopted in this study can be compared and assessed for their relevance, ultimately providing structured insight into the dynamics of upscaling potential of wind energy in The Netherlands. Each of the samples (which were thus analysed separately) was tested for normal distribution. The standard deviation (SD) from the mean than reveals the level of opinion polarisation (which is often thought to be high for wind energy discussions) regarding one particular function. The higher the SD, the more data-points, in this case opinions, deviate from the mean regarding the factors that affect the function. A SD score of 0 means all data-points have the same value. The highest possible SD score for this data set is 2, since the respondents can choose from only five scores (1-5) and N=15. This study adopts the following rule: SD scores lower than 1 indicate a certain level of consensus and SD scores higher than 1 indicates a lack of consensus. This also means that SD scores close to one can be considered to indicate a medium level of consensus. Appendix IV consists of an excel file in which all scores were computed. The file is accessible with Microsoft Word.

In addition to the relevance scores for each factor potentially affecting the functions, in conclusion of the interviews the respondents were asked to give a relevance score to each of the functions in their entirety. This allowed for additional more holistic statistical description of the functional relevance as well. Microsoft Excel was used to compute mean relevance scores for each of the functions, which in turn allowed for the comparison between the functions in terms of their relevance for upscaling potential at this time. Ultimately, the statistical description on different levels provided statistical scores (Mean, standard deviation etc.) and thereby shed light on which functions are most relevant at the current stage of the Dutch wind energy innovation system, and which barriers and stimuli are most relevant for each of these analysed functions.

3.3.2 Qualitative Data Analysis

Although the quantification of the interview results was successful, many of the scores given to the variables were accompanied by qualitative data as well. More often than not, the respondents stated some condition or remark when providing the variables with a score. Therefore, in order to increase the validity of the conclusions derived from the quantification, it is essential to analyse these references and remarks made in the interviews. The qualitative data that resulted from the quantification efforts was therefore coded and analysed using qualitative data analysis software NVivo.

NVivo is computer software designed and published by QSR, a qualitative research software developer based in Melbourne, Australia. The program has been continuously improved upon since its first publication in 1999. The program was designed for the purpose of aiding social scientists or scientists in any other fields that deal with qualitative data that does not initially show any structure or patterns. It was developed as a tool to help organise and analyse unstructured qualitative data, so that it may provide insights into potential patterns or observations that were otherwise not comprehendible. As the qualitative data that was collected in the interviews of this study is unstructured, NVIVO provides an opportunity to organise this data into theme categories, which are referred to as nodes. These nodes can contain subthemes which are referred to as child nodes. The program allowed for the codification of interview responses, so that the qualitative data provides insight that explains why the respondents may have given particular scores to particular variables. Moreover, polarisation regarding a certain issue, as evidence of a high SD value, can be explained by structuring the qualitative data. The categorisation of these codifications can be visualised by illustrating nodes, child nodes in different types of figures. Subsequently, the policy recommendations that can be formulated on the basis of the results are thorough and precise because, by using the NVIVO tool, they take all qualitative input from the interviews into consideration.

4. Results

The results chapter of this report is structured as such, that it adheres to the distinction between the functions of innovation. Consequently, each of the functions is discussed in a separate section. Each of these sections consists of a sub-section covering the descriptive statistics as computed by excel, a sub-section in which the results of the qualitative data analysis is presented, and a concluding sub-section in which the findings are put into context by comparison and integrated analysis. For the qualitative part of this study, a total number of 166 references were coded and categorised into a total number of 44 (child)nodes, each representing a collection of remarks all pointing out a particular qualitative observation regarding the discussed functions and factors. This allowed for the determining some of the reasons for any discrepancies between the different respondent opinions. The rationale for giving certain relevance scores to certain factor can also be examined by addressing the qualitative data. Although there were many references and themes, the structuring of these shed light on the dynamics that are at play within the different functions. In that way, the qualitative data analysis contributed to reaching valid conclusions regarding the upscaling potential of wind energy.

References of child nodes are **not** aggregated to their parent node, in order to make a distinction between references that are categorised in the parent node directly, and references that are included in a theme by means of a child node. The functions are captured by a set of nodes that, according to the respondents, relate to that particular function, or to the system in its entirety. Thus, including a node set for more general references, a total of 8 node sets were constructed. Subsequently, many nodes are adopted in the node set for multiple functions, since many references relate to multiple functions. The extent to which nodes reoccur in different functions can also indicate the level of relevance of that particular node. Appendix III contains a complete list with detailed description of each node, accompanied by the number of references and respondents. Some nodes may have a slightly different meaning for different functions. The chapter is concluded with an integration of all qualitative and quantitative results, so that they can be translated into policy recommendations. This last sub-section includes figures that provides a comprehensive overview of all the results discussed in this chapter.

4.1 Entrepreneurial Activity

4.1.1 Descriptive Statistics

For each of the functions, the interviewees were asked to score the function, on the basis of their own experience and expertise, in respect of the fulfilment of the function at this point. As such, the interviewees were asked if they thought there is enough *entrepreneurial activity* in the wind energy system in which we are embedded. The mean score for fulfilment of this function is precisely 4. With the maximum score, meaning optimally fulfilled, being 5, an average score of 4 suggests that *entrepreneurial activity* regarding wind energy is perceived to be well present in order for wind energy to be up-scaled. Only two of all respondents scored the fulfilment of this function lower than 4. Thus, there seems to be a relatively high level of consensus regarding the fulfilment of this function. The low standard deviation score of 0.76 supports that conclusion. As mentioned before, the higher the standard deviation the more likely the issue at hand is contested among the respondents.

The relevance score for *entrepreneurial activity* is somewhat lower than its fulfilment. The mean relevance rating of 3.47 suggests that this particular function is moderately relevant at this point. This contemporary measurement is unsurprising, since the function is relatively well fulfilled. The majority of the respondents that rated the fulfilment as high, scored the relevance of this function lower. The standard deviation regarding the relevance of this function points to medium consensus on the matter. A standard deviation score of 0.99 indicates there is some, albeit slight, disagreement regarding the relevance of this function. Most striking is that two of the respondent categories have a relatively higher relevance score for this function. The categories of companies and NGOs both have a mean relevance score of 3.67. It is however no surprise that companies and NGOs would consider entrepreneurial activity as relevant, since it is most relevant for their own sphere of activities.

In the first phase of this study, five factors were identified that either block or stimulate the fulfilment of this function, and thus the upscaling of wind energy technology. Figure 4.1.1 below shows a chart in which the mean relevance scores of all these identified factors is depicted. Moreover, the standard deviation is also included in order to shed light on the level of consensus regarding one particular factor. The extent to which the respondent feel that a *lock-in to established technologies* (e.g. conventional finite energy sources) is a barrier for entrepreneurial activity is scored lowest, with a mean relevance score of 2.2. This suggests this factor is regarded only slightly relevant at this point. The other factors are all considered moderately relevant to very relevant for the fulfilment of this function. The highest mean relevance score of 4.33 was given to *measures affecting price* (e.g. subsidies), which is considered to stimulate entrepreneurial activity. The SD value of 0.9 suggests the respondents are mostly in agreement about this. Only two of the respondents scored this factor below 4, and thus considered it less relevant. Both of these respondents are in the companies category. However, the other four factor seem to show a much lower level of consensus. The stimulant of *lack of long-term government vision* has been given the highest SD value of 1.35, which suggest the respondents disagree regarding the level of effect of this factor at this point.

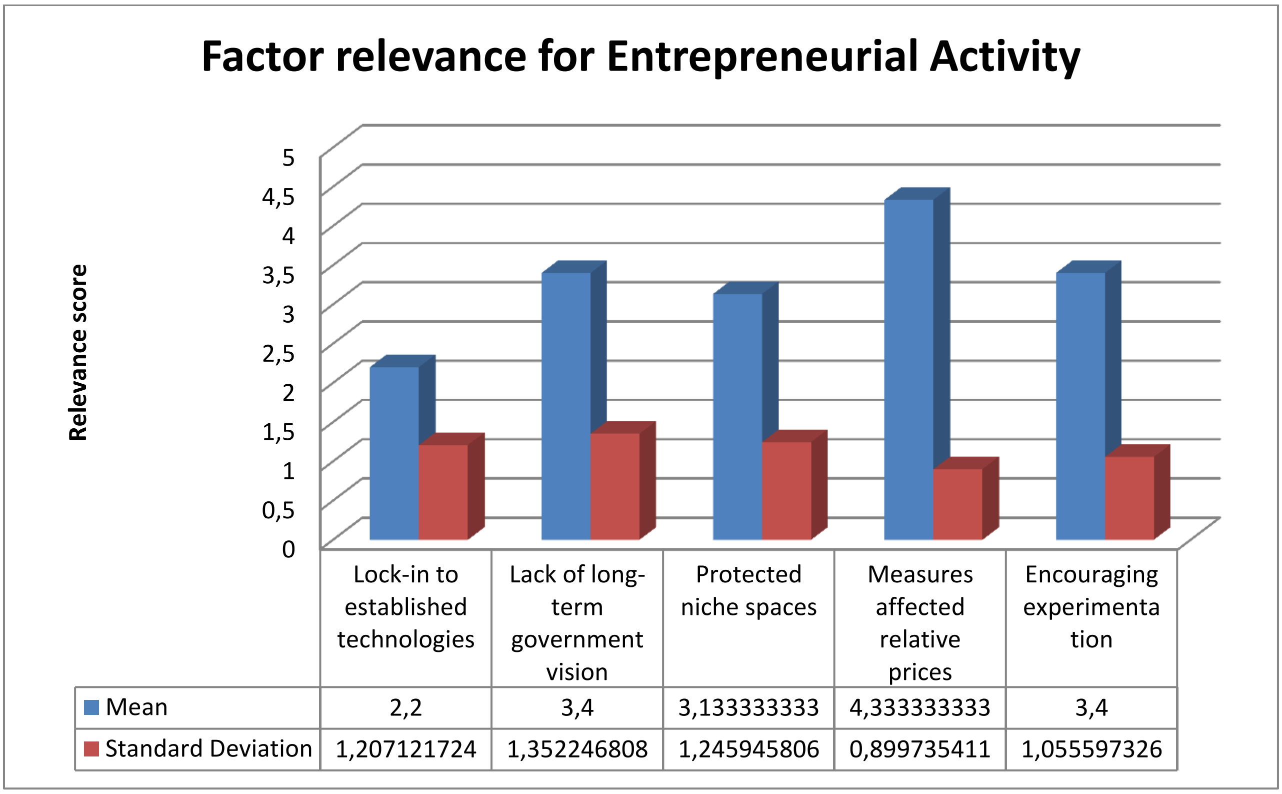


Figure 4.1.1. Relevance per factor affecting the fulfilment of entrepreneurial activity

4.1.2 Qualitative Data Analysis

For the function of *entrepreneurial activity*, the references regarding this function were categorised into a set of 9 nodes of which 2 contains child nodes. Figure 4.1.2 illustrates a visualisation of this set of nodes. The first number in the spheres indicates the number of references that were coded and categorised into that particular node. The second number indicates the number of respondents from which these references have spawned.

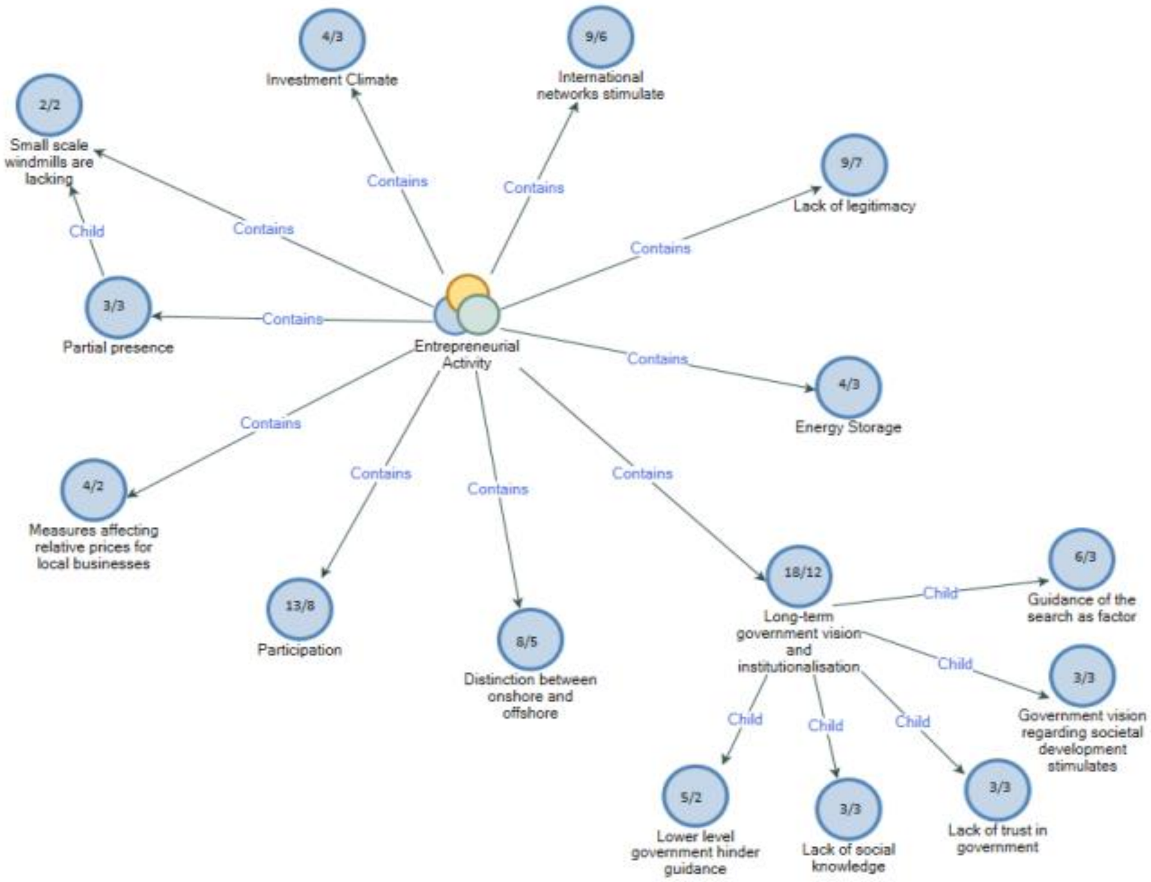


Figure 4.1.2 Categorisation of references into nodes and child nodes that regard entrepreneurial activity

The respondents were asked, for each function, if they perceived any additional factor as having influence on the fulfilment of this function. As a result, four additional factors that affect this function were derived from interviewee responses: *lack of legitimacy; investment climate; participation; energy storage capabilities*. Each of these are represented in the figure 4.1.2 as nodes as well. Since these factors were proposed as influential factors, and were references to multiple times by multiple respondents, these factor can be considered relevant. Among these additional factors, *participation* was most referenced to (13/8), indicating that this factor is even highly relevant for the fulfilment of this function. Nodes other than the ones that spawned from the question of additional factors contain references that were made during scoring of the factors that were given.

The most reoccurring theme regards the node of *long-term government vision and institutionalisation,* which contains 18 references by 12 different respondents. References in this node all pointed out that long term government vision and the resulting institutionalisation has or would have a stimulating effect on entrepreneurial activity regarding wind energy. Moreover, the role of the government in spatial planning and resource accessibility is addressed in this node as well. Strikingly, the factor of *lack of long-term* *government vision,* which constitutes the same theme, spawned the highest SD value of all factors, as depicted in figure 4.1.1. The child nodes of *long-term government vision and institutionalisation* shed light on this lack of consensus. One of these child nodes indicates that there were multiple references that indicate a lack of trust in the government. Besides the extent to which the government acts in the best interest of the public, there were also references that indicate that there is a lack of knowledge regarding the societal implications of wind energy, which is categorised in another child node. This may be one of the reasons why lower-level governments, like provinces and municipalities, are often, according to the respondents, opposed to wind energy in their region. The latter is also categorised in a child node.

4.1.3 Integrated Analysis

After establishing a hierarchy between the given factors in terms of their relevance, these were put in context by means of the codification of references, which in turn lead to additional factors. For the purpose of comprehensibility, the factors with the highest attributed relevance and the most referenced additional factors for the function of *entrepreneurial activity* are summarised here.

The function of *entrepreneurial activity* is considered to be well fulfilled and is also regarded to be very relevant for upscaling wind energy technology at this time. The respondents are in a medium to high level of consensus regarding this matter. Moreover, there are several factors that influence the smooth continuation or improvement of the fulfilment of this function. Three of the five factors that were measured are considered moderately relevant. The factor of *measures affecting relative prices*, such as subsidies, is of key importance for entrepreneurial activity, since it was scored highest in terms of relevance. In addition, *long-term government vision* is also considered to be essential, even more so because it was included in both the quantitative and qualitative analysis of this function. Another factor that is indispensable is that of *participation,* as it was referred to many times by many different respondents. Although the factors that have spawned from coding the references are certainly significant, it is difficult to rank them in terms of relevance since this was not measured. Yet, these factors can be considered to have significant influence on the fulfilment of this function.

4.2 Knowledge Development

4.2.1 Descriptive Statistics

The quantitative results of the interviews point towards a relatively high level of fulfilment of the function of *knowledge development*. The mean fulfilment score is 3.93, suggesting that knowledge development with regard to wind energy is sufficiently presenting order for the technology to smoothly diffuse and to be up-scaled. More than two thirds of the respondents (10) scored the fulfilment of this function at 4. The interviewees appear to be in agreement regarding this matter. The SD for the fulfilment of this function scored a 0.59, hence indicating a very high level of consensus.

The relevance of this function for upscaling wind energy is considered relatively high. The mean relevance score of 3.4 suggests that the function scored above moderately relevant. These quantitative results hence indicate that the respondents consider *knowledge development* to be relevant at this time for upscaling wind energy. The level of consensus regarding the relevance of this function is however low. Three of the respondents scored the relevance at a maximum of 5. It is most striking that two of these three are in the category of civil society. The third respondent in this category scored the relevance at 4, resulting in an average of 4.67 for that category. This thus indicates that *knowledge development* is considered highly relevant by civil society. Contrarily, three other respondent scored the relevance of this function at 2. Two of these are in the government category, suggesting that from a governmental perspective, *knowledge development* is at this time only slightly relevant for upscaling of wind energy. The difference in scores is also reflected in the SD, which was computed at 1.12. Notably, respondents in the same category mostly do seem to be in agreement regarding the relevance score. The lack of consensus thus originates from the different perspectives of the respondent categories.

Literature review spawned four factors that influence the fulfilment of this function. Two of these are considered barriers and the other two are considered to stimulate this function. Again, the quantitative results regarding these factors are depicted in a graph, as illustrated in figure 4.2.1. By far the most influential factor is that of *encouraging experimentation*, with a mean relevance score of 4. Only two of the respondents scored this factor lower than 4, suggesting that there is a relatively high level of consensus that suggests this function is most important for the fulfilment of the function of knowledge development. A very low SD score of 0.76 supports the latter claim. The factor of *R&D* was given the second highest mean score, 3.2, but is still only considered moderately relevant. Although, a SD of 1.08 indicates the respondent were not in agreement regarding this matter. Moreover, even among respondent of the same category, there is a lack of consensus regarding the relevance of *R&D* for knowledge development. Most striking for this function is that the two potential barriers, as identified in the literature review, have a significantly lower relevance scores that the two stimulants. *Weak network failure* and *lack of entrepreneurial activity* were given mean relevance scores of 2.33 and 2.47 respectively. Hence, this suggests that these barriers are considered only slightly relevant for the fulfilment of the function of knowledge development at this time. The SD scores for these factors are however relatively high, 1.11 and 1.06 respectively, indicating that the respondent are not in agreement. The consensus within each respondent category is significantly higher, with the exception of the civil society category.

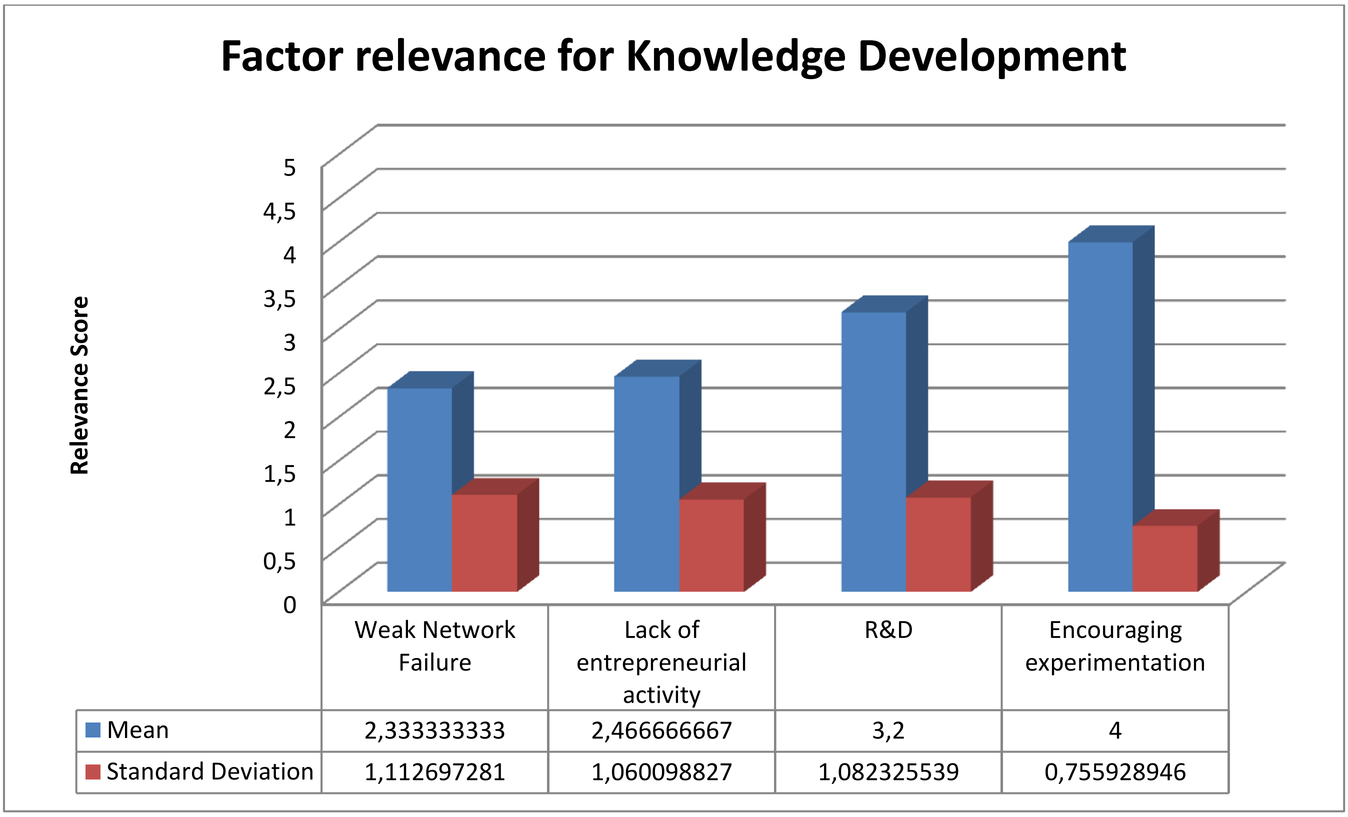


Figure 4.2.1 Relevance per factor affecting the fulfilment of knowledge development

4.2.2 Qualitative Data Analysis

References relating to the function of *knowledge development* were categorised into 12 nodes. One of these nodes, *participation*, is a directly adopted child node of one other included node for this set. Moreover, another child node, *lack of social knowledge*, for which the parent node is not included is adopted directly into this node set as well. Figure 4.2.2 depicts this set of nodes. Again, the first number in the spheres indicates the number of references that were coded and categorised into that particular node, and the second number indicates the number of respondents from which these references have originated.

The factors that were proposed as influential by the respondents are the following: *Competition; resource mobilisation; participation; educational climate; fragmentation.* Each of these factors are adopted as nodes, thus references that fit this their particular theme are categorised as such. The node of *participation* includes most references among the proposed factors (13/8). Besides the relevance of this factor for the previous function, it is thus also highly relevant for *knowledge development.* Especially participation in the development of knowledge regarding the social implication of wind energy is, according to the respondents, essential for the fulfilment of this function, and for upscaling wind energy entirely. *Competition* is another factor that often referred to. Many of the respondents indicated that competition between major players in the wind energy system hinders the sharing and further development of knowledge, both social and technical. *Collective goalsetting* and *international networks* in which to cooperate are therefore essential to overcome such isolationist behaviour. These factors are also included as nodes, both containing 9 references in the figure below.

Only one of the given factors revealed an SD value that indicates a lack of consensus. The factor of *weak network failure,* is considered only slightly relevant by the majority of the respondents. Yet, three respondents gave a high relevance score. Strikingly, these respondents all have a more social and institutional perspective regarding the wind energy system. This is reflected in some of the references made by these respondents. These references were coded in nodes that correspond to this perspective, *lack of social knowledge* and *international networks.*

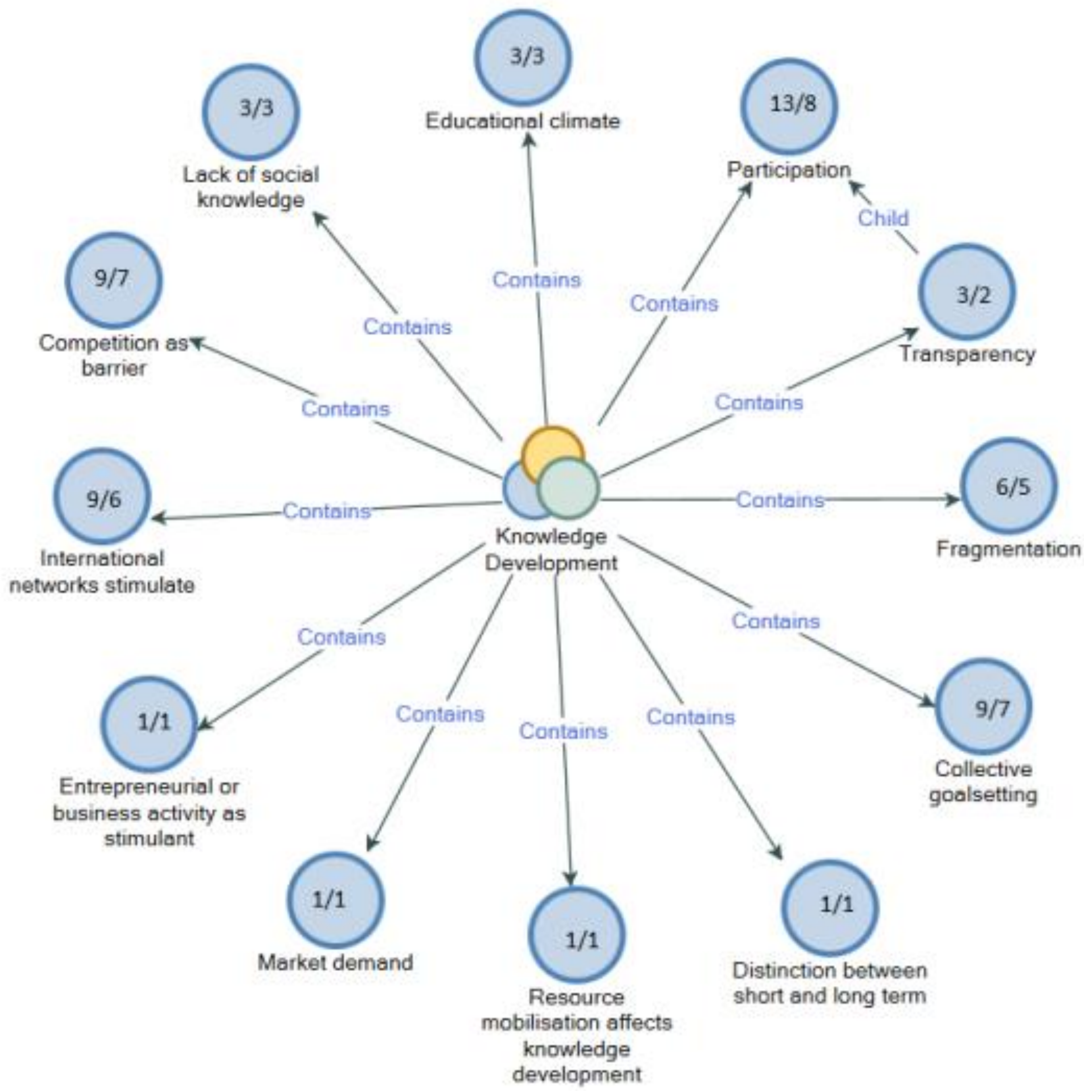


Figure 4.2.2 Categorisation of references into nodes and child nodes that regard knowledge development

4.2.3 Integrated Analysis

The function of knowledge development is considered, with an high level of consensus, to be well fulfilled. The function is regarded to be more than moderately relevant, however the level of consensus regarding this matter is low. The barriers that hinder this function from being better fulfilled were not identified in the literature review, since the given barriers were scored low in terms of relevance. Hence, the additional factors from the qualitative analysis need to be consulted. Still, of the given factors, the factor of *encouraging experimentation* is considered to be most important. The qualitative analysis however revealed that *competition* is a significant barrier for this, and for the function as a whole. This barrier can be overcome by *collective goalsetting*, which is another influential factor that was referred to by many respondents.

4.3 Knowledge Diffusion Trough Network

4.3.1 Descriptive Statistics

The extent to which knowledge is diffused through networks is considered only moderate. The mean fulfilment score for this function is 3.2. In comparison with the other functions, this is a rather low level of fulfilment. However, the extent to which this function is fulfilled is highly contested. The SD score of 1.08 points to a low level of consensus. When looking at the scores more closely, the difference between the respondent categories seem to be the main reason for a higher SD value. Contrarily, within each category the respondents are mostly in agreement with each other. The most striking difference in opinion is between civil society and the other categories. Civil society considers this function to be unfulfilled, with a mean score of 1.67. While the categories of knowledge institutions and government consider the extent to which knowledge is diffused through networks relatively high, with mean scores of 3.67 and 4.33 respectively.

Whether knowledge diffusion through networks is considered relevant at this time for upscaling wind energy technology was measured with relevance scores. The mean relevance score for this function is 2.93. This suggests a moderate relevance for knowledge diffusion. There is however significant difference in the relevance scores given by the respondents with outlier scores of both 1 and 5 included. The SD value of 1.1 is evidence of the lack of consensus regarding this matter. Most striking is that the respondent category of companies spawned a mean relevance score of 1.67, hence much lower than the mean of the entire sample. The respondent category of government are in complete consensus that this function is only slightly relevant, as they all gave a relevance score of 2.

Figure 4.3.1 depicts the relevance scores of the factors that influence knowledge diffusion through network, as determined in the literature review. One of these two is considered to stimulate diffusion, and the other to block it. As was explicated in the methodology chapter of this rapport, the respondents were also asked to provide additional factors if able. For this function this is of particular relevance, since only two factors were identified in the literature review. Still, the two factors that were identified were quantified for their relevance. The stimulant was given a significantly higher relevance score than the barrier. There is a relatively high level of consensus regarding the relevance of *interaction stimulation*, which was given a mean relevance score of 3.2. The SD value of 0.86 also points towards a high level of consensus. It is striking that there is however no consensus regarding this factor among the respondents in the category of knowledge institutions. The barrier, which was given a mean relevance score of 2.53, is somewhat more contested than the stimulant. A very high SD value of 1.19 indicates that opinions regarding the influence of *weak network failure* are divided. Most striking is that the respondent category of NGOs are in consensus that this barrier is at this time irrelevant (mean relevance score of 1.33) for the diffusion of knowledge.

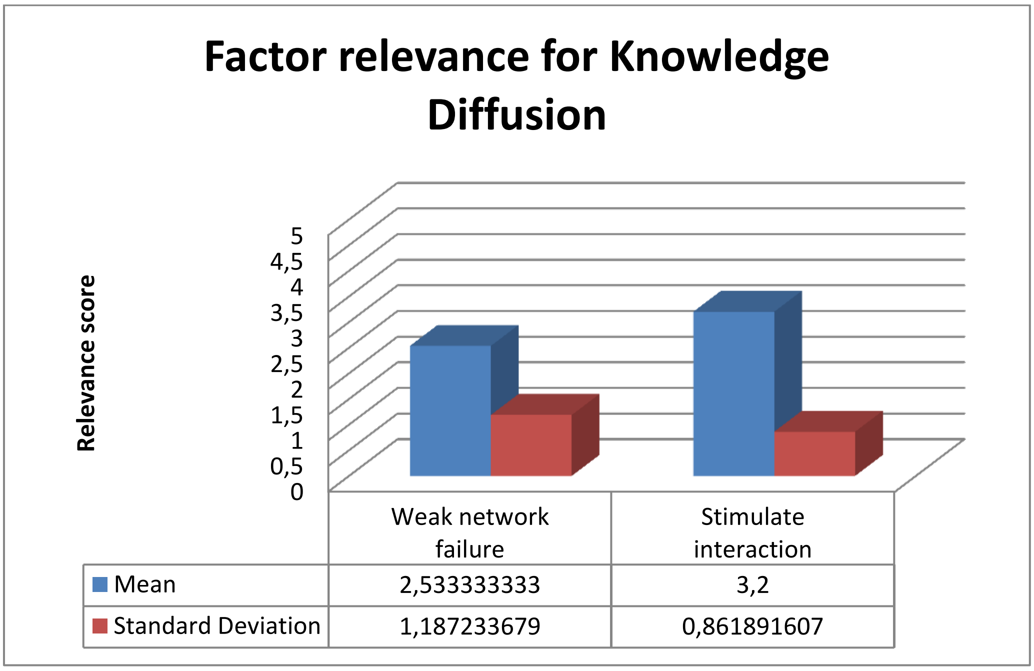


Figure 4.3.1 Relevance per factor affecting knowledge diffusion through networks

4.3.2 Qualitative Data Analysis

References that relate to *knowledge diffusion* were categorised into 6 nodes, none of which contain child nodes. However, *lack of trust in government* and *participation* are child nodes that are directly included, and of which the parent nodes are not adopted in this node set. Figure 4.3.2 illustrates the node set for this function. Once more, in order to read the figure the same rules apply as in the figures of the previous sub-chapters.

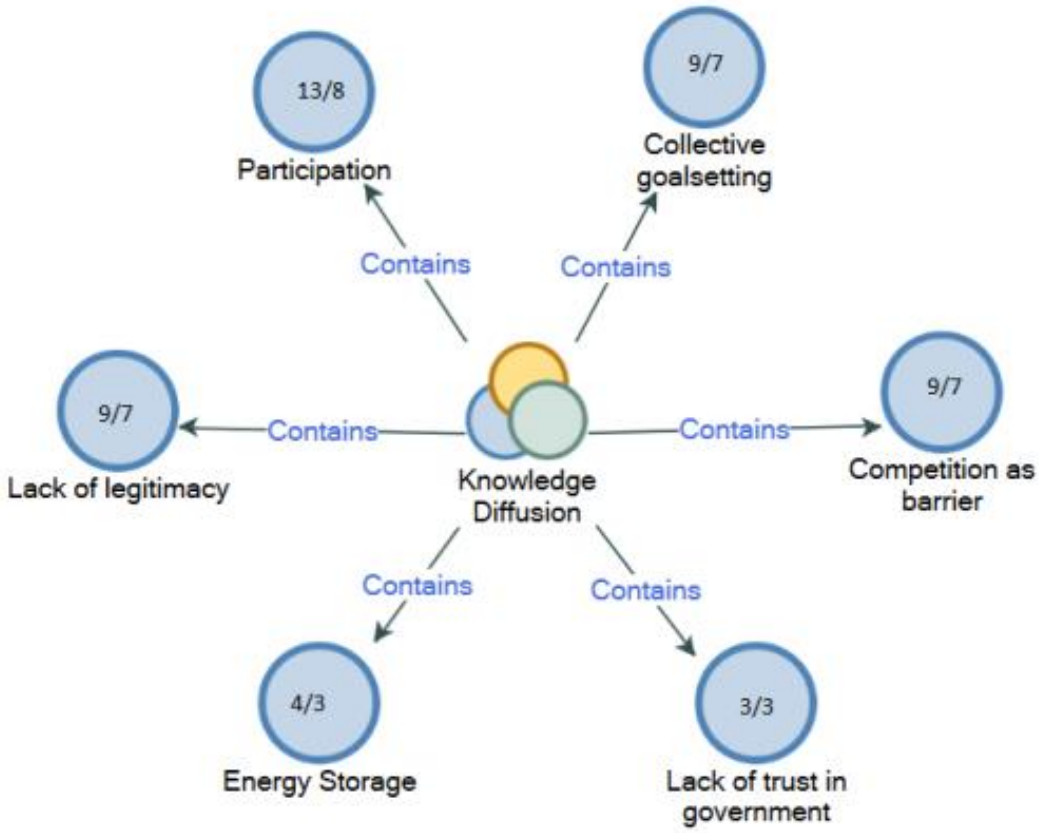


Figure 4.3.2 Categorisation of references into nodes and child nodes that regard knowledge diffusion

The additional factors of influence, as proposed by the respondents, were categorised into four different nodes: *Competition; lack of legitimacy; collective goalsetting; participation*. *Participation* is again adopted into this set, and again contains most references (13/8). As mentioned before, the function of *knowledge development* and *knowledge diffusion* are closely related. It is therefore no surprise that *participation* is again the most relevant factor. The other three coded factors each contain 9 references, and can thus be regarded as relevant as well. The same coherence between these factors as in the previous sub-chapter is observable here. The barrier of competition, which hinders the diffusion of knowledge, can be remedied by *collective goalsetting* and *participation*. The latter can also contribute to overcome the barrier of *lack of legitimacy.* The other two nodes that were adopted for this function regard the *lack of trust in government* and *energy storage*. Strikingly, those respondents who made references regarding the node of lack of trust in the government, also proposed a *lack of legitimacy* as a barrier.

Only two factors were initially given and scored by the respondents for this function. Both were considerate only moderately relevant. Although, the factor of *stimulate interaction* was scored in relative consensus, a high SD value for *weak network failure* indicates that there was no consensus for the latter factor. The *competition* barrier sheds light in this lack of consensus. The majority of respondents that consider *weak network failure* as a significant barrier (moderately relevant or higher), also pointed out that *competition* hinder the diffusion of knowledge. Subsequently, respondents that are less involved with the competitive nature of the wind energy system are less likely to consider *weak network failure* as a barrier.

4.3.3 Integrated Analysis

In sum, this function is considered moderately fulfilled; which is low in comparison to the functions previously discussed, and it is regarded to be less than moderately relevant for upscaling at this time. For both of the above estimations there is a relatively high level of consensus. Strikingly, the reviewed body of literature provided only two factors that potentially influence the fulfilment of the function of *knowledge diffusion trough networks.* The barrier that was scored by the respondents is considered only slightly relevant and the stimulant was regarded moderately relevant. The qualitative analysis revealed a wide range of influential factors of which *participation* was referred to most. Since the given factors scored relatively low in terms of relevance, it may indicate, although this was not measured, that the proposed factors are more important than the given factors. Similar to the previous function, *competition* and *collective goalsetting* were also referred to many times, hence suggesting these are significant influencers as well.

4.4 Guidance of the Search

4.4.1 Descriptive Statistics

The function of guidance of the search is by the respondents considered moderately fulfilled. The mean relevance score is 3.07, which indicates there a moderate fulfilment of the function. Most striking is that the respondents of the NGO category are in complete consensus, all considering the function of guidance of the search well fulfilled, with a fulfilment score of 4. The consensus is in contrast with overall agreement regarding the matter. The SD value of 1.17 suggests this function is a contested one. While the NGO category may consider the function well fulfilled, in the category of government, who are major players in this function, all respondent gave the this function a fulfilment score of 2.

Although the fulfilment is considered only moderate, the relevance of this function is regarded has high. The mean relevance was computed at 3.87, which indicates that the respondents consider guidance of the search very relevant for upscaling of wind energy. Moreover, there is a relatively high level of consensus regarding this relevance. Although the SD value of 1.13 may indicate there is some disagreement, a closer look at the data reveals there is two outliers (relevance score of 1 and 2), causing the SD value to be higher. If this outlier were to be excluded, the SD value would support that there is consensus regarding the high level of relevance of this function.

The literature review resulted in seven factors that potentially influence guidance of the search. Among these factor, four are considered to stimulate and three are considered to block the fulfilment of this function. Among the barriers, the *societal characteristics* are considered most relevant, with a mean relevance score of 3.93. Moreover, the SD value of 0.88 indicates there is a high level of consensus regarding this factor. The SD values of the other three barriers are considerably higher, and thus indicate that the respondents were not in agreement regarding these factors. Especially the factor of *lock in to established technologies* is highly contested, with an SD value of 1.36. Even within the respondent categories, with the exception of NGOs, the respondents were mostly in dispute regarding the relevance of these factors. Then, regarding the stimulants, two scored high in terms of relevance, and one relatively low. The most important stimulant for guidance of the search, as perceived by the respondents, is *increasing legitimacy*, with a mean relevance score of 3.73. The consensus regarding this factor, with an SD value of 1.1 is significantly lower than the most relevant barrier. The factor of *formulation of long term goals* is also considered relatively relevant, with a mean relevance score of 3.67. The agreement level among the respondents is medium to high for this function, with a SD value of 0.98. The respondents were however in consensus that the factor of *R&D* is not very relevant for the fulfilment of this function, with a SD value of 0.92.

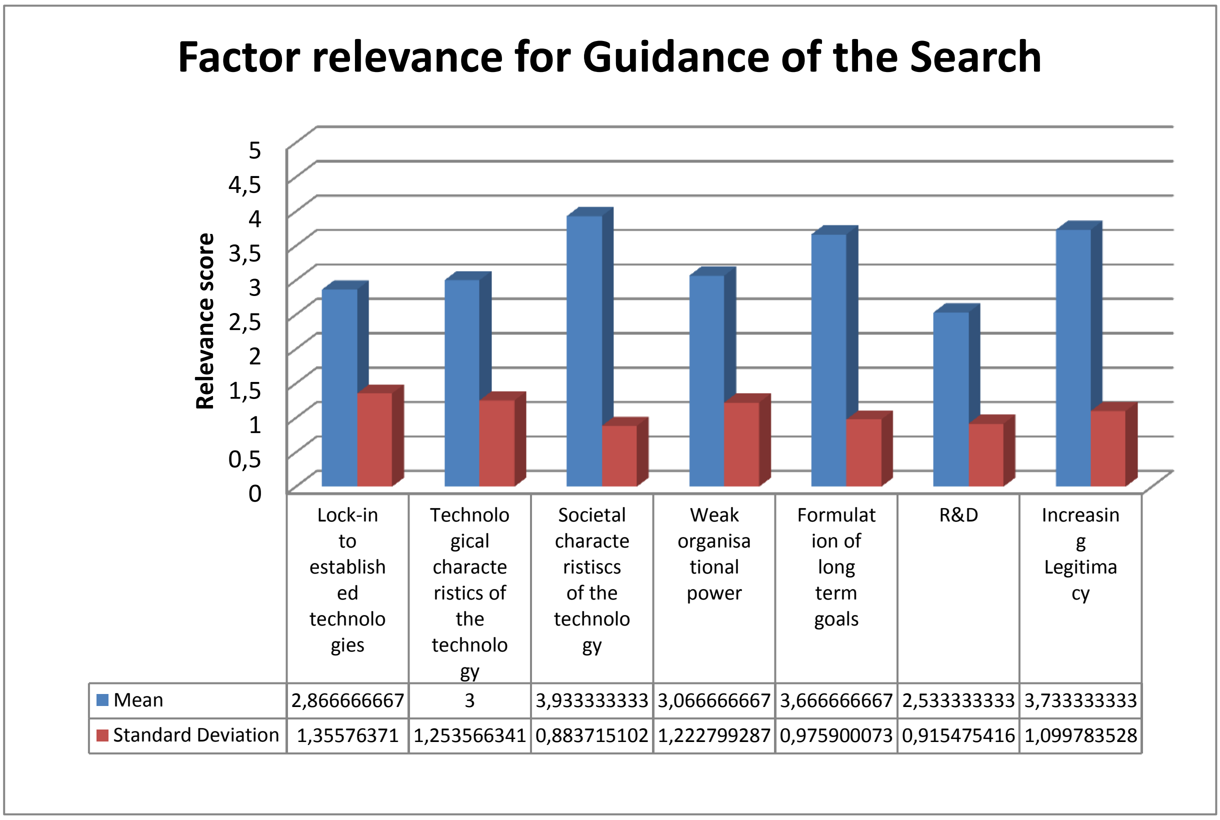


Figure 4.4.1 Relevance per factor affecting guidance of the search

4.4.2 Qualitative Data Analysis

References that concern the function of *guidance of the search* are categorised into 8 nodes, one of which is a child node of one other adopted node in this set. Moreover, *advocacy coalitions* and *participation* are included child nodes for which the parent nodes are not included. This set of nodes is represented in 4.4.2. The figure can again be read by means of previously stated rules.

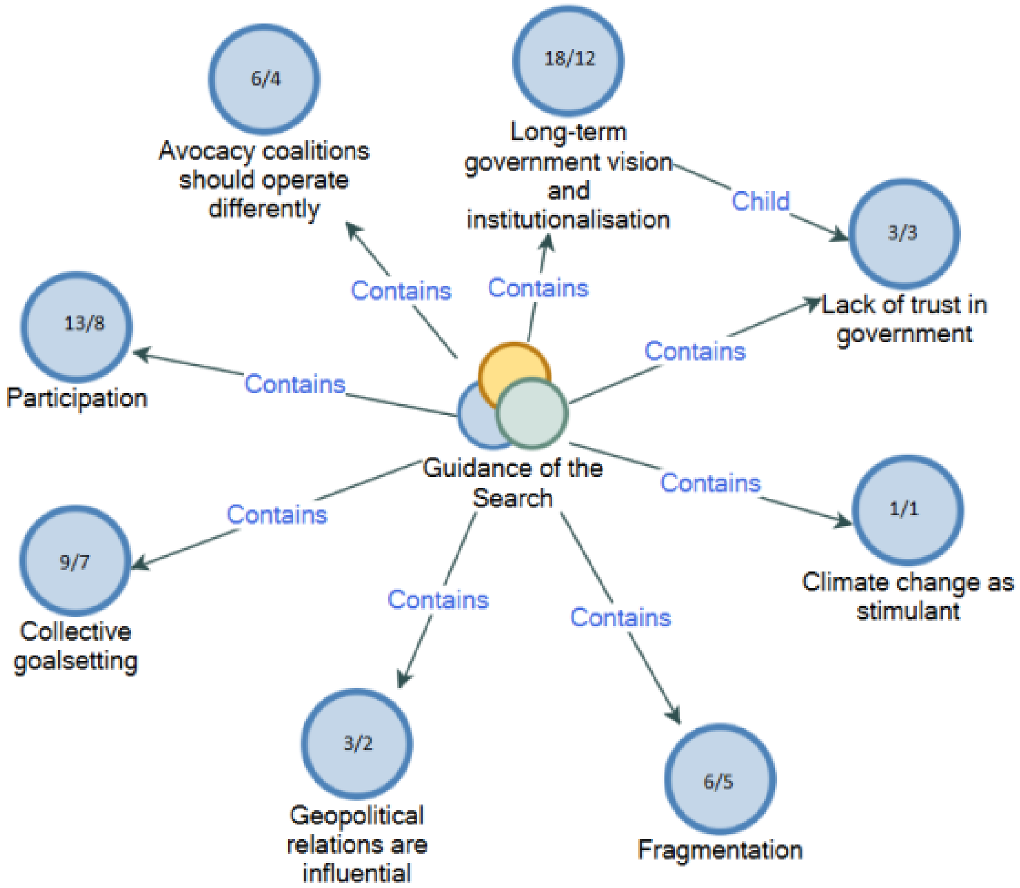


Figure 4.4.2 Categorisation of references into nodes and child nodes that regard guidance of the search

The following factors were proposed by the respondents as being influential: *collective goalsetting; participation; fragmentation. Participation* is again adopted in this node set. However, one other node contains more references, *long-term government vision and institutionalisation* (18/12) . The nodes of *participation* and *collective goalsetting* contain 13 and 9 references, respectively. The nodes of *fragmentation* and *advocacy coalitions should operate differently* each contain 6 references. The high number of references of many of these nodes indicates that the function of *guidance of the search* is influenced by a wide range of factors, that all bare a certain level of significance.

Three of the given factors that were scored for relevance lacked consensus, as evidence of a high SD value. The respondents that scored the relevance for *lock-in to established technologies* low (including three outliers with relevance scores of 1) did not give any additional explanation as to why they consider this factor irrelevant. Although, these respondents are either in the civil society category or in the knowledge institutions category. The categories of companies, government and NGOs, which due to their involvement have a more practical perspective regarding the wind energy system, do consider this factor as a significant barrier. The lack of consensus regarding the *techno-economic characteristics of* *the technology* is also not accompanied by qualitative data that might explain the difference in opinion. Neither can a categorical difference be observed that may explain the lack of consensus. However, the proposed factor of *fragmentation* sheds light on the lack of consensus regarding the factor of *weak organisational power*. The majority of the respondents that consider this to be a significant barrier, also made reference to fragmentation in policy formation and goalsetting.

4.4.3 Integrated Analysis

In conclusion, the function of *guidance of the search* is considered moderately fulfilled and is regarded to be highly relevant for upscaling at this time. This function is however controversial in terms of its estimated fulfilment and relevance. Furthermore, there is a high level of consensus that the factor of *societal characteristics of the technology* is the most relevant for the fulfilment of this function. This means that windmill features such as shadow cast and noise nuisance are considered to be a barrier for effective guidance towards further innovations regarding wind energy technology. Other given factors that were considered very relevant are *increasing legitimacy* and *formulation of long-term goals,* of which the former relates directly to the societal aspects described above. These features are also considered to be a barrier for increasing legitimacy. The importance of the latter is also reflected in the similar proposed factor of *long-term government vision and institutionalisation,* which was referred to most by the respondents. By establishing long-term goals and institutionalisation of these goals, overarching organisations such as the government can guide the system towards innovations that force back the negative societal features of wind energy. The factors of *participation* and *collective goalsetting* were also deemed relevant, as evidence of the number of references. All in all, for this function the qualitative analysis complements the quantitative analysis by increasing the range of influential factors, and pointing out which factor are referred to most.

4.5 Market Formation

4.5.1 Descriptive Statistics

The mean fulfilment for the function of market formation is 3.53. This suggests that the respondents consider market formation moderately to well fulfilled. However, the SD value for the fulfilment of this function is also relatively high, computed at 1.13. Although this may indicate a lack of consensus regarding the fulfilment of the function, a closer look at the data reveals there is a categorical difference of opinion. The respondent category of civil society are in consensus that this function is not well fulfilled, with a mean fulfilment score of 2. The other categories, in which there mostly is consensus, gave significantly higher scores with regard to the fulfilment of this function.

The relevance for function was valued at moderate, with a mean relevance score of 3.33. Notably, the overall agreement level is low regarding the relevance of this function. The SD value was computed at 1.18, suggesting a lack of consensus. Also among the respondent categories of civil society and NGOs there is no agreement. Although the other categories are somewhat more in consensus, the relevance of this function for upscaling wind energy can be deemed controversial.

For the function of market formation, nine factors were identified from the literature review that may be of influence. Five of these factors are considered potential barriers, and the other four are considered to potentially stimulate the fulfilment of this function, and hence upscaling of wind energy. Strikingly, not one of these nine factor scored higher than 4 in terms of relevance. Among the potential barriers, the factor of *societal characteristics of the technology* was given the highest relevance score, and was thus deemed most important for this function. The mean relevance score was computed at 3.47. The SD value of 1.06 indicates a medium level of consensus. Another barrier that is deemed moderately relevant for the fulfilment of this function is *lack of long term government vision*, with a mean relevance score of 3.07. The SD value for this factor was computed at 1.16. The factor of *lack of customer competence* was valued lowest in terms of relevance, with a mean relevance score of 1.87. Consensus regarding this factor is medium, with a SD value of 1.06. As for the stimulants, the most important two factors were given a mean relevance score of 3.8 and 3.73. There is however a difference in consensus between these two factors. The mean relevance score for *measures affecting relative prices*, 3.8, was established with medium level of consensus, with an SD value of 1.01. The scores given to the factor of *increased concern for the environment* carry a SD value of 1.16. As such, the respondents are not agreement regarding the relevance of this factor. There does not seem to be a pattern with regard to the respondent categories, meaning the outlier scores are randomly given by respondents from different categories. The same can be observed for the lack of consensus regarding the factor of *protected niche spaces*, which was scored lowest in terms of relevance, with a score of 2.33. The SD value for this factor was computed at 1.18.

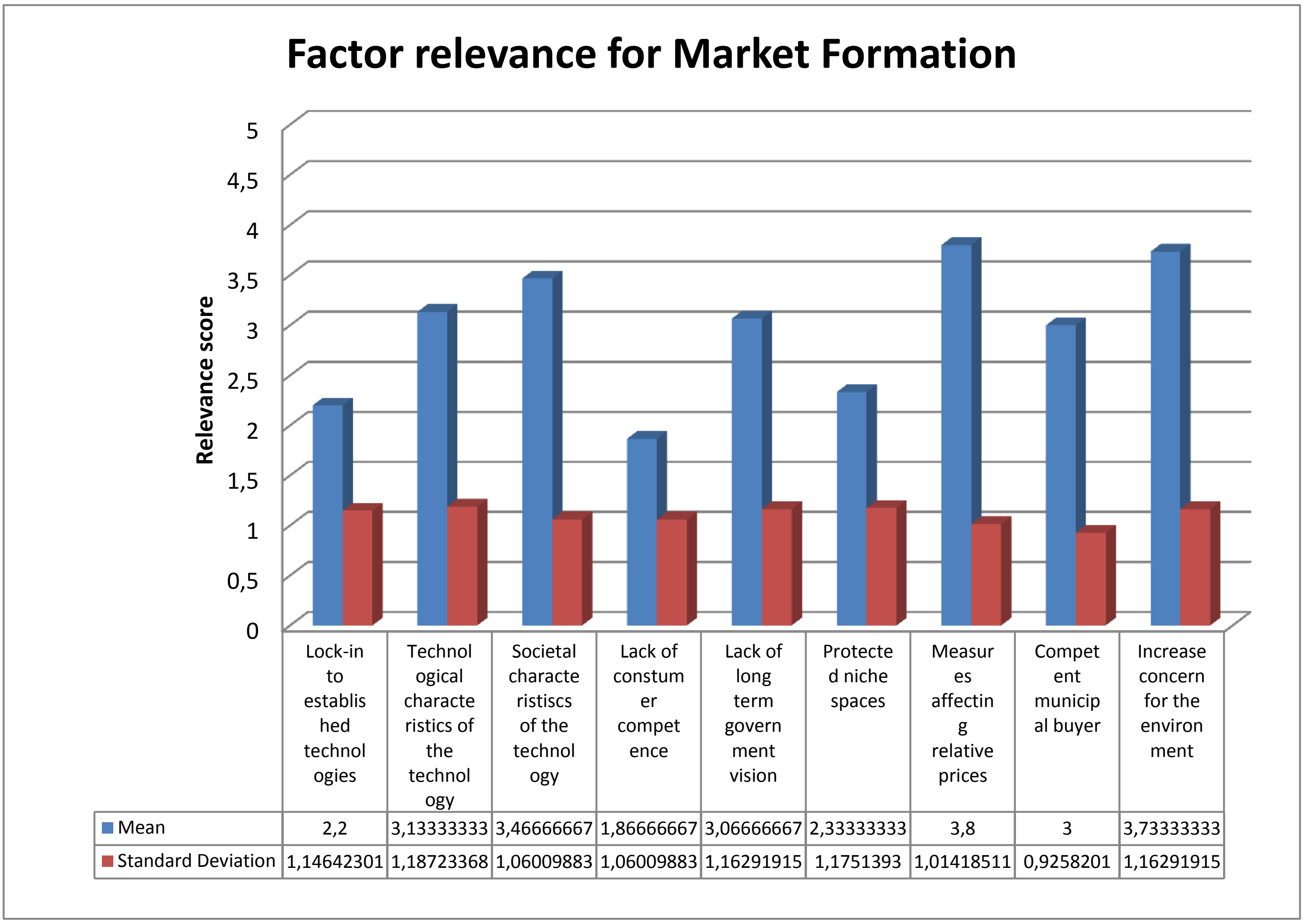


Figure 4.5.1 Relevance per factor affecting market formation

4.5.2 Qualitative Data Analysis

The node set that comprises all references that relate to the function of *market formation* is the largest of all eight node sets, with 15 nodes included. One of these nodes, *lower government hinder guidance,* is a child node of another node, *long-term government vision and institutionalisation.* Figure 4.5.2 depicts the node set for this function. Number of references and sources for each can be found in the node spheres.

Strikingly, despite this function is considered by the respondents to be only moderately fulfilled, the given barriers scored low in terms of relevance. Therefore, additional factors, as proposed by the respondents, need to be consulted to explain why this function is only moderately fulfilled. A wide range of factor were proposed as influential by the respondents: *Transparency; lack of legitimacy; long-term government vision and institutionalisation; public image; high market entry requirements; strong agricultural sector; export; success cases.* The latter four factors were only referred to once. Therefore, the relevance of these factors is difficult to determine. The former four factor however comprise multiple references.

The node of *long-term government vision and institutionalisation* contains the most references and can thus be considered most relevant for market formation. Two other nodes stand out in this set. *Lack of legitimacy* and *international network* both contain 9 references, and can hence be considered relevant as well.

For this particular function, many of the scored factors were controversial, and spawned a high SD value, thus indicated lack of consensus. Unfortunately, the qualitative data that was given when these factor were scored is limited. Therefore, the controversy surrounding many of these factor cannot be explained for each of them. The highest SD value was computed for the factor of *techno-economic characteristics of the technology*. The difference in opinion can here be explained by the nature of involvement with the system. The majority of the respondents that are directly involved with the process of wind energy upscaling (actual realisation of wind parks), do not consider these techno-economic aspects to be a problem. Rather, they consider the lack of government institutionalisation and lack of legitimacy as the most relevant barrier for the formation and growth of the market.

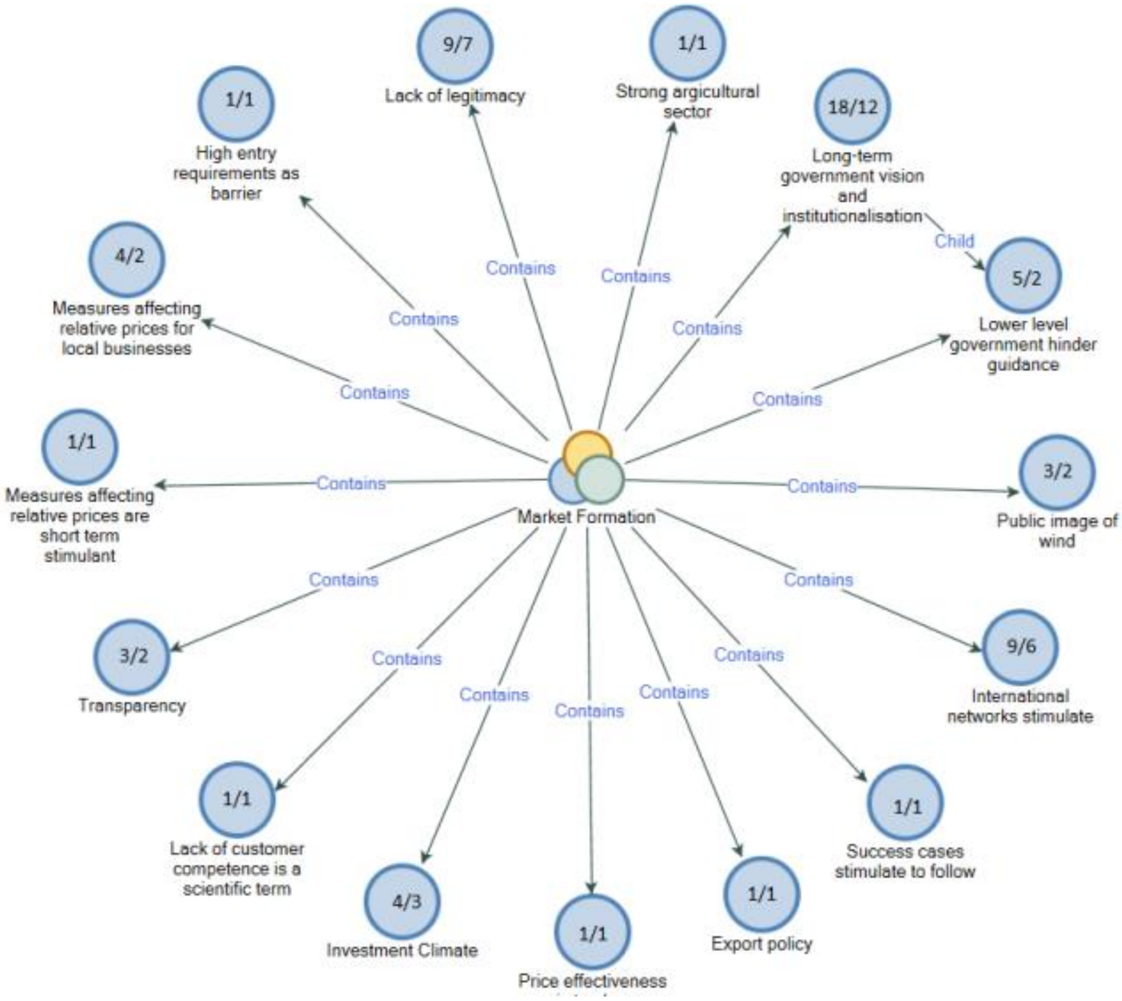


Figure 4.5.2 Categorisation of references into nodes and child nodes that regard market formation

4.5.3 Integrated Analysis

To put these results into context, the most striking results are summarised here. The respondents are in dispute regarding the fulfilment and relevance of *market formation.* The mean pointed towards a moderate fulfilment and moderate relevance for this function, with lack of consensus. The most influential factor, as estimated by the respondent scoring, is that of *measures affecting relative prices.* This indicates that measures such as subsidies are crucial for the market to further develop. Many of the respondents do feel however that this process of *market formation* will occur naturally if or when the *concern for the environment* increases in coming years. The *societal characteristics of the technology,* thus referring to shadow cast , noise nuisance etc., are also deemed highly relevant for this function. These features thus form a barrier for further development of the market. The qualitative analysis emphasised the importance of *long-term government vision and institutionalisation,* not only for the function as a whole, but in relation to the above mentioned factors as well. Government subsidies cannot exists without sufficient institutional backing. Moreover, institutionalisation is also deemed necessary to overcome *the lack of legitimacy* that spawns from negative societal features of windmills.

4.6 Resource Mobilisation

4.6.1 Descriptive Statistics

According to the respondents, the function of resource mobilisation scores highest of all functions in terms of fulfilment. The mean fulfilment score of 4.4 indicates that actor in the system have well access to almost all resources required for wind energy upscaling. Moreover, the respondents are in consensus regarding this matter, with a SD value of 0.63. Only one of the respondents indicated that the function is only moderately fulfilled. All other interviewees scored the fulfilment 4 or 5.

The mean relevance for this function was computed at 3.13, which indicates that resource mobilisation is considered moderately relevant at this time. Moreover, there is a lack of consensus regarding the relevance of this function. The SD value is computed at 1.19, which indicates a high level of disagreement. Also between the respondents of the same category the matter is disputed, including several outliers. Only the respondent category of companies seems to be in agreement that the relevance for this function is above moderate.

For this particular function, two barriers and one stimulant were identified on the basis of literature. As mentioned before, since the literature review only spawned one stimulant, analysis for this function depends on additional factors provided by the respondents. Among the two blocking factors, *lack of legitimacy* is considered most relevant, with a mean relevance score of 2.8. Note that this is only moderately relevant. Moreover, a SD value of 1.26 suggests that the respondents are not in agreement regarding the relevance of this factor. The factor of *lock-in to established technology* is considered only slightly relevant with a mean relevance score of 1.93. The SD value of 0.88 indicates that the respondents are in consensus with regard to this factor. The stimulant, *R&D,* was given a mean relevance score of 2.87, also slightly below moderately relevant. For this factor there is a medium level of consensus, with a SD value at 0.99.

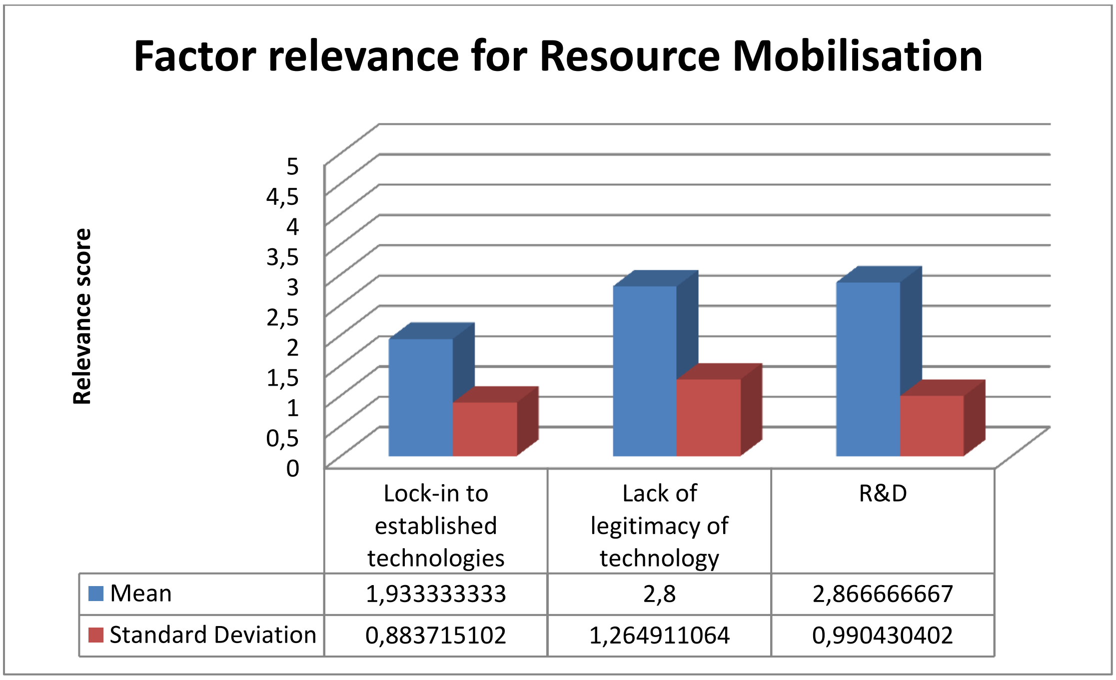


Figure 4.6.1 Relevance per factor affecting resource mobilisation

4.6.2 Qualitative Data Analysis

References that relate to resource mobilisation are categorised in a node set that consists of 12 nodes. Two of these nodes contain child nodes, which are also directly adopted into the node set. This node set is depicted in figure 4.6.2, for which the same reading rules apply as previous figures.

Only three factors that affect this function were identified in the literature review and given relevance scores by the respondents. It is therefore essential to confer with additional factors, as proposed by the respondents during the interviews. A wide range of factors were proposed as influential for this function: *Long-term government vision; guidance of the search; experimentation; local initiatives (participation); geopolitical relation; investment climate; educational climate. Long-term government vision* is the most referenced factor (18/12). This indicates that, on the basis of the interviews, the respondents feel that this factor is most relevant for the function of resource mobilisation. Other highly relevant factor, as determined by the number of references, are *participation* (13/8) and *international networks* (9/6). Although the other nodes contain less references, these need to be taken into account when assessing the fulfilment of this function as well. Another notable observation is that many of the respondents made a distinction between financial, physical and human capital. This was therefore also adopted as a node.

The factor that were given relevance scores all scored below moderately relevant, and for one there is a lack of consensus. The factor of *lack of legitimacy* spawned a high SD value, which indicates the respondents do not agree on this subject. Strikingly, the category of NGOs all consider this factor highly relevant, while government respondents consider it less than slightly relevant. The latter category hence does not attribute potential problems with resource accessibility to lack of legitimacy. Rather, they made reference to *geopolitical relations* and *lack of network infrastructure* as being a potential bottleneck. Note, however, that this function is relatively well fulfilled, meaning that barriers for this function, such as ones mentioned above, likely only have slight influence.

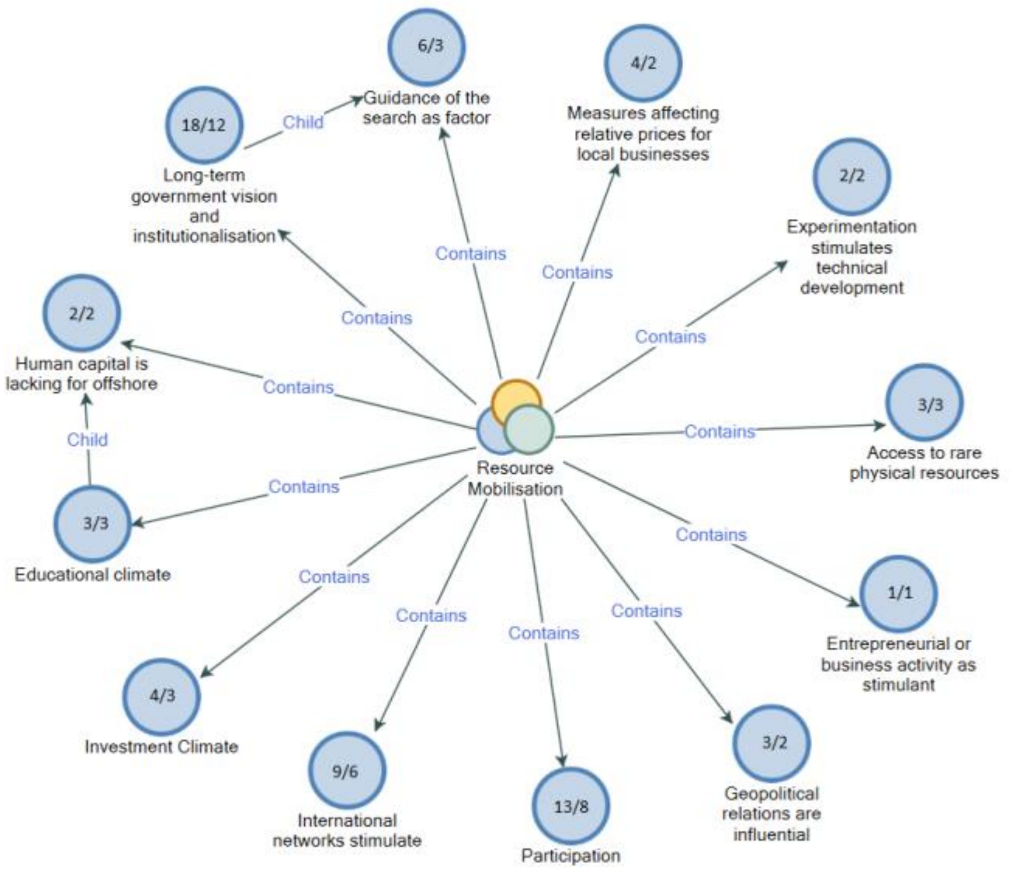


Figure 4.6.2 Categorisation of references into nodes and child nodes that regard resource mobilisation

4.6.3 Integrated Analysis

Resource mobilisation is the most fulfilled function of all, with a very high level of consensus among the respondents. The respondents are less in agreement regarding the relevance of this function, which is estimated at moderate at this time. The factors that were scored by the respondents are all considered less than moderately relevant. With the function so well fulfilled, it is no surprise that the barriers are not very relevant at this time. As for the stimulants, *R&D* was considered most relevant, yet still only moderately. The qualitative analysis revealed better insight regarding this function. The factor of *long-term government vision and institutionalisation* is the most referred to factor deemed relevant for this function. Access to financial and material resources is highly dependent on institutionalisation and the latter also on *geopolitical relations.* Access to human capital, mainly referring to technical skills of the labour force, is addressed in the factor of *participation*, which is also considered to be significant, as evidence of the number of references.

4.7 Creation of Legitimacy

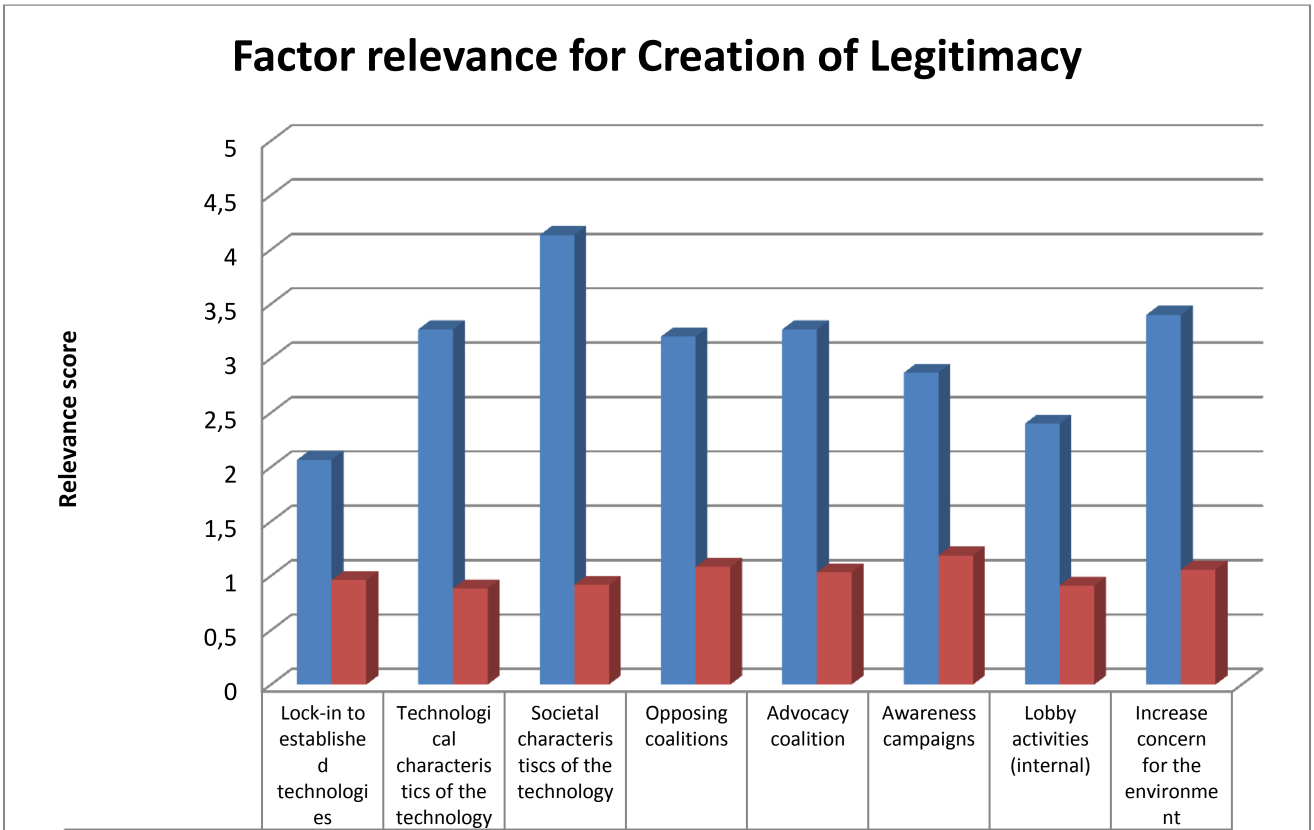
4.7.1 Descriptive Statistics

The extent to which the function of creation of legitimacy is fulfilled is controversial among the respondents. The mean fulfilment score is 2.6, which is well below moderate. This suggests that the respondents feel that there is insufficient creation of legitimacy for further upscaling of wind energy. The SD value of 1.12 indicate however that there is a lack of consensus regarding the fulfilment of this function. Moreover, there are outliers present on both sides of the spectrum, which supports this controversy. Within each of the categories, with the exception of NGOs, the consensus is significantly higher. The difference of opinion hence stems from the different professional perspectives of the respondents. Another striking observation is that the respondent category of civil society registered a mean fulfilment score of 1.33. This suggests that civil society feels there is a severe lack of legitimacy and the creation thereof.

Although this function is not well fulfilled according to the respondents, it is surely relevant. The mean relevance score is highest of all functions, computed at 4.4. This function is thus considered most important for upscaling of wind energy at this time. The SD value of 0.91 suggests that the respondents are also in agreement about this. Only two of the respondents gave this function a relevance score below 4. Furthermore, the respondent category of civil society, who considered this function severely unfulfilled, are in complete consensus that this function deserves the maximum relevance score. It is striking that the function that is considered to be least fulfilled, is also considered to be most relevant.

For this function four barriers and four stimulants were identified in the literature review. Figure 4.7.1 illustrates the mean relevance score and SD values for these factors. The most relevant barrier for the fulfilment of this function is *societal characteristics of the technology,* for which a mean relevance score of 4.13 was computed. The level of consensus regarding this factor is relatively high, with a SD value of 0.92. For the factor of *techno-economic characteristics of the technology,* which was given a mean relevance score of 3.27, there is also a high level of consensus. The SD value for this factor is even lower, computed at 0.88. Also for the factor deemed least relevant there was medium consensus, with an SD value of

0.96. The respondents are hence in agreement that the *lock-in to established technologies* is only slightly relevant at this time, with a mean relevance score of 2.07. Coalitions, either opposing or advocating, are deemed moderately relevant. The barrier of *opposing coalitions* scored a mean relevance of 3.2, with an SD value of 1.08. The stimulant of *advocacy coalitions* was given a mean relevance score of 3.27, with an SD value of 1.03. This indicates that there is medium consensus regarding the extent to which such coalitions are influential. Neither one is significantly more influential than the other. As for the factor of *awareness campaigns* (aimed at the public) and *lobby activities* (aimed at the actors within the energy sector), these also not much difference in relevance scores. Although, both were deemed below moderately relevant, the consensus regarding these factors is different.
For the factor of *awareness campaigns*, which was given a mean relevance score of 2.87, a SD value of 1.19 was computed, indicating lack of consensus. The factor of *lobby activities* on the other hand spawned a SD value of 0.91. This suggests the respondents were relatively in agreement regarding the mean relevance score of 2.4. Finally, the factor of *increase in concern for the environment* resulted in a mean relevance score of 3.4, with a SD value of 1.06, indicating medium consensus.



	Lock-in to established technologies	Technological characteristics of the technology	Societal characteristics of the technology	Opposing coalitions	Advocacy coalition	Awareness campaigns	Lobby activities (internal)	Increase concern for the environment
Mean	2,066666667	3,266666667	4,133333333	3,2	3,266666667	2,866666667	2,4	3,4
Standard Deviation	0,961150105	0,883715102	0,915475416	1,082325539	1,032795559	1,187233679	0,91025899	1,055597326

Figure 4.7.1 Relevance per factor affecting creation of legitimacy

4.7.2 Qualitative Data Analysis

The last function, creation of legitimacy, is addressed in a node set with 12 nodes. Two of these nodes contain child nodes, which are also adopted in this set. The node of *transparency* contains three child nodes, whereas the node of *long-term government vision* comprises two child nodes. Figure 4.7.2 illustrates this particular node set. Same legend applies as in previous figures.

Contrary to the previous function, for the *creation of legitimacy* a wide range of factors were identified in the literature review and scored by the respondents in terms of relevance. Yet, the respondents also proposed a wide range of additional factors for this function. The following factors were proposed: *Long-term government vision; transparency; participation; public image; collective goalsetting; international networks; compensation mechanisms.* The factor that contain most reference, and is influential for many function, is *long-term government vision* (18/12). Again this factor is most relevant, as evidence of the number of references. Additionally, the factors of *participation* (13/8), *international networks* (9/6) and *collective goalsetting* (9/7) are highly relevant for this function.

Among the given factors that were scored in terms of relevance by the respondents, there were few that can be deemed controversial. Only two of the factor spawned a high SD value, and thus bring about discussion. The factor with the lowest level of consensus is *awareness campaigns.* The category of civil society stands out in that all respondent consider this factor irrelevant. Generally speaking, they argue that these awareness campaigns are ineffective due to *lack of social knowledge* by the government, and that the *advocacy coalitions* operate in a manner that is not consumer-oriented (end-user). These remarks are adopted as nodes in this set.

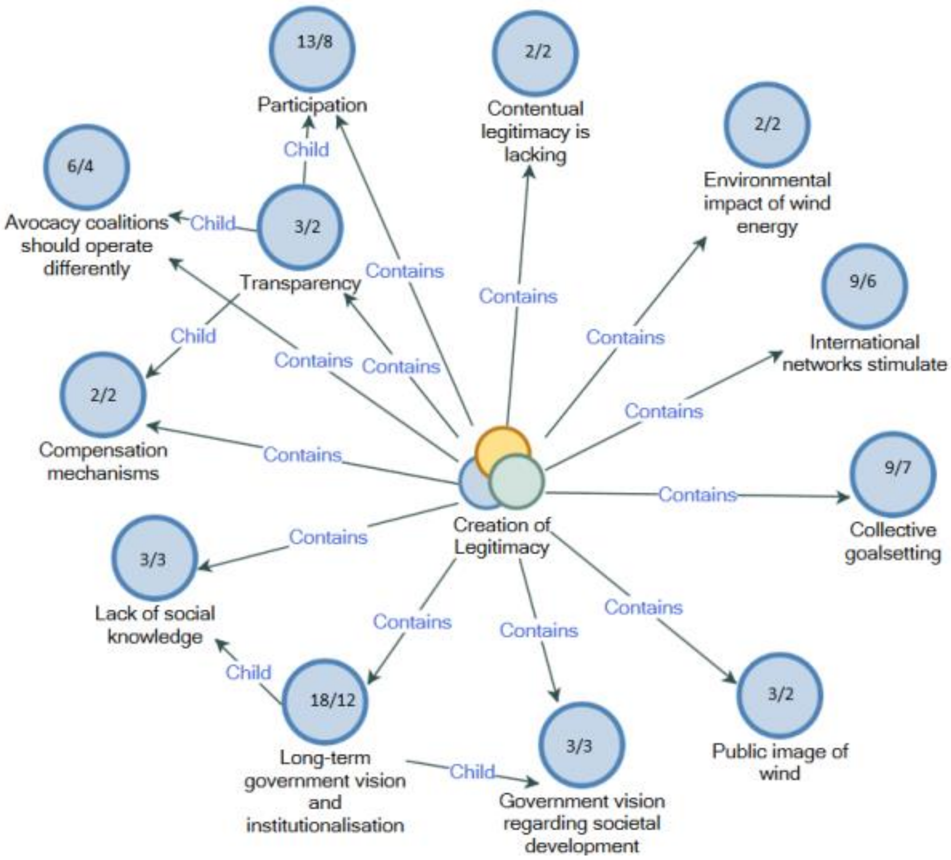


Figure 4.7.2 Categorisation of references into nodes and child nodes that regard creation of legitimacy

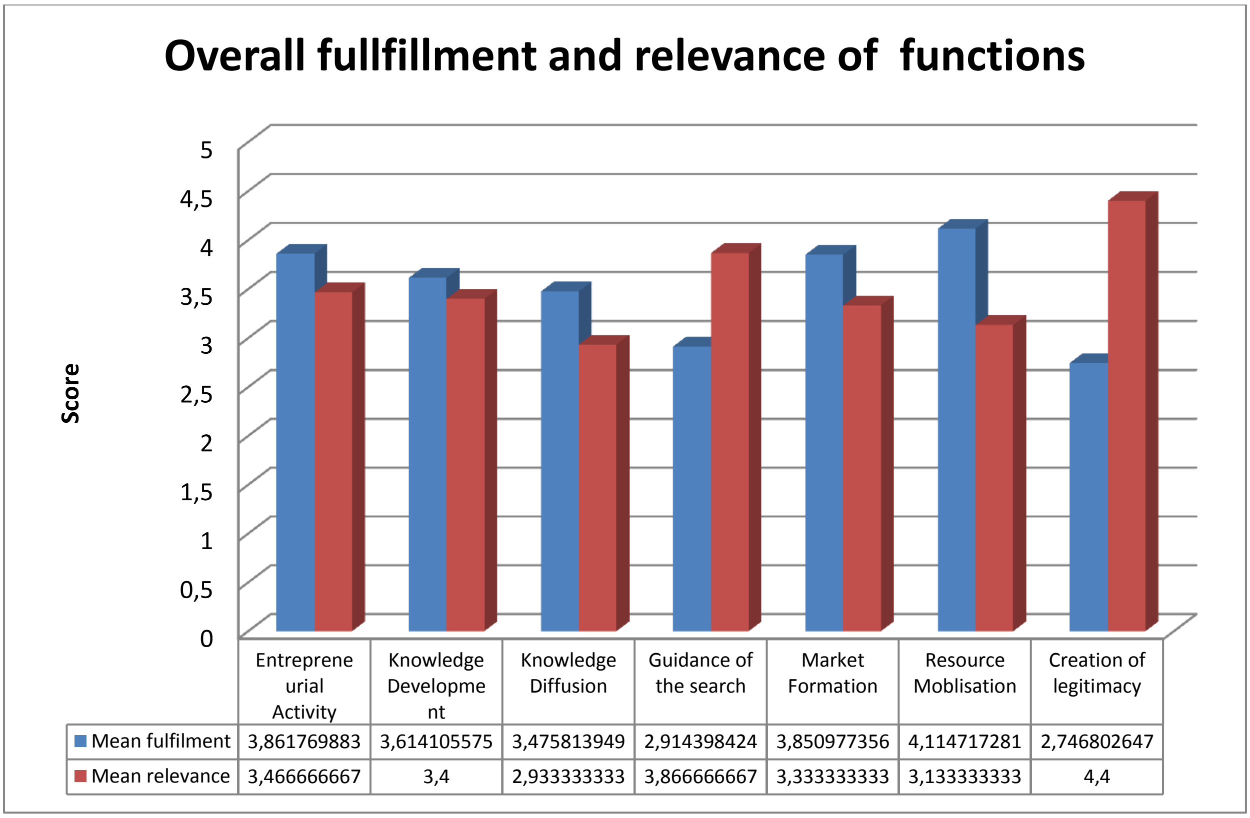
4.6.3 Integrated Analysis

The function of creation of legitimacy is considered to be the least fulfilled function, while regarded as highly relevant for upscaling wind energy at this time. The factor of *societal characteristics of the technology* scored highest, and is considered to be an highly relevant barrier for the *creation of legitimacy*. Features like noise nuisance, shadow cast and visual burdens are considered to hinder the creation of legitimacy for wind energy technology severely. Several other factors scored moderately in terms of relevance. There is only little difference in relevance between the factors of *increase concern for the environment, technological characteristics* (e.g. price-effectiveness), and *coalitions* (both advocacy and opposing). The qualitative analysis resulted in a wide range of additional factors of which *long-term government vision and institutionalisation* and *participation* are referred to most by the respondents. The respondents thus feel that institutionalisation, as well as the involvement of civil society, can help to create legitimacy and to balance out the negative societal features of wind energy. *International networks* and *collective goalsetting* should also be taken into account as stimulants that can help to overcome barriers and stimulate the function entirely.

4.8 Integration

4.8.1 Descriptive Statistics

In this subchapter, integration of the statistical results for the different functions is presented, providing a more holistic perspective. The mean fulfilment scores and mean relevance scores, are depicted in figures 4.8.1. This figure allowed for a more thorough analysis and comparison between all the functions and for the identification of potential patterns and correlations between fulfilment and relevance of particular functions.



	Entrepreneurial Activity	Knowledge Development	Knowledge Diffusion	Guidance of the search	Market Formation	Resource Moblisation	Creation of legitimacy
Mean fulfilment	3,861769883	3,614105575	3,475813949	2,914398424	3,850977356	4,114717281	2,746802647
Mean relevance	3,466666667	3,4	2,933333333	3,866666667	3,333333333	3,133333333	4,4

Figure 4.8.1 Fulfilment and relevance per function

The least fulfilled function is the *creation of legitimacy*, as opposed to the function of *resource mobilisation*, which is fulfilled the most. Strikingly, in terms of relevance the opposite can be observed for these function. Moreover, a negative correlation can be observed between the fulfilment and relevance of the functions. A negative correlation coefficient of -0.65, as computed in Microsoft Excel, supports the latter claim. Consequently, when a function is considered to be well-fulfilled, it is often considered to be only slightly relevant for further upscaling of the wind energy system. Vice-versa, functions that are not well fulfilled are often considered to be highly relevant at this point. Notably, the functions of *guidance of the search* and *creation of legitimacy* are least fulfilled and considered most relevant at this point. These functions are therefore an essential point of attention for the formulation of recommendation that can contribute to the upscaling process of the wind energy system.

4.8.2 Qualitative Data Analysis

References that concern the system in its entirety, and hence all function, were coded and categorised in a separate node set. This particular set includes 9 nodes of which two contain child nodes. Figure 4.8.2 contains a visualisation of this set of nodes. The legend for this figure is identical throughout this study. *Long-term government vision* (18/12) and *participation* (13/8) are the most referenced factors for the integrated node set. The factor of *lack of legitimacy* (9/7) can also be deemed relevant for the system as a whole, as evidence of the number of references.

The fulfilment and relevance scores of the functions also brought to light some controversy regarding the extent to which these processes are present and are relevant at this point. In terms of relevance, four of the seven functions lacked consensus, as indicated by high SD values. The highest SD value was computed for the function of *resource mobilisation.* Even among the respondents of the same category consensus was lacking. *The distinction between onshore and offshore* (8/5), as adopted in a node in the set below, sheds light on this controversy. The respondents that score this function in term of relevance from a perspective dominated by experience and expertise of onshore wind energy, may score differently than respondents that are more involved with offshore wind energy. Moreover, the distinction between different forms of capital, and the respondents experience and expertise regarding these, also influences the respondents score. The lack of consensus regarding the relevance of the function of *market formation* can be explained by a categorical difference. Respondents of the government and companies categories consider this function highly relevant, whereas the other categories score the relevance only moderate. Respondents who scored this function only moderately relevant or less argue that market formation is something that happens naturally, and that the market for wind energy is already sufficiently developed for further upscaling.

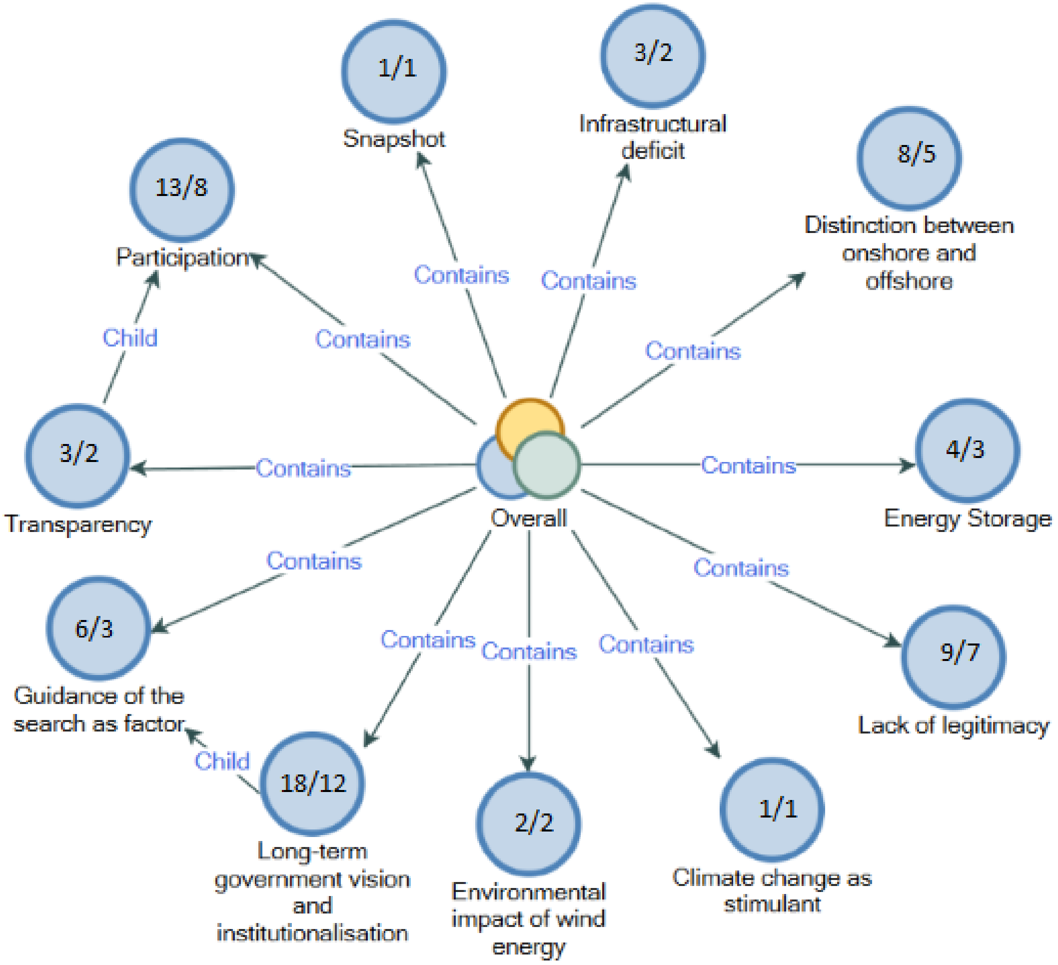


Figure 4.8.2 Categorisation of references into nodes and child nodes that regard all functions

The interconnectedness and interdependence of the functions has already been established in previous chapters. However, an integration of qualitative data revealed a more holistic picture of how the different functions are interactive. Besides what was already established in the literature review, the references illuminated the extent to which the function interact. Figure 4.8.3 illustrates which, as determined by the coded references and literature review, the functions influence each other. 10 instances of functions affecting each other were identified on the basis of the references and literature review.

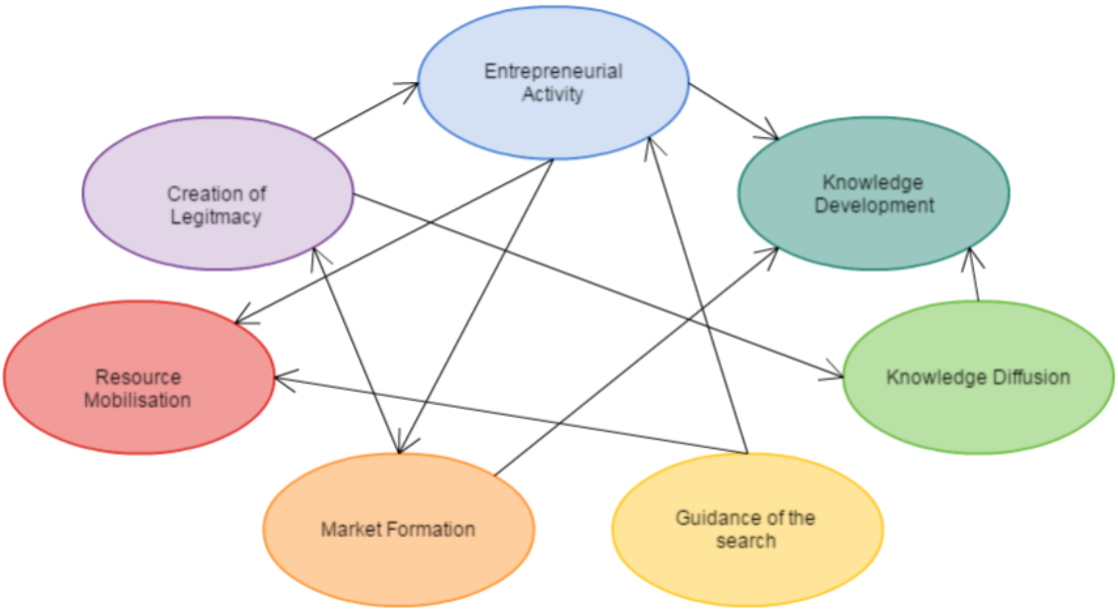


Figure 4.8.3 Schematic representation of interaction between functions

To conclude, figure 4.8.4 provides a comprehensive table in which the functions and associated factors are presented hierarchically, with the functions and associated factors with highest priority at the top, going down towards lower priority functions and factors. Note that all functions are deemed important, and thus that lower priority functions and factors can still be of significant influence on the upscaling process. The relevance scores for each function and factor is included between brackets i.e. Function x (relevance score x). The factors that were proposed by the respondents were ranked in this table according the number of references. This does not necessarily determine the relevance of these factors, it simply implies that by mentioning it often, the respondents feel these are significant for that function. Consequently, the hierarchical ranking is less meaningful for the additional factor than for the measured factors that were actually scored for relevance.

Function	Fulfilment	Measured factors	Additional Factors
Creation of Legitimacy (4.4)	Not well fulfilled (2.6)	Societal characteristics of the technology (4.13)	Long-term government vision and institutionalisation (18/12)
		Increase concern for the environment (3.4)	Participation (13/8)
		Technological characteristics of the	International Networks (9/7)

		technology (3.27)	
		Advocacy coalitions (3.27)	Collective goalsetting (9/7)
Guidance of the Search (3.87)	Moderately fulfilled (3.07)	Societal characteristics of the technology (3.93)	Long-term government vision and institutionalisation (18/12)
		Increasing Legitimacy (3.73)	Participation (13/8)
		Formulation of long-term goals (3.67)	Collective goalsetting (9/7)
Entrepreneurial Activity (3.47)	Well fulfilled (4)	Measures affecting relative prices (4.3)	Long-term government vision and institutionalisation (18/12)
		Lack of long-term government vision (3.4)	Participation (13/8)
Knowledge Development (3.4)	Well fulfilled (3.93)	Measures affecting relative prices (4.3)	Long-term government vision and institutionalisation (18/12)
		Lack of long-term government vision (3.4)	Participation (13/8)
		Encouraging experimentation (3.4)	Collective goalsetting (9/7)
Market Formation (3.33)	Moderate to well fulfilled (3.53)	Measures affecting relative prices (3.8)	Long-term government vision and institutionalisation (18/12)

		Increase concern for the environment (3.73)	Lack of legitimacy (9/7)
		Societal characteristics of the technology (3.47)	
Resource Mobilisation (3.13)	Very well fulfilled (4.4)	R&D (2.87)	Long-term government vision and institutionalisation (18/12)
		Lack of legitimacy (2.8)	Participation (13/8)
Knowledge Diffusion (2.93)	Moderately fulfilled (3.2)	Stimulate interaction (3.2)	Participation (13/8)
			Competition (9/7)
			Collective goalsetting (9/7)

Table 4.8.1 List of function and corresponding factors, hierarchical from top to bottom

The results, as summarised in the table above, revealed which functions are most important for upscaling wind energy at this time. Moreover, each function is affected by a set of factors which can also be categorised on the basis of priority. Strikingly, several factors are of influence on multiple function. Consequently, the factors influencing most functions can be considered most significant for the system in its entirety. The proposed factors of *long-term government vision and institutionalisation* and *participation* each affect six of the seven function, suggesting these are of key relevance for the system as a whole. As for the measured factors of *measures affecting relative prices* and *societal characteristics of the technology*, both affect three of the seven functions. Hence, these should be given more priority as well when assessing the system as a whole. Still, for policy recommendations, which is discussed in the final chapter of this report, the factor hierarchy for the each separate function should be consulted, so that these recommendations are well demarcated and precise.

5. Conclusions

5.1 Upscaling potential of wind energy in the Netherlands

This research project initially set out to answer the following research question: *What barriers and stimuli influence upscaling potential of wind energy in The Netherlands, and what is the respective weight of these factors?* Although there is no definitive answer to this question, the used methodology allowed for the question to be answered along the course of project. The question can be dissected into two parts, each requiring a particular methodology to answer that part of the question. The first part refers to the identification of barriers and stimuli that influence upscaling potential of wind energy. This was done by an extensive literature review of academic literature regarding upscaling, transition and socio-technical systems. A wide range of factors were established to potentially influence upscaling, by affecting the processes that make up an innovation system, which in turn facilitates upscaling of a technology. In addition to the factors that were identified in the existing body of literature, the interviewees proposed additional factors that they considered as being influential for a particular function. The analytical framework explicates a comprehensive list of influential factors, whereas the additional factors can be found in the results section regarding the qualitative analysis. The second part of the research question regards the establishment of hierarchy between the identified factors. The conducted interviews allowed for this prioritisation of factors on the basis of experience and expertise. Each function, and the factors affecting it, were scored for their relevance, hence determining the *weight* of these factors. This was not previously done, or at least reported on, in the existing body of literature.

The typology of the Dutch wind energy innovation system, as was discussed in chapter 1 of this study, suggested that the bottleneck for the lack of functioning of the innovation system could be attributed to a lack of legitimacy creation, a lack of guidance of the search, and a lack of market formation. In addition, access to resources was deemed to be only moderate. The preliminary analysis partially coincides with the results of this study. However, the functions of market formation and resource mobilisation were deemed relatively well fulfilled by the respondents, contrary to what preliminary analysis suggested. Still, on the basis of the results of this study, it can be concluded that the low level of functionality of the Dutch wind energy innovation system is due to the stagnation in the processes of legitimacy creation and guidance of the search. Strikingly, these functions are by the respondents also deemed most relevant for the realisation of wind energy upscaling.

The results have shown that regarding legitimacy of wind energy technology, there is an unanimous opinion that there is certainly a lack thereof. Moreover, efforts to increase legitimacy are minor and uncoordinated. There is however willingness among all respondent categories to cooperate in order to increase the legitimacy. Such cooperation is yet to be realised. The most prominent reason for this, as established in the qualitative analysis, is a lack of institutionalisation and government coordination. Qualitative analysis supports that the respondents feel the government should be a facilitator of objective knowledge about wind energy. Moreover, the coordination of cooperative efforts is essential for successful collaborations between multiple levels of society. Furthermore, the involvement of civil society is crucial for the distribution of objective knowledge, and thus the increase of legitimacy. These organisations represent the interests of many Dutch citizens that have to live with these windmills. It is also these organisations that can distribute knowledge to these people and it is these organisations through which civil participation can be facilitated. The social and techno-economic characteristics of wind energy are still deemed to be very significant barriers for upscaling, and for creating legitimacy. For this reason, participation, facilitated by government and institutionalisation, is all the more important. By involving all levels of society, the public can be made aware of the necessity of wind energy. Moreover, objective knowledge about the economic merit of wind energy can be distributed in that way. Although Dutch wind energy has a lot of potential for upscaling, since there is no lack of technical knowledge, resources and willingness, this potential is not realised. Concepts such as participation and cooperation are often deemed prerequisites for successful governance (Fung, 2015; Lange et al., 2013; Newig & Koontz, 2014), yet in the wind energy sector no emphasis is put on these most basic requirements for a successful upscaling process. In order for the wind energy system to meet its potential, it is essential that more collective efforts be put in the creation of legitimacy.

5.2 Reflections

5.2.1 Functions of upscaling

The current body of literature regarding socio-technical systems and transition is dominated by the distinction between macro and micro processes (Avelino & Rotmans 2009; Bergek et al., 2008; Hekkert et al., 2007). Hekkert et al. (2007) argue that theories on IS are too static and lack focus on the micro level. These systems, that are the units of interest in this body of literature, are intended to contribute to explaining why and how societal change occurs. Yet, the concept of an innovation system was at that time abstract, intangible, and undefined (Ibid.). Hekkert et al. (Ibid.) responded to this ontological deficit by devising the FIS framework, which allows the researcher to map the individual processes that occur within an innovation system, and hence define it. Although this framework certainly provides a more precise demarcation as to what constitutes an innovation system, it is still not entirely micro-level. The authors criticise theories on IS in that it lacks focus on the micro-level, and yet do not offer a substantial solution to this problem. The function themselves are still intangible at times, and are influenced by a multitude of micro-level factors. Although there are explicit suggestions in the framework as how to map each function, the framework does not offer a roadmap which can aid to explain the dynamics and factors that govern one particular process, or function. By assessing a wide range of literature on innovation systems and societal change (transition, upscaling etc.), this study addressed the lack of focus on the micro-level more thoroughly. The identification of barriers and stimuli that affect each of the functions allows for a more precise mapping of the system in which these functions play such a prominent role. The individual factors constitute a sub-level to the level in which the functions are embedded, hence focussing more on the micro-level than the FIS framework. Not only does this study apply the functional approach, it also improves upon the framework by identifying the influential factors within each function. Ultimately, this makes the framework more applicable to examine the diffusion and upscaling of one particular technology, such as wind energy. By creating a sub-level to the level of the functions, the functions of innovation in a sense become the functions of upscaling.

Bergek et al. (2008) have also addressed the lack of knowledge regarding what factors affect the system processes, or functions of innovation. Blocking mechanisms and inducement mechanisms are in their study posited to hinder or stimulate the functions of innovation. Although these blocking and inducement mechanisms certainly zoom in on the dynamics of the different functions, and these are used as a basis for the development of the analytical framework used in this project, there is no established hierarchy between these factors. Both the FIS framework, and the complementation of it by the above described mechanisms lack a tool or roadmap that can contribute to establish which factors are more significant than others. For certain technologies, at certain stages of development, one function may be more important than another. The same is true for the factors that affect these functions. In order to really pinpoint weak links or bottlenecks in the system that may prevent further diffusion or upscaling, it is essential to differentiate between the priority of factors. This study, by measuring the weight of the factors and relevance of the function at this time, allows for this differentiation. Although the focus of this study lies with the wind energy system in The Netherlands, the analytical framework that was constructed to adhere to the micro-level measurement requirements, is applicable to other technologies and the systems in which they are embedded as well. The results of this study revealed which functions and factors are most important and should have priority when considering governance policy for the practise of wind energy upscaling.

5.2.1 Methodology

Although the approach used in this study has provided a unique perspective on the dynamics of the upscaling process, there are some significant drawbacks and points of attention that need to be addressed. The first point of attention that is essential for the validity of the line argumentation regards the compatibility of the FIS framework with technologies, such as wind energy, that are not entirely new. In order for the framework to be applicable, it is pivotal that it is amended to gauge the exact stage of development of the technology at hand. Although the assumption that diffusion equals upscaling seems logical enough, it requires thorough explication in order for the framework to actually explain upscaling processes. The perspective and competence of the researcher is hence highly determinant for the validity of this assumption. Furthermore, a lack of objectivity may also affect the interviewee selection process, which is entirely dependable on the judgement and competence of the researcher as well. Although such a selection bias is difficult to prevent due to the specific knowledge requirements of the interviewees, it is essential that this shortcoming be recognised.

Another such objectivity deficit arises when the qualitative data that spawns from the interviews is coded and categorised into themes, represented by nodes. The interpretation of the remarks made by the respondents, and labelling of the themes in which these are categorised is subject to the researchers' perspective. Ironically, this perspective is highly affected by conducting the interviews, before analysing them. In order to ensure that the remarks are categorised in the correct theme with the correct label, because it was intended so by the respondents, it may prove valuable to reconcile with the respondents after the results of the research are established. The respondents can then confirm or deny the categorisation of references as interpreted by the researcher, ultimately leading to a better understanding of the hierarchy between influential factors.

Another point of attention is that not all factors involved in this study were measured for relevance. The fact that the proposed factors were not measured on the same scale as the given factor that were identified from the literature, makes it difficult to compare these in terms of their relevance. The figures that were used for the qualitative and the quantitative analysis were consequently of a different nature, and difficult to compare as well. Since the goal of this project was to establish some sort of hierarchy between the factors and functions that affect the upscaling process, this may be considered to be a weakness of this methodology. The limited scope of this study however prevented the proposed factors to be measured on the same scale. Further research can remedy this problem.

Another methodological decision that needs re-examination regards the theoretical concepts that were used in the interviews. The abstract and intangible nature of many of the theoretical concepts incorporated into the analytical framework, and hence included in the interviews, made it difficult for some respondents to immediately understand these embedded concepts. Although these concepts are often difficult to simplify, in retrospect a simpler, more understandable labelling of the concepts may have made it easier for the respondents to provide their opinion on the matter. As such, it is prudent for researchers that may apply this framework to measure upscaling potential for other technologies, that the concepts be thoroughly defined and simplified as much as possible.

Finally, it is important to recognise that this study provides a contemporary picture of the status of wind energy upscaling. Societal transition is highly susceptible to a wide range of factors and external influences, as evidence of the results of this study. As a result, the dynamics of the systems that facilitate societal change like technological upscaling is in flux, rather than static. It may well be that even in a short time span of only a year, the function and factor hierarchy has changed entirely. Still, this report is a steppingstone for understanding the significance, albeit short-term, of the many different factors that are involved with the upscaling process of wind energy in The Netherlands. Moreover, the analytical framework shows great potential to provide similar insight for other technologies that are on the verge of being scaled up.

5.3 Further Research

Many of the drawbacks of this study that have been addressed in the previous section can be remedied by further research. Moreover, the scope of this study has limited the validity of the results in some respects. Hence, there are several points to consider when continuing this line of research, either when assessing the wind energy system in even more detail or when applying the analytical framework to other technologies.

In order to improve upon our understanding of the dynamics of the wind energy upscaling process, there several recommendable steps that are likely to do so. As mentioned before, the interviews are merely one method of assessing the fulfilment of the functions. The FIS framework provides multiple indicators that contribute to explaining the status of each function. Mapping the functions as such according to the FIS framework would, although it would require a significant expansion of the scope of the study, surely provide more insight in the current status of the innovation system in which Dutch wind energy is embedded. Furthermore, the influential factors that were proposed by the respondents were not measured on the same scale as the given factors that were identified from the literature. It is highly recommended to do a more extended search for influential factors and measure these, and the ones already proposed, on the same scale as the given factors. This would increase the level of inclusiveness of the methodology. Moreover, to ensure the inclusion of more factors does not infringe upon the level of revelation of hierarchy, the scale with which the factors are measured can be expanded in its entirety (i.e. 1-10). Another recommendation for further research regards reengagement of the respondents as well. As mentioned before, the qualitative data analysis, in which the references were coded and categorised into nodes, is vulnerable to researcher’s bias. Another session with the respondents in which they can provide feedback regarding such labelling would greatly improve the objectivity of the labelling of the nodes, and thus benefit the study as a whole.

The analytical framework that was used in this study can be applied to assess the upscaling potential of other technologies as well, under the condition that the rationale behind the applicability is well explicated. Another condition for the application of the analytical framework to other technologies is that the framework is tailored to acknowledge the nature and the stage of the innovation system in which that particular technology is embedded. The different functions can have entirely different connotations for different technologies and stages of development.

Finally, there are recommendations made here that are not aimed to improve the validity of the results revealed here, but are rather a continuation from where the scope of this study ends. Although, the SP framework allows for policy-makers to have a general idea of which policy instruments are relevant at a certain point, the impact of either the policy status quo and proposed instruments on the fulfilment of the functions is not yet addressed. Studying the effectiveness of policy instruments to improve the fulfilment of the most relevant functions is the logical next step to contribute to the upscaling process of wind energy in The Netherlands.

6. Recommendations for policy practise

In this final chapter, recommendations for policy practise are formulated. The chapter consists of five sections, each dedicated to one particular respondent category. Within each section, each of the functions is briefly addressed as to what the responsibility of that particular group entails regarding the improvement of that function, so that the upscaling process can be improved altogether. Note that the functions that are fulfilled the least are the most relevant to address in policy practise. Still, recommendations for all the functions are included. Before different respondent categories are addressed in separate sections, the most relevant factors are summarised, so that they may provide a steppingstone for the formulation of recommendations.

The scope of this study does not allow for the assessment of the effectiveness of policy status quo or specific policy instruments. However, the level of fulfilment of particular functions, or rather the lack thereof, does say something about the effectiveness of the entire policy arena regarding wind energy. Since *creating legitimacy* is the least fulfilled function, it can be assumed that current policy regarding legitimacy creation is ineffective. The weight of the measured factors, as determined in this study, can aid policy-makers when formulating policy that is aimed to stimulate a certain function. The factor of *participation* is deemed highly relevant for legitimacy creation. Policy instruments that aim to facilitate participation are thus highly recommendable. The high level of relevance of the factor of *long-term government vision and institutionalisation* suggests that more stringent institutionalisation regarding wind energy, that among other things lays down a long-term government vision, is desirable. Policy *measures that affect the relative prices*, such as subsidies, are still highly relevant and desirable as well. Although the factor of *societal characteristics of the technology* is also deemed highly relevant, this can only be indirectly impacted in the form of *guidance of the search*. Other than that, it is essential that such characteristics are recognised and minimized, which can be done by means of measures that address participation and institutionalisation. Two other factors that are difficult to affect regard *competition*, resulting in isolationist corporate policy, and *collective goalsetting* among corporate entities to remedy such isolation. This yet again points out that *participation*, and all measures facilitating it, it highly relevant for policy-makers to consider.

6.1 Companies

The most prominent actors for the function of entrepreneurial activity are logically the entrepreneurs. Hence, the category of companies plays the greatest role in this process. Among the factors that were measured, there is one particular factor that companies can significantly influence. Experimentation (learning-by-doing) is the foremost activity in which companies can contribute to the upscaling process. The projects with an experimental nature are highly recommended for the improvement of the innovation system and hence the upscaling process.

Companies develop knowledge by means of trial and error. Experimentation, which results in learning-by-doing, is regarded as the most important factor for knowledge development. As mentioned before, it is the responsibility of companies to continue experimentation so that the knowledge base regarding wind energy is continually improved. The diffusion of knowledge through networks can, according to the results, be obstructed by isolationist corporate policy that spawns from competition. In order to overcome such barriers, it is essential for companies to engage in collective goalsetting. Communication and collaboration among companies is crucial for the fulfilment of the knowledge functions.

Although the role that companies play in the guidance of the search is marginal, they do from the backbone of the market formation process. It is the cumulative entrepreneurial activity that forms the market for wind energy. By continually investing in wind energy, companies ensure that the market keeps growing. Furthermore, with regard to wind energy innovations, larger entrepreneurial players are in the position to protect such innovations from market pressures and enable it to develop and mature into more robust technologies.

Access to sufficient resources is according to the results of this study not an issue for companies in the Dutch wind energy innovation system. The establishment and maintenance of international networks should however be continued, in order to maintain the fulfilment of this function on this high level.

As previously established, the creation of legitimacy is the most prominent bottleneck for the upscaling process. Each of the societal groups discussed here bears responsibility to improve this process. Collaboration, not only among companies, but among all societal groups is necessary in order to facilitate effective legitimacy creation. It is the companies that actually develop and build the windfarms, it is therefore only logical that they should take up some of the responsibility to legitimise what they are doing. Involvement of the public by means of awareness and information campaigns can enable companies to contribute to the creation of legitimacy.

6.2 Government

Since institutionalisation is considered to be highly relevant for entrepreneurial activity, the government, mainly on a national level, can have a major impact on this function, by establishing relevant institutionalisation that is based on the long-term vision. Currently, entrepreneurs that plan to engage in renewable energy projects compete for government subsidy in the form of the SDE+ (RVO, 2016). This program allows for the most promising projects to receive subsidy. This can however lead to selections which do not contribute to the upscaling process of wind energy. Therefore, it is recommended to look into the establishment of subsidy policies for which only wind energy projects are eligible. Furthermore, the government actor group is in an ideal position to combat the isolationist corporate policy that results from competition. The cooperation between entrepreneurs in the form of collective goalsetting needs to be facilitating by the government. Platforms on which entrepreneurs can cooperate to set and reach collective goals should be established by a neutral party, such as local governments.

Research and development that is funded and/or facilitated by the government is an important part of the development of knowledge in the innovation system. It is also a means by which governmental actors can guide the search for wind energy innovations. As such, government actors can certainly contribute to the development of knowledge by facilitating research that aims to improve the knowledge base regarding wind energy. Furthermore, the distribution of knowledge regarding the economic merit and social implications of wind energy is also, according to many of the respondents, the responsibility of the government. Many of the remarks made during the interviews pointed towards a lack of coordination by governmental actors. A lack of objective knowledge can be remedied if the government takes up the responsibility to provide this knowledge. Many misconceptions regarding wind energy technology can in that way be eliminated.

Market formation is also highly determined by the presence and quality of institutionalisation. As mentioned before, governmental actors, either on national or local level, can have significant influence on the upscaling process by establishing rules and regulation regarding wind energy. Such institutionalisation should reflect the long-term vision of large-scale market formation and thus upscaling wind energy.

The geopolitical relations between the national government and the rest of the world is highly relevant for the access to resources. As such, the function of resource mobilisation is also impacted by governmental actors. It is thus up to these governmental actors to ensure that all required resources are accessible to the Dutch wind energy system. According to the results, this is currently not a significant barrier.

The most important responsibility of the government is to contribute to the creation of legitimacy. The national government has chosen a particular trajectory towards upscaling of wind energy, and it is thus their responsibility to justify these choices to the public. Obtaining objective and valid knowledge regarding wind energy is the first step for governmental actors that attempt to increase the legitimacy of wind energy. The diffusion of this knowledge with the public is the second step toward this goal. Awareness and information campaigns (i.e. infomercials, workshops etc.) are means with which the government can achieve this. Moreover, the government should facilitate cooperation between all societal groups, so that these can work together towards a more legitimate wind energy sector.

6.3 NGOs

NGOs are effective facilitators of knowledge sharing (Hasnain & Jasimuddin, 2012; Hurley & Green, 2005). Knowledge exchange enables learning-by-interacting (Hekkert et al., 2007). Therefore, NGOs can contribute to knowledge development by facilitating cooperation and knowledge sharing. NGOs can also serve as platforms and facilitators of entrepreneurial collaboration. The functions of entrepreneurial activity, knowledge development and knowledge diffusion are therefore all influenced by NGO activity. The obtainment and distribution of objective valid knowledge is a crucial aspect of the contributions NGOs can make to the upscaling process. These organisations should be used as liaisons between all the different societal levels, so that there are no misconceptions regarding the societal and techno-economic characteristics of wind energy. In that respect, NGOs can contribute to the creation of legitimacy as well. Preconceptions regarding the government or companies involved with wind energy projects can be a barrier for the creation of legitimacy among the public. NGOs can therefore act as a more neutral party to facilitate the sharing of knowledge and cooperation between different societal groups.

6.4 Knowledge Institutions

The function of knowledge development is mostly impacted by the role of knowledge institutions. Knowledge is continually scrutinised and improved upon by doing research in knowledge institutions. The results of the study suggest that there is a sufficient knowledge base for the upscaling process to be successful. Therefore, knowledge institutions should be consulted by entrepreneurs for valid and relevant information regarding wind energy. These institutions can help to expand the knowledge base of companies, so that strategic decisions are made that contribute to the upscaling process. Collaboration with companies and other actor groups is essential for the application and ultimately the improvement of the knowledge base. The guidance of the search can also be influenced by knowledge institutions, since they determine the field of study they engage in. Continuous research in the field of wind energy can have a major contribution to the upscaling process, and it therefore highly recommended. The creation of legitimacy can only be done if valid and objective knowledge is available and accessible. Independent knowledge institutions are in a unique position to provide this knowledge. Not only can these institutions improve the technical knowledge base, but they can also contribute to the elimination of misconceptions about wind energy and to create sustainable legitimacy.

6.5 Civil Society

Civil society can only have a marginal influence on the function of entrepreneurial activity. Collaboration with entrepreneurs, so that the interests of citizens are represented in the entrepreneurial arena, is however recommended. Furthermore, although civil society can hardly contribute to the development of technical knowledge, it is the most significant source of knowledge regarding the social implication of wind energy. It is therefore of utmost importance that civil society be involved in the decision-making process. Spatial planning and development of windfarms should take into account the interest of the citizens that have to live with these windmills. Participation was deemed to be a highly relevant factor for almost all of the functions. This means that local initiatives and social movements that regard wind energy should be taken very serious, and even encouraged. For civil society itself it is highly recommendable to make sure their voice is heard. Such initiatives and movements are a way to collectively contribute to the decision-making process regarding the upscaling of wind energy. Moreover, civil society organisations are in an unique position to objectively inform the public about wind energy. These organisations can thus be the intermediary between the public and the societal actors that attempt to increase the legitimacy for wind energy.

In essence, the most prominent actors in the Dutch wind energy innovation system have thus far failed to create enough legitimacy for the innovation system to function sufficiently, so that wind energy can be scaled-up. Cooperation and participation are key concepts in the road to success. These processes should however be supported by a collective long-term vision, which in turn should be backed up by quality institutionalisation established by government actors.

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Appendix I Interview Design

Interviewer: Simon Zijlstra

Interviewee:

Position and relation to Dutch wind energy sector:

Function: Entrepreneurial activities

1. **What is your own impression of the fulfilment of this function within the Dutch wind energy innovation system? Is there sufficient entrepreneurial activity?**

2. **On a scale from 1 to 5, with 1 being totally unfulfilled and 5 being optimally fulfilled, how would you rate the fulfilment of this function?**

3. **Literature review and the development of the analytical framework revealed the existence of potential barriers and stimuli to the fulfilment of this function. In your experience/opinion, how relevant would you say these barriers/stimuli are in the Dutch wind energy innovation system? Please rate the relevance on a scale from 1 to 5, 1 being totally irrelevant and 5 being of utmost importance.**

For example, one could argue that the barrier of lock-in to established technologies is of great influence (very relevant) on the fulfilment of the function of entrepreneurial activities.

Barrier	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Lock in to established technologies					
Lack of long-term government vision					
Stimuli	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Protected niche spaces (nursing markets)					
Measures affected relative prices (e.g. tax exemption)					
Encouraging experimentation (learning by doing)					

4. **In your own experience/opinion, are there any other barriers and stimuli that affect the fulfilment of this function?**

Function: Knowledge development

1. **What is your own impression of the fulfilment of this function within the Dutch wind energy innovation system? Is there sufficient knowledge development?**

2. **On a scale from 1 to 5, with 1 being totally unfulfilled and 5 being optimally fulfilled, how would you rate the fulfilment of this function?**

3. **Literature review and the development of the analytical framework revealed the existence of potential barriers and stimuli to the fulfilment of this function. In your experience/opinion, how relevant would you say these barriers/stimuli are in the Dutch wind energy innovation system? Please rate the relevance on a scale from 1 to 5, 1 being totally irrelevant and 5 being of utmost importance.**

Barrier	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Weak network failure					
Lack of entrepreneurial activities (F1)					
Stimuli	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Government RD&D programmes					
Funding RD&D projects					
Encouraging experimentation (learning by doing)					

4. **In your own experience/opinion, are there any other barriers and stimuli that affect the fulfilment of this function?**

Function: Knowledge diffusion through networks

1. **What is your own impression of the fulfilment of this function within the Dutch wind energy innovation system? Is knowledge sufficiently diffused?**

2. **On a scale from 1 to 5, with 1 being totally unfulfilled and 5 being optimally fulfilled, how would you rate the fulfilment of this function?**

3. **Literature review and the development of the analytical framework revealed the existence of potential barriers and stimuli to the fulfilment of this function. In your experience/opinion, how relevant would you say these barriers/stimuli are in the Dutch wind energy innovation system? Please rate the relevance on a scale from 1 to 5, 1 being totally irrelevant and 5 being of utmost importance.**

Barrier	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Weak network failure					
Stimuli	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Stimulate interaction (learning by interacting) in the form of workshops, conferences, forums					

4. **In your own experience/opinion, are there any other barriers and stimuli that affect the fulfilment of this function?**

Function: Guidance of the search

1. **What is your own impression of the fulfilment of this function within the Dutch wind energy innovation system? Is there sufficient guidance of the search?**

2. **On a scale from 1 to 5, with 1 being totally unfulfilled and 5 being optimally fulfilled, how would you rate the fulfilment of this function?**

3. **Literature review and the development of the analytical framework revealed the existence of potential barriers and stimuli to the fulfilment of this function. In your experience/opinion, how relevant would you say these barriers/stimuli are in the Dutch wind energy innovation system? Please rate the relevance on a scale from 1 to 5, 1 being totally irrelevant and 5 being of utmost importance.**

Barrier	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Lock-in to established technologies					
Characteristics of new technology					
Weak organisational power					
Stimuli	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Formulation of long term goals (i.e.renewable energy)					
Government RD&D programmes					
Increasing legitimacy (F7)					

4. **In your own experience/opinion, are there any other barriers and stimuli that affect the fulfilment of this function?**

Function: Market formation

1. **What is your own impression of the fulfilment of this function within the Dutch wind energy innovation system? Is there sufficient market formation?**

2. **On a scale from 1 to 5, with 1 being totally unfulfilled and 5 being optimally fulfilled, how would you rate the fulfilment of this function?**

3. **Literature review and the development of the analytical framework revealed the existence of potential barriers and stimuli to the fulfilment of this function. In your experience/opinion, how relevant would you say these barriers/stimuli are in the Dutch wind energy innovation system? Please rate the relevance on a scale from 1 to 5, 1 being totally irrelevant and 5 being of utmost importance.**

Barrier	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Lock-in to established technologies					
Characteristics of new technology					
Lack of customer competence					
Lack of long-term government vision					
Stimuli	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Protected niche spaces (nursing markets)					
Investment subsidies Measures affected relative prices (e.g. tax exemption)					
Competent municipal buyer					
Increase concern for the environment					

4. In your own experience/opinion, are there any other barriers and stimuli that affect the fulfilment of this function?

Function: Resource mobilisation

1. **What is your own impression of the fulfilment of this function within the Dutch wind energy innovation system? Are resource sufficiently accessible?**

2. **On a scale from 1 to 5, with 1 being totally unfulfilled and 5 being optimally fulfilled, how would you rate the fulfilment of this function?**

3. **Literature review and the development of the analytical framework revealed the existence of potential barriers and stimuli to the fulfilment of this function. In your experience/opinion, how relevant would you say these barriers/stimuli are in the Dutch wind energy innovation system? Please rate the relevance on a scale from 1 to 5, 1 being totally irrelevant and 5 being of utmost importance.**

Barrier	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Lock-in to established technologies					
Legitimacy of innovations (F7)					
Stimuli	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Funding R&D projects					
Government RD&D programmes					

4. **In your own experience/opinion, are there any other barriers and stimuli that affect the fulfilment of this function?**

Function: Creation of legitimacy

1. **What is your own impression of the fulfilment of this function within the Dutch wind energy innovation system? Is legitimacy sufficiently created?**

2. **On a scale from 1 to 5, with 1 being totally unfulfilled and 5 being optimally fulfilled, how would you rate the fulfilment of this function?**

3. **Literature review and the development of the analytical framework revealed the existence of potential barriers and stimuli to the fulfilment of this function. In your experience/opinion, how relevant would you say these barriers/stimuli are in the Dutch wind energy innovation system? Please rate the relevance on a scale from 1 to 5, 1 being totally irrelevant and 5 being of utmost importance.**

Barrier	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Lock-in to established technologies					
Characteristics of new technology					
Opposing advocacy coalitions of incumbent regime					
Stimuli	**Irrelevant (1)**	**Slightly relevant (2)**	**Moderately relevant (3)**	**Very relevant (4)**	**Utmost importance (5)**
Formulation of advocacy coalitions					
Awareness campaigns					
Lobby activities, including workshops, conferences, web-tools					
Increase concern for the environment					

4. **In your own experience/opinion, are there any other barriers and stimuli that affect the fulfilment of this function?**

Appendix II List of interviewees

Candidate	Actor position	Dimension	Geographical location	Email address
Fred Jansen (Voorzitter van Nationaal kritisch platform windenergie (NKPW))	Civil society	Social	Schagen	jhfj@xs4all.nl
Prof. Dr. Albert Koers (Voorzitter Nederlandse Vereniging Omwonenden Windturbines (NLVOW))	Civil society	Social/ Institutional	Utrecht	albert.koers@nlvow.nl
Prof. ir. R.W.J. (Rob) Kouffeld (Voorzitter raad van toezicht - Energie - Stichting Groene Rekenkamer (SGRK))	Civil society	Social/ Political	Utrecht	Rob.Kouffeld@ziggo.nl
Ir. Ijssebrand Ziel (EAZ, start-up)	Companies	Technical	Den Haag	ijssebrand@eazwind.nl
Arjan Donker (Directie Eneco Offshore Wind, large firm)	Companies	Technical/ economic	Gorichem	arjan.donker@eneco.com
Teun van Dijk (Notaris Van Dijk De Jongh Notarissen)	Companies	Institutional	Dronten	vandijk@flevium.nl
Dr. Harmsen (Copernicus Institute, UU)	Knowledge Institutions	Social/ Political	Utrecht	r.harmsen@uu.nl

Prof. Dr. Kramer (Copernicus Institute, UU)	Knowledge Institution	Technical	Utrecht	g.j.kramer@uu.nl
Remko Ybema (Energy Academy Europe)	Knowledge Institutions	Technical/ Institutional	Groningen	info@energyacademy.org remko.ybema@energyacademy.org
Gert-Jan Tillema (D66 gemeente Enschede)	Government	Institutional/ political	Enschede	gertjan.tillema@d66enschede.nl
Robin Wessels (Groenlinks gemeente Enschede)	Government	Institutional/ political	Enschede	robinw@xs4all.nl
Teun Lamers	Government	Institutional/ political	Utrecht	teun.lamers@rws.nl
Karen Kooi (NWEA)	NGO	Social/technical	Utrecht	info@nwea.nl
Bob Meijer	NGO	Social/technical	Utrecht	meijer@tki-windopzee.nl
Prof. Dr. Catrinus Jepma (Senior Expert Energy and Sustainability EDI)	NGO	Technical	Groningen	c.j.jepma@rug.nl

The selection of the interview-candidates allowed for each dimension to be addressed by at least 6 interviewees that are considered to have expertise in that particular area.

Appendix III Description of nodes

Node	Sources	References	Description of node
Transparency	2	3	Better transparency regarding wind energy projects is necessary, e.g. regarding spatial planning. Government strategies should be well communicated.
Participation	8	13	Democratic policy regarding wind energy is required. Involve all parties in decision-making process. Local initiatives and involvement of civil society is key.
Compensation mechanisms	2	2	People need to be compensated for any negative societal implications
Advocacy coalitions should operate differently	4	6	Consumer oriented campaigns are necessary. Role of media is important in framing the climate problem
Success cases stimulate to follow	1	1	e.g. Denmark and Germany
Strong argicultural sector	1	1	Small scale windmills are dependent on this sector
Snapshot	1	1	All these functions and factor are highly fluctuating. This is a contemporary view
Resource mobilisation affects knowledge development	1	1	Financial resources are necessary for research
Public image of wind	2	3	Make windmills cool and fashion. As example, Tesla vehicles. Make wind energy national pride.
Price effectiveness is too low	1	1	Wind energy is still an expensive technology
Partial presence	3	3	Entrepreneurial activity can be really high in one form, and low in another. Netherlands are very good at deployment, but less in turbine development.
Small scale windmills are lacking	2	2	Small scale means -15m windmills
Measures affecting relative prices for local businesses	2	4	Current measures are effective for major players, but not so much for local enterprises
Measures affecting relative prices	1	1	These measures cannot hold

are short term stimulant			in the long run.
Market demand	1	1	Demand stimulates knowledge development
Long-term government vision and institutionalisation	12	18	Long-term government vision can stimulate wind energy, e.g. regarding spatial planning and resource accessibility. Institutionalisation should adhere to this vision
Lower level government hinder guidance	2	5	Provinces and municipalities, as opposed to national government, are often against wind energy upscaling (NIMBY)
Lack of trust in government	3	3	Government only presents knowledge that fits current policy. Trust in government policy is lacking
Lack of social knowledge	3	3	There is a distinction between technical and social knowledge regarding wind energy. Contrary to technical knowledge, social knowledge is lacking.
Guidance of the search as factor	3	6	Guidance of the search influences multiple functions
Government vision regarding societal development stimulates	3	3	Government can hardly stimulate technical development. However, social knowledge can be stimulated. Government should lead discussion and provide objective information
Lack of legitimacy	7	9	Lack of legitimacy blocks upscaling
Content legitimacy is lacking	2	2	There is a distinction between institutional and judicial legitimacy, and content legitimacy
Lack of customer competence is a scientific term	1	1	This term would never be used by a producer or provider
Investment climate	3	4	Economic weather is determinant for the wind energy market, and for individual investors and entrepreneurs
International networks stimulate	6	9	Distance can be barrier, well-connected networks can

			overcome this
Infrastructural deficit	2	3	Large scale upscaling requires additional investment in infrastructure to transport and deliver the actual energy
High entry requirements as barrier	1	1	Entry into the market is difficult due to large players (oligopoly)
Geopolitical relations are influential	2	3	Government policy is always dependent of global politics
Fragmentation	5	6	Fragmented innovation and development is barrier. Coordination is highly relevant and is currently fragmented
Export policy	1	1	Exporting platforms are important for upscaling
Experimentation stimulates technical development	2	2	Experimentation (business) may result in further development of e.g. generator. This may in turn lead to less resource requirements for wind energy
Environmental impact of wind energy	2	2	Environmental impact as separate factor
Entrepreneurial or business activity as stimulant	1	1	Through corporate experimentation
Energy Storage	3	4	Lack of storage capacity is a bottleneck
Educational climate	3	3	Human capital is highly relevant for further development
Human capital is lacking for offshore	2	2	Technical jobs
Distinction between short and long term	1	1	Experimentation by companies is short-term oriented. Government R&D should be long-term oriented
Distinction between onshore and offshore	5	8	Offshore wind energy has more potential for further technical and institutional development, but is currently more reliant on subsidies. Onshore wind is mature and fully developed
Competition as barrier	7	9	Competition results in isolation policy. No sharing of knowledge between

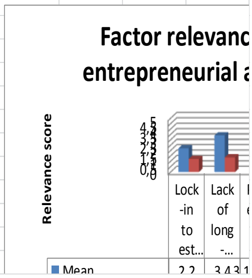
			competitors
Collective goalsetting	7	9	e.g. efficiency and lower costs. Overcome isolation policy. Among private sector actors, but also government (international)
Climate change as stimulant	1	1	Increasing climate change consequences give wind energy more momentum
Banks are barriers	1	1	Banks have a major financial role and are risk evading
Access to rare physical resources	3	3	Rare elements can be bottleneck for resource mobilisation

Appendix IV Excel file

User instructions:

Open this document in Microsoft Word (2010 or later), then double-click on the image below to enable editing mode. Note that there are 9 different tabs.

Responde	Lock-in to estal	Lack of long-t	Protected niche	Measures affecte	Encouraging expe	Suggested factor with score
Koers	2	5	1	5	3	Lack of legitimacy as barrier: 5
Jansen	2	1	5	5	3	
Koeffeld	2	3	2	4	4	Characteristics of the technology (energy storage): 4
Donker	1	4	4	5	4	
Van Dijk	4	5	4	3	2	Legislation as barrier and stimulant: 2-4
Ziel	1	2	4	2	4	Legislation as barrier and stimulant: 2-4 ; Characteristics of the technology: 4 ; Participation as stim
Kramer	1	4	4	5	2	Location selection as stimulant: 4
Ybema	3	4	4	5	3	Legislation and investment climate can be barriers and stimulant
Harmsen	1	1	4	4	5	Too high expections as barriers: 3
Tillema	4	4	4	5	4	Legislation as stimulant: 4
Wessels	3	5	2	4	2	Legislation as stimulant: 4
Lamers	1	4	3	4	2	
Kooi	4	3	2	5	5	Lack of legitimacy as barrier: 5
Meijer	3	2	1	4	4	Long term government vision as stimulant: 4
Jepma	1	4	3	5	4	Lack of legitimacy as barrier: 5
Mean	2,2	3,4	3,133333333	4,333333333	3,4	
Standard	1,207121724	1,352246808	1,245945806	0,899735411	1,055597326	



Appendix V NVivo file

Instructions:

Open this document with Microsoft Word (2010 or later). Double-click on NVivo icon. Open with NVivo 11.

NVivo file.nvp