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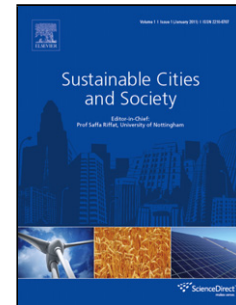
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How municipalities act under the new paradigm for energy planning

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Highlights

- National framework conditions for strategic energy planning in Denmark could be improved.
- Successful strategic energy planning requires national as well as local action.
- Identifies strategic and practical barriers for local strategic energy planning.

Abstract

Radical changes in energy production, going from sector-based energy systems based on fossil energy resources to smart energy systems based on renewable resources are starting to occur worldwide. This transition is a matter of balancing technical solutions with societal needs and possibilities, which requires a large effort in terms of policymaking and energy planning. This paper investigates how Danish municipalities are currently dealing with these issues through strategic energy planning. Through a case study of a Danish municipality, strategic and practical barriers to municipal strategic energy planning are identified. The paper ends by presenting recommendations

on how to eliminate the identified barriers. In doing so, this paper brings new knowledge into further research of national and local framework conditions for strategic energy planning and thereby, the green transition of the energy system.

Keywords: strategic energy planning; policymaking; implementation strategies; local planning

1 Introduction

Over time, the focus in energy planning has changed several times due to different incidents in history. In Denmark, the 1973 oil crisis triggered a shift towards natural gas and later on a paradigm shift towards 100% renewable energy systems both in Denmark [1] and internationally can be identified. Countries [2–4], municipalities [5–7] and cities [8,9] have developed energy policies, goals and plans aiming for low-carbon and renewable energy systems. Several initiatives are supporting the development of energy plans worldwide.

In Denmark, local energy planning is connected to the national goal of a 100% renewable energy system in 2050 [2], through an expectation of the municipalities conducting strategic energy planning [10][11]. Strategic energy planning is a holistic energy planning approach to secure long-term goals within the energy system. However, there is an expectation by the Danish government of the Danish municipalities to conduct local strategic energy planning, although it is not made a mandatory task and there is no willingness to support the local development of strategic energy planning financially. Several studies emphasise the importance of local authorities' knowledge in the energy planning [6,8,12–14]. Local energy planning is important because energy is no longer a service provided from central production units, located away from consumers. This makes the local authorities important actors in energy planning, since the local implementation requires local knowledge of not only geographical conditions but also of how the local communities function in

order to involve private consumers in a suitable way. Conducting energy planning at a local level makes it easier to meet local needs. Furthermore, is it easier for citizens to interact and communicate with the municipalities than authorities located at a national level [15].

However, the voluntariness in Danish energy planning leaves the municipalities to decide themselves if or how much they want to prioritise strategic energy planning in a municipality. The municipalities do however, develop strategic energy plans on their own initiative. Petersen [5] analysed the prevalence of municipal energy strategies in Denmark. Fifty per cent of Danish municipalities have already approved strategic energy plans and an additional 25% have strategies related to strategic energy plans. This indicates that the municipalities have taken their part of the responsibility for the transition of the energy system. However, previous studies have proven that the quality of the strategic energy documents in the municipalities are of a very varying character [5–7,16]. This means that the full potential for the transition towards 100% renewable energy will most likely not be reached under the current circumstances. Studies point to a lack of funding for local strategic energy planning from a national level as one of the main factors in the varying quality [6,8,11,13]. Allman et al. [13] found that a lack of funding is often an important factor for less successful authorities, as scarce budgets means that they do not have the right amount of competent staff time to develop the strategic plans. Furthermore, Allman et al. argued that a lack of funding results in local authorities chasing funding for pilot projects, resulting in ad hoc energy planning and a lack of coordinated strategic visions [13]. Therefore, allocation of long-term funding to local authorities for strategic energy planning could provide a more homogeneous level of quality in the development of a local strategic energy plan (e.g. in terms of analyses and details). However, there will still be challenges that cannot be solved only by a flow of financial support from a top-down level. A challenge that has proven difficult to eliminate in energy planning processes is local

resistance towards larger energy production units such as wind turbine farms and biogas plants [17]. This is especially a problem due to the need for local integration of fluctuating renewable energy into the energy system. Furthermore, other challenges for strategic energy planning have also been identified as including a lack of implementation strategies, missing interplay between local and national energy targets and policies and a shift in political agendas requiring short-term planning when long-term planning is desired [11]. The transition to 100% renewable energy systems still requires large changes in the organisation of the energy systems as well as the technical composition. Therefore, strategic energy planning is important, because if long-term strategies and plans are not being developed, the large changes will never happen.

Only a few studies of strategic energy planning can be found in the academic literature [6–8] and most of the literature operates on an overall level and does not analyse strategic energy planning in practice [5]. This could be due to energy planning being developed into many more or less uniform approaches overtime and shaped to fit into specific conditions and locations [18–22]. Different institutional levels with relevance for energy planning are mentioned in the literature, ranging from a community/city level [22–28], to municipality level [6,29–32], regional level [21,23,31] and all the way up to a governmental level [23,31]. Even though these different levels are identified in the literature, most studies only consider one level in relation to the different energy planning approaches. The focus in this paper is on strategic energy planning at the municipality level, though with the assumption that municipal energy planning cannot happen without strong communication between the above-mentioned institutional levels, the reason behind this is explained further in the theoretical framework in section 2. While only a few studies on municipal strategic energy planning can be identified, there are international studies that investigate how municipalities/local authorities in practice work with energy and climate planning through different approaches [33–

36]. Several countries have introduced legislation and strategies to support the municipal and local transition towards renewable energy, examples of which are the Energy Transition for Green Growth Law in France [33] and the Community Energy Strategy in the UK [14]. However, these studies show that although political initiatives were introduced there is still a gap between the national and local level when it comes to realising political plans. For instance, local authorities often seem to struggle due to a lack of resources and specific knowledge [14,36], but also due to missing consistency in the energy policymaking at the national level [14,33,36].

With the focus on Danish strategic energy planning in this paper, a theoretical analytical framework for strategic energy planning is shaped (see Section 2), as and within a holistic approach, attempting to include all relevant institutional levels in the strategic process to reach an adequate balance in energy planning between national and local goals and policies. The here established analytical framework is used to analyse a specific case in order improve scientific knowledge of strategic energy planning and barriers related to the process. With inspiration from the Danish investigation of barriers within municipalities for the implementation of CO₂-reducing actions [37], this paper distinguishes between strategic barriers and practical barriers. Strategic barriers are barriers that come from the national level and in general, limit municipalities in their options (e.g. legislation, tax, funding, national politics) and practical barriers are locally anchored barriers (e.g. local geography, resistance, local politics) and these barriers can only be understood through local knowledge of the individual municipalities. Furthermore, it is interesting to investigate if there is a connection between the strategic energy plans and actions made locally, to analyse the role of the strategic energy plan in a municipality.

1.1 Problem

The aim of this paper is to investigate the current status of Danish municipal strategic energy planning in practice. To do so, the following questions are asked:

1. How does a typical Danish municipality currently work with local (strategic) energy planning?
2. How well connected are the strategic energy plans with the actual energy projects carried out in the municipality?
3. What are the barriers to a successful strategic energy planning process, seen from a municipality's perspective?

To investigate these questions a case study was chosen. The studied municipality is Hjørring municipality and the analysis is limited to mapping energy projects conducted in the municipality, comparing them with goals in the local strategic energy plan, and not evaluating the quality of the single projects in detail. It should be emphasised that Hjørring Municipality is a rural municipality, like the majority of Danish municipalities. Consequently, this means that the case study will not represent the few city-municipalities in Denmark. The choice of the case study is motivated further in the methodology section.

1.2 Structure of the paper

In Section 2, the theoretical framework for the study is outlined. Section 3 describes the methodology used and presents the analytical framework. In Section 4, the analysis is carried out and the results are presented. In Section 5, a concluding discussion of the findings end the paper.

2 Theoretical framework

Even though strategic energy planning is not mandatory, there is still an unwritten expectation for municipalities to conduct strategic energy planning. In 2010, the Danish Energy Agency introduced municipal strategic energy planning as a necessity for reaching national energy goals and keeping

Denmark's position of strength within the green economy [38]. In recent years, a focus on smart energy systems has started to occur within academic research arenas [39]. Smart energy systems seek to combine and integrate all energy sectors to achieve optimal solutions for the overall energy system [39]. The fact that the design of smart energy systems integrates all energy sectors makes the development of future energy systems more complex, as all synergies in the energy system are prioritised to reach an overall optimal energy system. This also make strategic energy planning an even more important task in the municipalities, since the municipalities have a great local knowledge due to their location close to local communities where many of the synergies should be reached.

The Danish Energy Agency have not adjusted their definition of strategic energy planning to keep up with the development in the understanding of how energy systems should be designed and implemented in society. The lack of a clearly defined national framework for strategic energy planning in Denmark and the different definitions of the concept makes it difficult to validate how well it is currently executed. Therefore, the analysis in this paper is based on the theoretical framework developed by Krog and Sperling [11]. Krog and Sperling's theoretical framework is based on a literature review of strategic energy planning. In the framework, the smart energy system [40] is brought in as a premise in the definition of strategic energy planning.

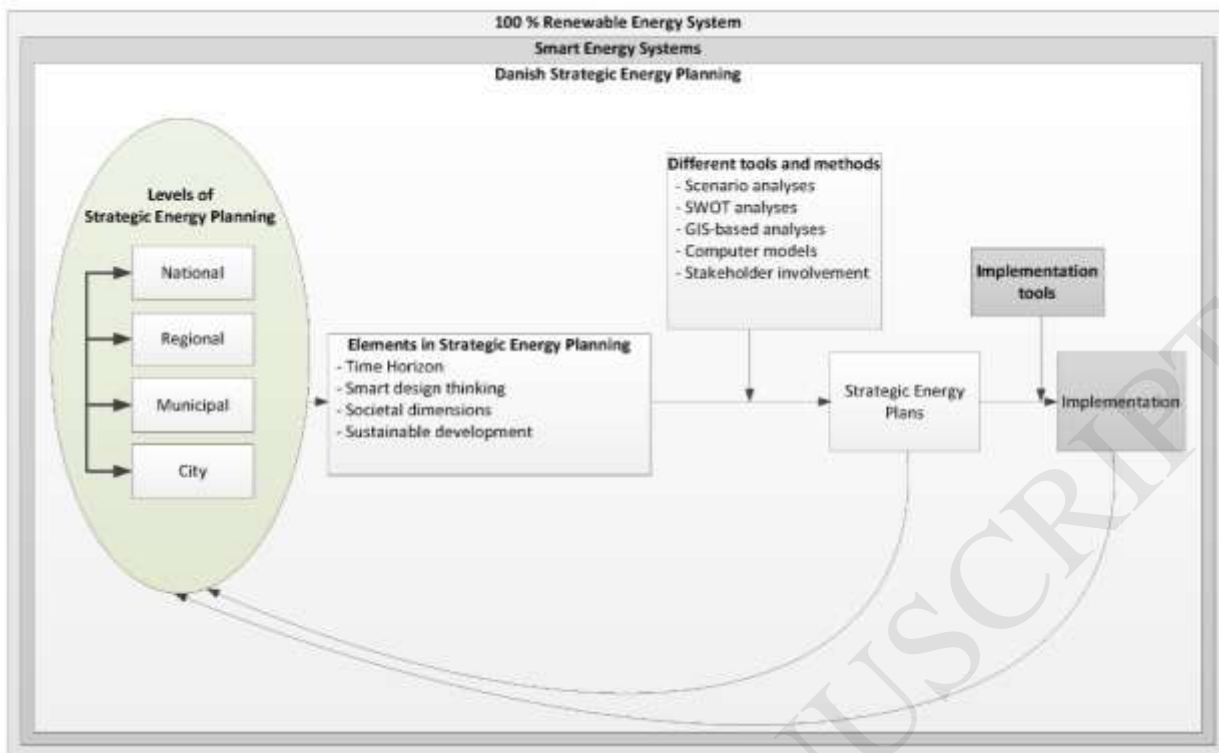


Figure 1: Theoretical framework of strategic energy planning inspired by Krog and Sperling [11]. The framework can be divided into five different steps. Step 1 is the institutional arena, where it is decided which institutional levels to include in the strategic energy planning process. Step 2 concerns the elements in strategic energy planning, which includes refereeing the decision-making regarding the content of the strategic energy plan. Step 3 refers to the tools used to develop the strategic energy plan. Step 4 is the strategic energy plan as a product of the strategic energy planning process. Finally, Step 5 includes the implementation tools and implementation of the strategic energy plan.

The theoretical framework for this paper is illustrated in Figure 1, which sets out the framework for analysing strategic energy planning. This understanding of strategic energy planning should be used to develop and implement smart energy systems based on renewable energy. Under this theoretical framework, strategic energy planning is defined as a dynamic process that should be able to adjust to society and the development occurring for utilising renewable energy, but at the same time be able to keep the development focused on the central goals through different projects. This process consists of several steps (processes and products), where the first step (steps follow Figure 1,

moving from left to right) can be seen as the institutional arena for conducting strategic energy planning at or between different institutional levels. The first step is very much the arena for setting clear national goals and framework conditions, based on cooperation across institutional levels.

The cooperation between especially the national and municipal level are important for the strategic energy planning due to the different responsibilities at the two levels. The national level should have the overall overview to make framework conditions that steer the green transition in the desired direction through national visions, legislation and regulation through tax and subsidy schemes. Whereas the municipalities have a focus on what is best for the local conditions in the individual municipality. The municipalities are currently responsible for project approvals of heating projects and pointing out areas for wind and biogas. This means that the municipalities possess great local knowledge that are important to recognise when planning for the overall Danish energy system, and it is therefore important to establish a strong coordination between the levels in strategic energy planning should be successful. Furthermore, it is also important that there is good communication between the levels in the development of local plans and their implementation. While communication between all levels is important in the development of local strategic energy plans, there could be a greater focus on communication between the municipality and local communities/cities in the implementation phase.

The second step is to define the main content to include in the strategic planning document, which is based on the goals and discussions in step one. This step is especially important to balance national and local visions and targets. In Figure 1, the second box is changed from the framework developed by Krog and Sperling [11], to include four main elements to be considered in strategic energy planning, rather than including a long variety of keywords. The four elements are: time

horizon, smart design thinking, societal dimension and sustainable development. The time horizon refers to the synergies between short-term and long-term planning. While long-term targets are important to secure the direction of the development, short-term goals are important to ensure that actions are being implemented locally. In particular, short-term goals are important at the political level, as politicians are elected for a four-year period [16]. Smart design thinking covers concepts such as flexible energy systems, holistic interplay between demand and supply, interdisciplinary comprehensive energy systems, cost structure of energy production and so on. All of these are concepts that are related to the technical design of the energy system. The societal dimension refers to elements outside the technical design, but which are an important part of strategic energy planning to consider if the strategic plans should succeed. These elements are in keywords, e.g. stakeholder involvement, improving welfare, local energy conditions and community goals. Lastly, sustainable development refers to the development of renewable energy systems should happen in a sustainable way.

The third step in the theoretical framework is to select and use different tools and methods to develop targets and scenarios for the selected content of the strategic energy plan. These targets are combined and presented as goals and visions for a future energy system within a given timeframe in the strategic energy plan.

After the development of the strategic energy plan, an implementation process starts in the fifth step to realise the visions and goals in the strategic energy plan. This process will include development of local action plans, identifying and using different implementation tools for implementing technological solutions in the local societies of the municipality. The process should

not be seen as a linear and closed process, it should be open towards including, in the course of the process, new projects and inputs that go beyond the actions outlined in the strategic energy plan.

The theoretical framework in this paper is used to gain an understanding of how strategic energy planning is conducted in a Danish municipality today and to identify the strategic and practical barriers they face in the implementation process of the strategic energy plan. In order to do so are the theoretical framework used to build the analytical framework for the analysis conducted in this study. The analytical framework is described in the following methodology section.

3 Methodology

3.1 Case study of Hjørring municipality

According to Yin [41], a case study makes it possible to investigate a certain case through a real-world perspective. It is a common understanding that case studies and cases does not have any scientific value by themselves, they have to be connected to a hypothesis. Flyvbjerg [42] argues that this comprehension is a misunderstanding. Flyvbjerg notes that case studies can be used as a broader range of research activities and that it is possible to generalise based on a case study. The generalizability of a case study is largely dependent of the type of case chosen [42].

The approach chosen for this study is a single instrumental case study, allowing a single case act as a representative case for investigating the current status for strategic energy planning in Denmark [43]. Hjørring municipality can be defined as a representative case for the examination of how Danish municipalities currently work with strategic energy planning. This is due to the fact that 50% of Danish municipalities have politically approved strategic energy plans [5], which indicates that municipalities are working actively with strategic energy planning. Furthermore, Hjørring municipality is a rural municipality like the majority of Danish municipalities and the case study is

expected to be representative for these municipalities. The case study will most likely not be representative for the few Danish city municipalities such as Aarhus, Copenhagen and smaller municipalities within the capital area.

Hjørring municipality is a rural municipality with 65,185 inhabitants in 2018 and covers an area of 92,734 acres. Hjørring is the main town with 25,994 inhabitants, with the remaining inhabitants living in smaller towns and villages or in rural areas [44].

In 2010, during the development of the investigated strategic energy plan for Hjørring municipality, the gross energy consumption in the municipality was 9300 terajoule(TJ) and one third of this consumption was covered by renewable energy. The renewable energy was mainly coming from wind, biomass, biogas and waste. The residential heating was primarily covered by district heating provided by 12 combined heat and power(CHP) or heating plants located in the municipality. Furthermore, there were a large amount of oil boilers in the rural areas outside the district heat areas. Furthermore, there were three biogas plants (producing approx. 220 TJ biogas yearly, using 17% of the potential biogas resources) and 120 wind turbines (covering approx. 23% of the electricity demand in the municipality) [45].

Hjørring municipality is chosen as a case, since renewable energy is highly prioritised from the political level in the municipality and strategic energy planning and renewable energy projects are therefore also relatively highly prioritised in the municipality's budget. Even though studies show a variety in the quality of the strategic energy plans, it is assumed in this paper that municipalities that choose to develop strategic energy plans also consider this area as something to prioritise in the municipality. Based on this, it can be argued that if Hjørring municipality experiences difficulties

in implementing a strategic energy plan, other municipalities are most likely to also have difficulties in implementing their strategic energy plans. However, no cases are identical [43] and therefore the barriers for strategic energy planning can vary from one municipality to another.

3.2 Data collection

A document analysis was made of written material related to strategic energy planning in Hjørring municipality. Besides the document analysis, interviews were used to generate data for the analysis.

A total of five interviews [46–50], were carried out as a part of the data collection for the analysis in this paper. First, a focus group interview was conducted with four employees from technical administration in Hjørring municipality. The aim of this interview was to identify all the energy projects that the municipality is involved in. Therefore, the interview was conducted as an open focus group interview where the employees were asked to mention the projects they were involved in and the interaction between the employees helped to identify more projects which were forgotten by individual employees [43]. The remaining four interviews were carried out as semi-structured interviews with each of the employees from the focus group interview. The aim of these interviews was to gain more detailed information regarding the single projects to identify how well connected the projects are with the strategic energy plan. It was chosen only to interview administrative employees from Hjørring Municipality even though it could also have been interesting to investigate how the energy projects fit into the strategic energy plan from the actor's point of view. However, the aim of the study was to gain a broad overview of all energy projects within the municipality. The administrative employees are in a position where they have a great overview and knowledge of the ongoing projects in the municipality and in the same time do they possess a great knowledge of the actors and politicians due to their ongoing interaction with these.

3.3 Analytical framework

The analysis in this paper consists of two main parts. The first part of the analysis is concerned with the strategic energy plan document. The second part is primarily concerned with the practical implementation of the strategic energy plan and the barriers experienced by the administrative employees in the municipality.

3.3.1 The strategic energy plan

Based on the theoretical framework for analysing strategic energy planning in practice, an analytical framework for analysing Hjørring municipality's strategic energy plan was developed. The theoretical analytical framework can be split into five analytical steps:

1. Step 1: Communication between hierarchical institutional levels in the strategic energy plan and actual projects.
2. Step 2: Elements included in the strategic energy plan.
3. Step 3: Tools used to develop the strategic energy plan.
4. Step 4: Strategic energy plan – visions and goals.
5. Step 5: Level of implementation strategies included in the strategic energy plan.

An analysis of Hjørring municipality's strategic energy plan relating it to each of the five steps was carried out and the results presented in this paper.

3.3.2 The implementation process

The aim of the second part of the analysis was to identify how well connected the actual energy projects carried out in the municipality are with the strategic energy plan. Furthermore, the practical barriers to strategic energy planning were identified through the interviews conducted. Therefore, the second part of the analysis was split into two themes: energy projects and their relation to the strategic energy plan, and barriers to the implementation of the strategic energy plan.

Under the theme of energy projects and their relation to the strategic energy plan, energy projects in Hjørring municipality were identified, mapped and compared with the goals of the local strategic energy plan. The parameters used to analyse the actual project's connections to the strategic energy plan were:

- Project theme in relation to the five focus areas and the actions connected to them in the strategic energy plan.
- How the projects are facilitated either by the municipality or by external actors.

Under the theme of barriers to the implementation of the strategic energy plan, strategic and practical barriers are identified and described based on the interviews conducted. Furthermore, the results were compared to theoretical identified barriers to strategic energy planning, introduced in the introduction section of this paper.

4 Analysis and results

4.1 The strategic energy plan

The current strategic energy plan in Hjørring municipality 'Bæredygtig Energi – vejen til grøn vækst (Sustainable Energy – the road to green growth)' was published in 2012 and has local goals up until 2025 [45]. Hjørring municipality had several reasons for developing this first strategic energy plan for the municipality. First, the administrative employees were inspired by the work with strategic energy planning in the organisation, Local Government Denmark and in Randers Municipality, which was the first municipality to develop such a document. Secondly, within the employees, there was a desire to have an overview of the energy balance and to set a framework for further work through goals and actions. Furthermore, there was a political expectation that strategic energy planning could help solve some of the challenges with the placement of biogas plants and wind turbines [51].

The strategic energy plan was developed in collaboration with a consultancy company, who also devise energy balances for most municipalities in Denmark [45]. This is in line with the findings of Petersen[5] which show that it is not common that a consultancy firm completely or partly develops strategic energy plans for municipalities. In the strategic energy plan for Hjørring municipality, five main focus areas are described, connected to eight goals and 33 actions in total [45]. The five main focus areas are: energy savings, solar cells, wind turbines, green district heating and biogas. The municipality has made conscious choices in the plan not to include transport, off-shore wind and wave energy. Regarding transport and off-shore wind, it is because these are areas highly controlled by the government. The argument for not including wave energy is that it is an untried technology [45]. The focus in Hjørring municipality's strategic energy plan is in line with Petersen's [5] study of strategic energy plans in Denmark. Petersen found that the heat sector is the main one addressed, power production is only addressed to a small extent (mainly in rural municipalities) and transportation is primarily mentioned in relation to biogas and biomass, but only briefly.

The strategic energy plan is structured into three main chapters: 1. Background, presenting the background for the development of the strategic energy plan; 2. The energy system in Hjørring municipality, describing the current status of the energy system based on 2010 numbers; 3. Plan of action, where the 33 actions connected to the five main focus areas are presented. Furthermore, a scenario showing the consequences of implementing the 33 actions is presented along with milestones for the implementation process [45].

Step 1: Communication between hierarchical institutional levels in the strategic energy plan and actual projects

The strategic energy plan is only concerned with the local energy system in the municipality. However, in their argumentation for developing the plan, several references are made to the Danish

government's goal from 2012, that Denmark should be free of fossil fuels in 2050. Also, references to the Danish Energy Agreement from 2012 are identified as an argument in the decision-making concerning the five focus areas in the strategic energy plan.

Step 2: Elements included in the strategic energy plan

The document analysis of the strategic documents reveals keywords and elements in the strategic energy plan connected to the four elements that should be considered in such documents.

First, the time horizon in the strategic energy plan is set for 2025. It can be debated whether this is a short-term, midterm or long-term timeframe. Long-term targets and planning are a central part of strategic planning, and a time horizon up to 2025 is, in this paper, not considered a long-term strategy. Hjørring municipality's strategy is considered a more midterm strategy when compared to the national timeframe going to 2050.

Smart design thinking is identified in the plan through the use of the terms whole energy chain (complete energy system), dynamic strategy, energy savings, reduce energy demand and energy efficiency. In particular, the consideration of the complete energy system and a dynamic strategy is very much connected to smart design thinking and the concept of a smart energy system. However, most of the keywords are related to energy savings and not so much to the technical integration of the energy system, such as long-term smart energy system analysis and scenarios for the local energy system.

An important statement in relation to energy savings in the strategic energy plan is:

"[...] Important that energy saving is thought into all actions towards the sustainable energy system, e.g. it is a good idea to conduct energy renovations before looking at replacement of energy sources." [45], p. 13] (translated from Danish).

This is in line with the study by Naves et al. [52], who also point out the importance of the end-use system. They highlight that understanding the end-use system gives an understanding of the energy needed in the future and thereby, the possibility to find better solutions for meeting the energy demand [52].

With the keyword dynamic strategy, the municipality state that the plan should be adjusted in the reality of constant development. To meet this reality, they state that the plan should be revised at least every second year. This is directly in line with the theoretical framework, which frames strategic energy planning as a dynamic process where the strategic energy plan is just the first step of several [11]. However, the strategic energy plan was approved by the city council in 2012 and is yet to be revised by the municipality.

The societal dimension is included in the development of the strategic energy plan through a number of meetings with the energy actors in the municipality prior to the development of the strategic energy plan. It appears from the strategic energy plan document that the purpose of the meetings was to give the local energy actors a possibility to express their wishes and plans for the future [45]. The societal dimension is furthermore, briefly touched upon in the strategic energy plan using the terms green growth and job creation in relation to implementing photovoltaic, biogas and energy saving measures. Another element in the strategic energy plan is that the municipality wishes to develop a business case for one or more photovoltaic parks, which should secure local support and local ownership. Furthermore, local ownership is mentioned in relation to wind power and biogas. Settlements are also mentioned but not elaborated on.

Sustainable development is brought into the plan as an underlying idea, that the municipality should be a sustainable municipality with an energy system that is fossil free and based on renewable energy sources.

Step 3: Tools used to develop the strategic energy plan

It is stated in the strategic energy plan that the methodology used to find focus areas in the plan are Global Footprint. Additionally, several methods are mentioned throughout the strategic energy plan. Meetings with local energy actors, letting actors come with input regarding their plans and visions for the future, are used as input in the decision-making process. In relation to describing the current and future energy system in Hjørring municipality, a scenario analysis is made. In this analysis, energy balance (a detailed overview of the entire local energy system), CO₂-accounting (overview of CO₂-emissions within the municipality) and a heat atlas (overview of estimated heat demand) are used as tools [45].

Step 4: Strategic energy plan – visions and goals

Hjørring municipality, with the strategic energy plan, wishes to lay the foundations for a fossil free society by 2025. In order to do so, eight goals have been developed, divided between the five focus areas.

Within the focus area of energy savings, two goals have been developed:

- *'The classical electricity demand should be reduced 15% compared to the level in 2010'* [[45], p. 5] (translated from Danish).
- *'The heat demand should be reduced 20% compared to 2010'* [[45], p. 5] (translated from Danish).

For the focus area of wind turbines, the goal is defined as:

- *'The yearly electricity production from wind turbines should in 2025 be 1,000 TJ/yr or what corresponds to approximately 60% of the electricity demand in the municipality in 2010'* [[45], p. 5] (translated from Danish).

In the focus area of photovoltaic, the goal is that:

- *'The yearly electricity production from solar panels should in 2025 be 170 TJ/yr, or what corresponds to approximately 10,000 household plants of nearly 5,000 kWh'* [50, p. 5] (translated from Danish).

For biogas, the goal is that:

- *'Minimum 75% of all manure in the municipality should in 2025 be utilised for biogas'* [[45], p. 5] (translated from Danish).

Lastly, three goals are stated for the focus area of green district heating, these are:

- *'Where it is economically and practically possible, there should be complete connection to district heating in existing district heat areas'* [[45], p. 5] (translated from Danish).
- *'So far it is economically and practically possible, a more interconnected district heating network should be established'* [[45], p. 5] (translated from Danish).
- *'All district heat should be based on ground heat, solar heat, geothermal, biogas, biomass and/or waste heat'* [[45], p. 5] (translated from Danish).

To give an overview of the fulfilment of the goals, are there for each of the focus areas made estimates for the increased amount of renewable energy in the energy system, investment cost,

reduced cost from import of fossil fuels, reduced amount of CO₂-emissions and the reduced energy use. It is stated that most of the numbers are estimates and it is unclear how these have been derived. The interviews reveal that the five focus areas are defined based on local interests in the municipality and national statements. Furthermore, the current numbers, which are the basis for the goals within the strategic energy plan, are not stated clearly. This makes it difficult to estimate whether or not the goals are set ambitiously.

Step 5: Level of implementation strategies included in the strategic energy plan

A focus on implementation strategies is identified in the strategic energy plan. The plan includes 33 concrete actions divided between the five focus areas in order to reach the goals within these [45]. These actions are considered implementation strategies. Some actions are the responsibility of the municipality, such as those within the municipal buildings, while others should be fulfilled by private citizens and companies.

4.2 The implementation processes

In this section, the results from the first part of the analysis combined with data from the interviews are used to analyse how actual energy projects carried out in the municipality are related to the strategic energy plan. Furthermore, strategic and practical barriers to the implementation of the strategic energy plan are identified through the interviews with the administrative employees.

A total number of 49 actual projects were identified [46], with most of them related to at least one of the five focus areas. Eight projects were outside the focus of the strategic energy plan. In Figure 3, the number of projects related to each focus area and projects outside the focus areas can be seen. Furthermore, the figure illustrates the extent to which different projects are related to the strategic energy plan (the different colours). Projects marked with 'high' (blue) are directly connected to the strategic energy plan and the projects work with the focus areas and the plan of

actions. The 'medium' (green) projects are not directly targeting the focus areas, they are however, still influencing the implementation of the strategic energy plan and the overall goals for the focus areas in a positive way. Projects marked with 'low' (red) are related to the focus areas in the strategic energy plan but they do not target any goals or actions from the plan. The last category 'no' (purple) indicates no connection to the strategic energy plan. Eight projects are outside the themes in the strategic energy plan but are related to energy and sustainability. Four of these projects were ongoing before the development of the strategic energy plan which is a reasonable explanation for the missing connection. The remaining four projects are concerned with gas for transportation, sustainable canteens (food waste, ecological food and energy savings) and a liquefied natural gas fired plant on a harbour in the municipality [46]. The analysis also reveals two projects covering all focus areas. These two projects are here exemplified as one, since one is a continuation of the other. This project was originally supported by the Danish Energy Agency with the purpose of promoting the development of strategic energy planning [53], [54]. The project was based on cooperation between nine out of 11 municipalities in Northern Jutland regarding strategic energy planning. The project was primarily organised as a network consisting of different groups, each working with a theme (wind, transport, green district heating, energy savings and energy supply outside the collective supply, and energy and business development) [55]. The result of the project was seven minor reports on each theme and a small publication connecting the conclusions from the work groups at the regional level. This study has not investigated the cross-municipal project further, as this was not the purpose of the study. However, it is interesting to note that the interviews showed that the attitude in the municipality is that they will only consider involving or getting involved with other municipalities if the municipality will benefit from the cooperation [47]. This is despite the good collaboration and results in the cross-municipal project.

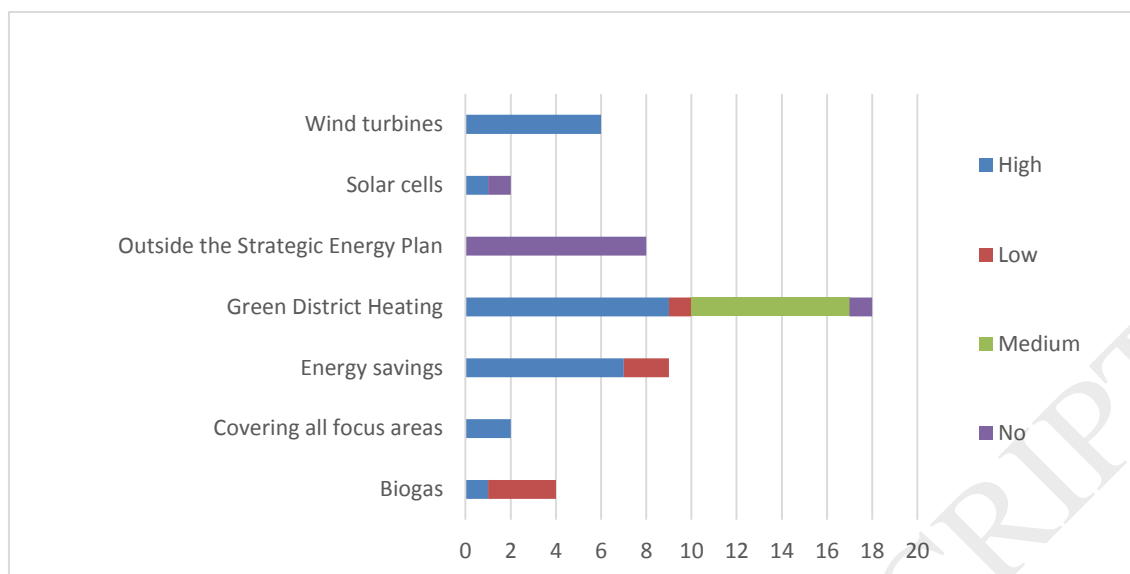


Figure 2: Actual energy projects connected to the strategic energy plan. The figure shows the number of projects related to each focus area plus projects that cover all focus areas or projects outside the focus of the strategic energy plan. Each project is evaluated based on its connection to the strategic energy plan. 'High' projects are working directly with the focus areas and the plan of action. 'Medium' projects are addressing the overall goals in the strategic energy plan and focus areas, but are not connected the plan of action. 'Low' projects are somehow related to the strategic energy plan but do not target any goals or actions in the plan. The 'No' projects are energy projects that fall completely outside the strategic energy plan.

Based on the interviews, an increase in the number of energy projects was identified after the strategic energy plan was published in 2012. It is difficult to tell if the increased number of energy projects has a direct connection to the development of the strategic energy plan, but it can be assumed that the political decision to make a strategic energy plan raised the awareness of energy projects among employees in the municipality.

Another parameter investigated is where the projects have been developed, if projects are facilitated within the municipal organisation or if it is an incoming project from external actors. In Figure 4, the projects are shown in relation to their origin facilitation. Most of the projects are incoming projects from external actors. Thirty-two of the total of 49 projects were developed

externally, while only one project was developed in synergy between the municipality and different local actors. The project developed in synergy is a project on Hirtshals harbour, where the municipality helped finding the financing for the project and developed the project in collaboration with Hirtshals harbour [47]. You could argue that it is a surprising finding that not more projects are developed in synergy or in the municipality, based on the fact that the municipality has developed a strategic energy plan including goals and actions to be fulfilled. However, the document analysis of the strategic energy plan shows that the document is framed in a way where the municipality states that it will develop framework conditions and plans that can support the development of projects within the focus areas. The municipality sets the direction and prepares the ground for project developers and local actors to realise the strategic energy plan. Going more into depth with the projects developed by external actors, it may be seen that these projects cover areas where the municipality already, through a long period, has set the overall framework for projects to be developed. It is primarily the areas of heating, wind turbines and biogas, and these are all areas where the municipality is obliged to conduct planning. The municipality is obliged to conduct heat planning [56], and for technical plants such as wind turbines and biogas it is obliged to point out areas suited for each purpose [57]. This means that the municipality makes frameworks for external project developers to act upon, but they cannot force actors to do so and they are therefore dependent on the interest and willingness of local actors and project developers.

One area where the municipality can have had an influence on the number of external projects is within the district heating area. Fourteen external district heating projects has been identified and only one of these projects was carried out before the development of the strategic energy plan. Since the study does not include interviews with external actors, we cannot completely identify the reasons behind the individual project proposals in this paper. Nevertheless, a couple of indicators

were identified throughout the interviews. The first is a project born inside the municipality in 2013 regarding action plans for district heating companies. This project was financed through the Danish Energy Agency's funds for strategic energy planning [54]. The focus of this project was to bring the district heating companies closer together, for them to find synergies and collaboration possibilities within actions towards a renewable heating system. As a part of this project, the municipality visited each of the 12 district heating companies in the municipality and talked to them about future plans for the district heating plant [47]. Furthermore, in 2014 the government decided to give some of the natural gas fired district heating plants under the most economic pressure the opportunity to install a 1 MW biomass plant. These two actions can possibly have had an influence on the incoming project proposals.

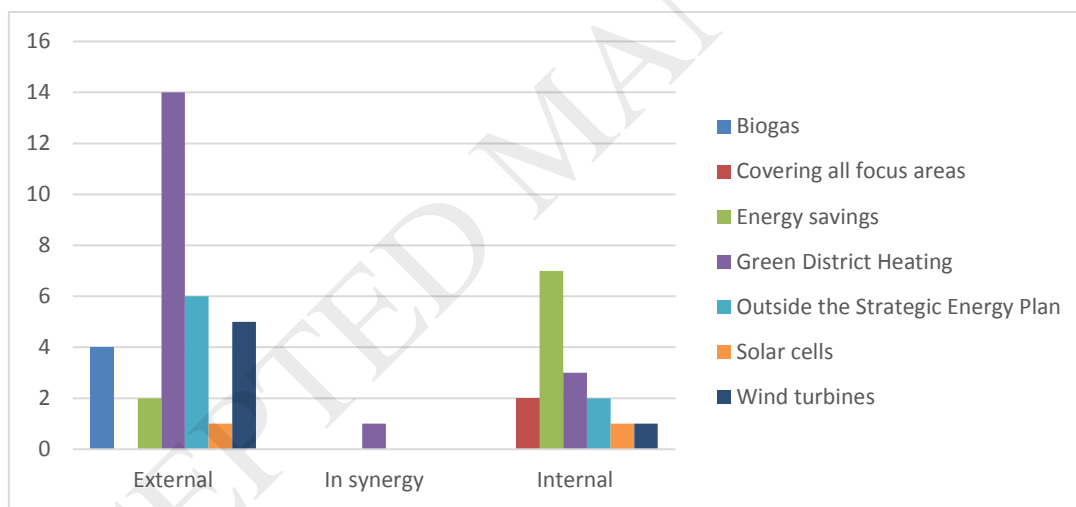


Figure 3: Number of energy projects in Hjørring municipality facilitated by external actors (not by the municipality), in synergy with external actors and the municipality, or internally in the municipality. The projects are further divided into the focus areas.

Projects started internally in the municipality are primarily energy saving projects, which are projects where private citizens are influenced, internal projects regarding the organisation itself or projects that work across municipal or national borders. What is characteristic for the energy saving

projects is that almost every one of them was started by the municipality and every one of them was financed by the municipality. The municipality has chosen to finance several projects where they hire a consultant to go out and make energy assessments of different target groups in the municipality. They have done this with the hope that some of the energy assessments will eventually result in energy saving initiatives [49].

4.3 Barriers to the implementation of the strategic energy plan

A result of the interview analysis is a list of the practical and strategic barriers that different employees experience through their work with different energy projects. In the following, the strategic and practical barriers are described in four groups (national political barriers, local barriers among local actors, internal barriers within the municipal organisation and external barriers). This is done to give a better overview of the themes of barriers, however, the division of the barriers does not mean that the barriers can easily be put into these groups as some of the barriers are very much connected to each other. *Strategic barriers*

Many of the municipality's tasks are related to fulfilment of national legislation and decisions are often made referring to specific laws. An example within the energy sector is heat planning, where municipalities approve heating plant projects in relation to the Heat Supply Act [56]. However, a large variety of legislation is often relevant in different projects, which makes the planning and implementation processes of projects a very complex matter.

The interviews show that the municipal employees experience a tendency from the national level to make rapid changes in rules and legislation, meaning that employees are continuously adapting their work processes to the new legislation. In relation to planning for areas for actors to put up specific technologies, says one of the municipal employees:

“[...] it can be absolutely crucial how the subsidy scheme and tax system are put together, we can find good enough areas, but if there is no economy in it, then there is no economy in it.” [48](translated from Danish).

This makes it difficult for the municipalities to make long-term or even midterm plans. Two examples from the interviews in relation to the rapid changes in legislation are identified. The first example is in relation to wind turbine projects where the employees have a long list of different laws they have to take into the authorisation procedure. Rapid changes in the legislation makes it difficult for the employees to handle these projects and makes an already long process even longer [50].

The second example given by the employees involved are the changes in support schemes for specific technologies. In the strategic energy plan, there is a focus on installing solar power plants on private houses as well as on the municipality's own buildings and large-scale solar power parks. However, almost no action has happened within this area. The employees explain the missing actions with changes in the support scheme for solar cells just after the development of the strategic energy plan [48]:

“What occurred right after the plan was approved was that they simply changed the subsidy scheme and tax system pretty quickly, pushing the economic state negatively.”

[48](translated from Danish).

The employee expresses an understanding for the change in the support schemes to avoid an overweight of solar power (or other technologies) in the energy system. However, it is also made clear in the interview that these changes make it difficult for the municipalities to develop long-term strategies that follow the desired direction for the national energy system, when the subsidies and tax levels changes from 'day to day'.

Even though barriers are found in the legislation today, the interviews reveal that municipal employees still have a trust in the effect legislation and regulation can have. However, the employees underline that the legislation will only work if municipalities' local knowledge is considered in the development of the laws [49]:

"I think you can come a long way with rules and legislation and I think definitely it should be done, however, you also have to connect it to what we go out and find out, what is it actually people need." [49] (translated from Danish).

This indicates a lack in the connection between nationally developed legislation and municipalities' practical knowledge, which makes it difficult for the municipalities to plan for the most optimal local solutions.

A finding that can be concluded through the identified national barriers is that the municipality, to a great extent, follows the, at the time of the development of the plan, current regulations and rules. This means that they limit their plan to consider subjects that are supported nationally in a way that makes it possible to realise the goals. If the support changes or is withdrawn, the result will be that the targets are not met. This is identified through the example of photo voltaic in Hjørring municipality [48]. Other themes that could be relevant from a smart energy system perspective are either not mentioned at all or consciously eliminated from the process. One of the things that is eliminated from Hjørring municipality's strategic energy plan is private transport, e.g. in terms of getting people to drive electrical vehicles by securing the right charging infrastructure. This could either be because they do not see the barriers due to their local focus or that they see them but do not think that they can do anything about them. The municipality seems to be aware

of these strategic barriers, however, they do not do anything to challenge the political system to change them.

Practical barriers Local barriers in the study are primarily connected to local citizens. Local resistance to wind turbines is one of the large barriers in the energy planning process globally [17]. The resistance to wind turbines makes the processes of the projects long and difficult [50]:

“[...] The Planning Act state that some pre-public hearing, where you very early in the process are out to hear the neighbours in relation to, that there will be wind turbines installed in this area. [...] Maybe also some public meeting involved and, not as the main rule, but often a massive pile of protests. [...] Because it is something that can get people out of the deep sofa and over to the PC.” [50](translated from Danish).

Local resistance makes it difficult for the administrative employees to administrate these projects and to get the projects approved in the city council, as the city council is often influenced by the protests and therefore, stalls the decision-making [50].

The municipality recognises the importance of local support and willingness to act both in and outside their own homes [49]. The municipality do not have legislation they can use to force citizens to take actions. At the same time, they experience that it is not enough to put advertisements in newspapers to engage people [49]. The municipality finds it difficult to activate the citizens and they emphasise that they must find a way to activate them because they do not have time to wait for the government to act on that front [49].

Even though there are local political support to develop and implement a strategic energy plan for the municipality, this is not equal to no barriers being found within the organisation. Different barriers can be found within the organisation.

Local political conditions and actions have a strong influence on the development and implementation of the strategic energy plan. Through the interviews, the importance of the administrative employee's knowledge of the political 'game' was identified [49,50]:

“The challenge locally is to do with finding the right time, where the administrations have time and resources to start a process. To find the right time, where the politicians are interested, meaning they see the challenges/problematics in it and that we can get the people we want to speak to, to speak.” [47](translated from Danish).

Even though the employees have good technical skills, this is not enough to get the strategic plan or other projects onto the local political agenda. Timing and argumentation is everything if the plan should be realised in the municipality [47]. If the administrative employees come up with proposals for the city council at a time when the politicians are not ready to respond, the changes will be dismissed no matter how good the argumentation [47]. The employees use a lot of time and resources developing a strategy that corresponds to the development desired by the city council. This finding is in alignment with the findings of Hoff and Strobel, who found that municipal climate policies *‘Have to follow certain “rationalities” in order to get accepted by the majority in the local council’*. They furthermore identified that these rationalities are connected to short-term visible projects and to showing economic feasibility in the climate plans [16]. This could likely be connected to the fact that there are elections in the municipalities every fourth year, and the politicians would like to show their actions within their election period. The four-year election period also creates

uncertainties in planning, as an election can result in a new city council. The new city council might not have the same visions as the former, and if the strategy work happens to be done in that period it can result in a setback in the work. This is what Hjørring municipality currently (primo 2018) are experiencing with their update of their strategic energy plan.

Another identified barrier connected to local political conditions is the difference in the time horizon the politicians and administrative employees respectively relate to. The employees experience that they have a longer time horizon than the politicians and that makes it difficult to get subjects onto the political agenda, if some of the issues presented by the employees have not yet occurred for politicians to see the problem in reality [50].

The implementation of the actions in the strategic energy plan requires actions from many different actors, both within the organisation and across departments. Several internal barriers have been identified through the interviews. One is to make the employees that have been part of developing the strategic energy plan act in new ways, it is another thing to make employees with no connection to energy and environmental issues act in a certain way. One example is a project that has been brought into the municipality through an external actor. It is a project where the aim is to save energy in municipal institutions by changing the behaviour of the users in the buildings. In this project, it has proven difficult to get the users to change their behaviour, since they cannot see the motivation for doing so:

“... This is where I think it is difficult, we have had some projects in our own institutions in relation to savings, but who get the savings, is it the institutions themselves – Yes, maybe for a short time, but then afterwards are they drawn in grants because it is seen that they don't use as much as they should do and it was not the meaning that they

should buy toys for the money they saved. So, I think it is difficult to go out, what is the carrot for them? Because they do not care how much, a little rough said, but they do maybe not care how much water they use, because they do not get the money they save.” [49](translated from Danish).

The last identified barrier within the organisation is a gap in the management’s understanding of how complex and time consuming some of these energy projects are [49]. In relation to wind turbine projects, the experience of the employees concerns the understanding of the management who expect the process to be done within a certain timeframe, which is impossible to achieve due to public hearings and lot of local resistance that often leads to further technical analyses. Additionally, changes in the local political position can put the projects on hold [50]. This could indicate that communication between the local political level and administrative level in the municipalities could be improved in order to gain the right support for complex energy projects.

In Hjørring municipality, some energy projects are working with external municipalities and consultancy companies. These are specific projects financed fully or partly by external funding, and where cooperation between different partners was a demand. The employees see these projects as a great way to share knowledge and learn from other actors who have similar problems as themselves. However, a barrier in these projects are differences in approaches and expectations among the different actors making it hard and time consuming to set up cooperation [49]. The municipality has good experiences with cooperation with other municipalities, both Danish and foreign, and they also see the necessity for such cooperation in the future, as one employee states [47]:

“If some of the projects that go across municipalities can support the national goal and give a little extra to the different municipalities, then are we in. This is how it is, this is how it often is for some of the activities that have to be stated to reach this goal. There are some activities that do not make any sense to work within every single municipality.” [47] (translated from Danish).

5 Concluding discussion

This study has investigated how municipalities currently work with strategic energy planning in practice. The analysis is based a theoretical framework for strategic energy planning that form the analytical framework for analysing the current strategic energy plan in Hjørring Municipality. The theoretical framework for strategic energy planning includes the complete process and the strategic energy plan is only one part of strategic energy planning and it will therefore be ideal to use the theoretical frame work to analyse the strategic energy planning process form even before the strategic energy plan is finished. However, the current strategic energy plan in Hjørring Municipality are from 2012 and it was therefore not possible to use the theoretical framework on the complete process. The analyses have therefore been reliant on the information written in the strategic energy plan, to gain information on if and how the municipality have included the different steps from the theoretical framework. However, that fact that the strategic energy plan has been present since 2012 gives us the opportunity to analyse how the strategic energy plan is put into action within the municipality and to go deeper into the implementation of the plans of action. Analysing the strategic energy plan and especially the implementation in form of the energy projects carried out in the municipality from 2012 until today, have also made it possible to not only identify missing aspects from the theoretical framework for strategic energy planning in the strategic energy plan but also identify the strategic and practical barriers for strategic energy planning occurring in the execution of energy projects in the implementation phase.

The case study demonstrates that the municipality put an effort into the strategic energy planning process. The municipality has cooperated with both consultancy companies and local actors in the development of a strategic energy plan that includes implementation strategies. Connections between the strategic energy plan and the actual projects have been identified, and they show that the strategic energy plan is used to steer the direction for energy projects in the municipality. Even though the study shows that Hjørring municipality is on the way with strategic energy planning, it also reveals how complex the strategic energy planning task is for the municipalities. In particular, strategic and practical barriers anchored in national and local politics have been identified as some of the biggest barriers for municipalities. The study has been carried out around three research questions which are individually addressed below.

1. How does a typical Danish municipality currently work with local (strategic) energy planning?

The case study shows that Danish municipalities are on their way in terms of taking responsibility for the green transition of the energy system. However, when analysing Hjørring municipality's strategic energy plan in relation to the theoretical framework, the plan falls short in some areas. Firstly, there is no indication of direct interaction between Hjørring municipality and other institutional levels, such as the national level and regional level (other municipalities), neither in the strategic energy plan or during the interviews; even though the Energy Agreement from 2012 and the national goals of becoming fossil free in 2050 are used as argumentation for the development of the local strategic energy plan. According to the theoretical framework, it would have been beneficial for the strategic energy planning if there had been an ongoing interaction between the different levels [11], e.g. to limit the possibilities of sub-optimisation in the individual municipalities [58]. Carney and Shackley [59], Kierstead and Schulz [60] as well as Sovacool and Brown [61] argue

that neither national or local planning can stand alone, they emphasise that a balance between centralised policy/decision-making and local implementation is required if the green transition should succeed.

One of the main purposes of strategic energy plans is to set long-term goals for municipalities. However, in the case of Hjørring municipality's strategic energy plan, the overall goal is not completely clear and it can be argued that their time horizon of 2025 is midterm rather than long term. They indicate that a fossil free society is the ideal goal but at the same time, they set the goal that this plan should only lay the foundations for a fossil free society. They do however, set up eight concrete goals that they directly connect to a plan of actions, including milestones for when the actions should be carried out.

In the development of strategic energy plans, Petersen [5] found that most municipalities use external consultancy firms to develop their strategic energy plans and his critique is that this results in a top-down plan with little or no connection to local communities. Furthermore, Bale et al. [62] critiques the planning of energy systems today for being based on primary techno-economic computer models which cannot include political and societal issues and they point out the importance of a stronger connection between technical and societal aspects in the planning process. However, external consultancy firms and computer models could also be beneficial in strategic energy planning, since these can provide inputs to the process which would not have been seen by the internal employees in the municipality. In the case of Hjørring municipality, an external consultancy firm was also involved and model tools have been used in the development of the strategic energy plan. However, the strategic energy plan also reveals that local actors have been allowed to provide input into the decision-making process. Given that Hjørring municipality has

completed and started a number of projects within the frame of the strategic energy plan and the fact that they have included input from local actors in the process, shows that it is possible for municipalities to combine the technical and societal aspects in strategic energy planning.

2. How well connected are the strategic energy plans with the actual energy projects carried out in the municipality?

This study finds that 26 of 49 energy projects are closely connected to the strategic energy plan and its plan of action. This indicates that the municipality, to some extent, has succeeded in realising the strategic energy plan. This is contrary earlier studies stating that energy strategies primarily are promises that are not being implemented in reality [5,63].

The fact that Hjørring municipality has a focus on implementation strategies and many projects are highly connected to the plan of action, signals that the municipalities and local actors are willing to participate in the green transition, although it is a voluntary task and they are not financially supported from a national level. This finding can be seen as going against earlier studies which indicated that the voluntariness and lack of financing from the national level is one of the main strategic barriers [6,7,11]. However, it should be remembered that it is up to the individual city council how they structure the budget for the municipality and there can therefore be a large difference in how energy actions are prioritised in the municipalities. The lack of financial support from the national level might not be a large problem for Hjørring municipality, since energy is a priority in the municipality. However, the case study can nevertheless indicate a problem for strategic energy planning; the voluntariness gives municipalities the opportunity to leave out themes they find difficult to handle (e.g. transportation in the case of Hjørring municipality). This

goes against smart energy system thinking where the complete energy system should be taken into consideration [40]. If strategic energy planning in the municipalities was to be supported financially by the government, it would make strategic energy planning a mandatory task and it would secure a more homogeneous quality in the local strategic energy plans [5,6].

3. What are the practical barriers to a successful strategic energy planning process, seen from the municipalities perspective?

Barriers to strategic energy planning in the municipalities are identified throughout the study. The identified barriers are presented in Table 1, alongside suggestions for both the national and local level on how to overcome these barriers. The paper does not go deeply into how the suggestions of how to overcome the barriers should be realised and implemented since this will require further research and several in-depth analyses of the individual barriers.

The identified barriers are divided between strategic and practical barriers to obtain an overview of if the barriers are anchored locally or at the national level. Dividing between the two types of barriers would help the administrative employees in the municipalities to be aware of which barriers should be addressed locally and which barriers require a pressure on the national politicians and their supporting agencies.

Table 1: Overview of identified barriers and suggestions on how to eliminate these barriers in the strategic energy planning process.

| Barriers | Suggestions |
|--|---|
| Strategic barriers | |
| Lack of connection/communication between the national and local level. | <ul style="list-style-type: none"> - A better communication channel between the national and local level is needed in order to secure a match of expectations between levels. But also, to make sure that local barriers and challenges are communicated to the national level, so that this can be included in the development of national policies. |
| Rapid changes in subsidies and tax levels. | <ul style="list-style-type: none"> - Rapid changes in, e.g. subsidies and tax levels at the national level makes it very difficult for the municipalities to realise the long-term goals [54,64]. The national level should therefore, be aware of the consequences that changes in the policy instruments have for long-term planning at the local level. |
| Strategic energy planning as a voluntary task. | <ul style="list-style-type: none"> - Strategic energy planning should be a mandatory task for municipalities and should be supported financially from the national level. |
| Practical barriers | |
| Lack of clearly defined long-term goals. | <ul style="list-style-type: none"> - The national policy framework should be shaped in a way that makes it easy for the municipalities to make long-term goals for the energy sector. |
| Timing in relation to local political agendas. If the timing of initiatives is wrong in relation to political agendas, it can result in projects being turned down despite solid, professional argumentation. | <ul style="list-style-type: none"> - It is important that administrative employees know the political 'game' and have extensive knowledge of the political structures within the municipality. - Making strategic energy planning a mandatory task for municipalities will force local politicians to prioritise energy initiatives on their agenda. |
| The long time between revision of the strategic energy plan. | <ul style="list-style-type: none"> - If the municipality revises the strategic energy plan regularly, they would be able to continuously follow-up on barriers and give feedback to the national level of what is working and not working at the local level. - However, ongoing changes also imply that the right resources and competences for conducting strategic energy planning in the municipalities is needed, if strategic energy planning should succeed. |
| Municipalities can develop strategic energy plans that include implementation strategies. However, the actual implementation is deeply dependent on citizens and other actor's willingness to take actions in the direction desired by the municipality. | <ul style="list-style-type: none"> - Municipalities should involve a wide range of local actors (citizens and local companies) in the early beginning of the development of strategic energy plans for them to be able to include local knowledge and interests in the strategic energy plan. |

This study shows the complexity of the context in which municipalities currently conduct strategic energy planning and highlights several strategic and practical challenges that are important to be aware of in future studies of the field. Municipalities seem not to work specifically with smart energy

system solutions, but rather try to match the current national framework conditions, although they are aware of the changing regulations. Consequently, this results in missing local actions in some areas of the energy system. The municipalities try to take responsibility with strategic energy planning, however, the poor national framework conditions from the national level makes it difficult to reach the common goals for the energy sector. The municipalities and other actors operating at the local level need to communicate their practical experiences of barriers and successes to the national level. Political changes will not happen out of the blue and this is why there is a need for the actors to communicate their needs and wishes based on their local knowledge [65]. Furthermore, to be able to obtain a more complete understanding of the complexity of strategic energy planning and the practical barriers involved, more case studies are needed to investigate the relations between the involved actors, both at the national and local level.

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7 Bibliography

1. Chittum, A.; Østergaard, P. A. How Danish communal heat planning empowers municipalities and benefits individual consumers. *Energy Policy* **2014**, *74*, 465–474, doi:10.1016/j.enpol.2014.08.001.
2. The Danish Government *Our Future Energy*; 2011; ISBN 978-87-7844-915-3.
3. Komiyama, R.; Fujii, Y. Assessment of post-Fukushima renewable energy policy in Japan's nation-wide power grid. *Energy Policy* **2017**, *101*, 594–611, doi:10.1016/j.enpol.2016.11.006.
4. Koskela, S.; Seppälä, J.; Lipp, A.; Hiltunen, M.-R.; Pöld, E.; Talve, S. Estonian electricity supply scenarios for 2020 and their environmental performance. *Energy Policy* **2007**, *35*, 3571–3582, doi:10.1016/j.enpol.2007.01.001.
5. Petersen, J.-P. The application of municipal renewable energy policies at community level in Denmark: A taxonomy of implementation challenges. *Sustain. Cities Soc.* **2018**, *38*, 205–218, doi:10.1016/j.scs.2017.12.029.
6. Sperling, K.; Hvelplund, F.; Mathiesen, B. V. Centralisation and decentralisation in strategic municipal

- energy planning in Denmark. *Energy Policy* **2011**, *39*, 1338–1351, doi:10.1016/j.enpol.2010.12.006.
7. Damsø, T.; Kjær, T.; Christensen, T. B. Local climate action plans in climate change mitigation – examining the case of Denmark. *Energy Policy* **2016**, *89*, 74–83, doi:10.1016/j.enpol.2015.11.013.
 8. Bale, C. S. E.; Foxon, T. J.; Hannon, M. J.; Gale, W. F. Strategic energy planning within local authorities in the UK: A study of the city of Leeds. *Energy Policy* **2012**, *48*, 242–251, doi:10.1016/j.enpol.2012.05.019.
 9. Leal, V. M. S.; Azevedo, I. Setting targets for local energy planning: Critical assessment and a new approach. *Sustain. Cities Soc.* **2016**, *26*, 421–428, doi:10.1016/j.scs.2016.04.010.
 10. Energistyrelsen Strategisk Energiplanlægning i kommunerne - Vejledning i kortlægning og datafangst Available online: http://www.ea-energianalyse.dk/reports/1154_vejledning_i_kortlaegningsmetoder_til_strategisk_energiplanlaegning_metodebeskrivelse.pdf.
 11. Krog, L.; Sperling, K. A comprehensive framework for strategic energy planning based on Danish and international insights. *Accept. Publ. Energy Strateg. Rev.* **2019**.
 12. Lund, R. S.; Sperling, K.; Mathiesen, B. V.; Connolly, D. *Strategic Energy Planning in the Öresund Region*; 2013;
 13. Allman, L.; Fleming, P.; Wallace, A. The Progress of English and Welsh Local Authorities in Addressing Climate Change. *Local Environ.* **2004**, *9*, 271–283, doi:10.1080/1354983042000219379.
 14. Fudge, S.; Peters, M.; Woodman, B. Local authorities as niche actors: The case of energy governance in the UK. *Environ. Innov. Soc. Transitions* **2016**, *18*, 1–17, doi:10.1016/j.eist.2015.06.004.
 15. Busche, S. *Clean Energy Policy Analyses: Analysis of the Status and Impact of Clean Energy Policies at the Local Level*; 2010;
 16. Hoff, J. V.; Strobel, B. W. A Municipal ‘ Climate Revolution ’? The Shaping of Municipal Climate Change Policies. *J. Transdiscipl. Environ. Stud.* **2013**, *12*, 4–16.
 17. Devine-Wright, P. *Renewable Energy and the Public: From NIMBY to Participation*; Earthscan, 2011; ISBN 978-1-84407-863-9.
 18. Prasad, R. D.; Bansal, R. C.; Raturi, A. Multi-faceted energy planning: A review. *Renew. Sustain. Energy Rev.* **2014**, *38*, 686–699, doi:10.1016/j.rser.2014.07.021.
 19. They, R.; Zarate, P. Energy planning: a multi-level and multicriteria decision making structure proposal. *CEJOR* **2009**, *17*, 265–274, doi:10.1007/s10100-009-0091-5.
 20. Cormio, C.; Dicorato, M.; Minoia, A.; Trovato, M. A regional energy planning methodology including renewable energy sources and environmental constraints. *Renew. Sustain. Energy Rev.* **2003**, *7*, 99–130, doi:10.1016/S1364-0321(03)00004-2.
 21. Mirakyan, A.; De Guio, R. Integrated energy planning in cities and territories: A review of methods and tools. *Renew. Sustain. Energy Rev.* **2013**, *22*, 289–297, doi:10.1016/j.rser.2013.01.033.
 22. Huang, Z.; Yu, H.; Peng, Z.; Zhao, M. Methods and tools for community energy planning: A review. *Renew. Sustain. Energy Rev.* **2015**, *42*, 1335–1348, doi:10.1016/j.rser.2014.11.042.

23. Cajot, S.; Peter, M.; Bahu, J.-M.; Guignet, F.; Koch, A.; Maréchal, F. Obstacles in energy planning at the urban scale. *Sustain. Cities Soc.* **2017**, *30*, 223–236, doi:10.1016/j.scs.2017.02.003.
24. Collier, M. J.; Nedović-Budić, Z.; Aerts, J.; Connop, S.; Foley, D.; Foley, K.; Newport, D.; McQuaid, S.; Slaev, A.; Verburg, P. Transitioning to resilience and sustainability in urban communities. *Cities* **2013**, *32*, S21–S28, doi:10.1016/j.cities.2013.03.010.
25. Atwood, T.; Merritt, W.; Kalloz, J. Strategic Planning for Energy and the Environment Baltimore: Strategic Energy Planning In Charm City. **2017**, doi:10.1080/10485236.2016.11674930.
26. Morlet, C.; Keirstead, J. A comparative analysis of urban energy governance in four European cities. *Energy Policy* **2013**, *61*, 852–863, doi:10.1016/j.enpol.2013.06.085.
27. Ohnishi, S.; Fujii, M.; Ohata, M.; Rokuta, I.; Fujita, T. Efficient energy recovery through a combination of waste-to-energy systems for a low-carbon city. *Resour. Conserv. Recycl.* **2016**, *In Press*, doi:10.1016/j.resconrec.2016.11.018.
28. Phdungsilp, A. Futures studies' backcasting method used for strategic sustainable city planning. *Futures* **2011**, *43*, 707–714, doi:10.1016/j.futures.2011.05.012.
29. Energistyrelsen Strategisk energiplanlægning i kommunerne: Metodebeskrivelse - Vejledning i kortlaegningsmetoder og datafangst Available online: https://ens.dk/sites/ens.dk/files/Varme/metodebeskrivelse_280916.pdf (accessed on Mar 8, 2017).
30. Gustafsson, S.; Ivner, J.; Palm, J. Management and stakeholder participation in local strategic energy planning – Examples from Sweden. *J. Clean. Prod.* **2015**, *98*, 205–212, doi:10.1016/j.jclepro.2014.08.014.
31. O'Rourke, F.; Boyle, F.; Reynolds, A. Tidal energy update 2009. *Appl. Energy* **2010**, *87*, 398–409, doi:10.1016/j.apenergy.2009.08.014.
32. Niels I. Meyer; Brian Vad Mathiesen; Frede Hvelplund Barriers and Potential Solutions for Energy Renovation of Buildings in Denmark. *Int. J. Sustain. Energy Plan. Manag.* **2014**, *1*, 59–66.
33. Dreyfus, M.; Allemand, R. Three Years After the French Energy Transition for Green Growth Law: Has the “Energy Transition” Actually Started at the Local Level? *J. Environ. Law* **2018**, *30*, 109–133, doi:10.1093/jel/eqx031.
34. Webb, J.; Hawkey, D.; Tingey, M. Governing cities for sustainable energy: The UK case. *Cities* **2016**, *54*, 28–35, doi:10.1016/j.cities.2015.10.014.
35. Petersen, J.-P.; Heurkens, E. Implementing energy policies in urban development projects: The role of public planning authorities in Denmark, Germany and the Netherlands. *Land use policy* **2018**, *76*, 275–289, doi:10.1016/J.LANDUSEPOL.2018.05.004.
36. Kasa, S.; Westskog, H.; Rose, L. E. Municipalities as Frontrunners in Mitigation of Climate Change: Does soft regulation make a difference? *Environ. Policy Gov.* **2018**, *28*, 98–113, doi:10.1002/eet.1791.
37. Grontmij/Carl Bro *Kommunebarrierekatolog - Rapport vedrørende kommunernes barriereropfattelse for implementering af CO2 reducerende tiltag*; 2009;
38. Energistyrelsen Oplæg om strategisk energiplanlægning Available online:

http://www.kl.dk/ImageVaultFiles/id_41857/cf_202/Opl-g_om_strategisk_energiplanl-gning.PDF.

39. Lund, H.; Hvelplund, F.; Østergaard, P.; Möller, B.; Mathiesen, B. V.; Connolly, D.; Andersen, A. N. Chapter 6 - Analysis Smart Energy Systems and Infrastructures. In *Renewable Energy Systems*; 2014; pp. 131–184.
40. Lund, H. *Renewable Energy Systems : A Smart Energy Systems Approach to the Choice and Modeling of 100% Renewable Solutions*; Academic Press: Burlington, USA, 2014; Vol. 2;.
41. Yin, R. K. *Case Study Research: Design and Methods*; Fifth edit.; SAGE Publications Ltd, 2014;
42. Flyvbjerg, B. Five Misunderstandings About Case-Study Research. *Qual. Inq.* **2006**, *12*, 219–245.
43. Creswell, J. W. *Qualitative inquiry & research design: choosing among five approaches*; 2nd ed.; Sage Publications, Inc., 2007; ISBN 978-1-4129-1606-6.
44. Hjørring Kommune Fakta om kommunen Available online: <https://hjoerring.dk/om-kommunen/fakta-om-kommunen> (accessed on Jun 11, 2018).
45. Hjørring Kommune *Bæredygtig Energi - vejen til grøn vækst*; 2012;
46. Hjørring Municipality Focus group interview with Hjørring Municipality - Four employees.
47. Hjørring Municipality Interview with Hjørring Municipality - Employee 1 2016.
48. Hjørring Municipality Interview with Hjørring Municipality - Employee 2 2016.
49. Hjørring Municipality Interview with Hjørring Municipality - Employee 3 2016.
50. Hjørring Municipality Interview with Hjørring Municipality - employee 4 2016.
51. Hjørring Municipality E-mail correspondence with Hjørring Municipality 2018.
52. Neves, A. R.; Leal, V.; Lourenço, J. C. A methodology for sustainable and inclusive local energy planning. *Sustain. Cities Soc.* **2015**, *17*, 110–121, doi:10.1016/j.scs.2015.04.005.
53. Ea Energianalyse *STRATEGISK ENERGIPLANLÆGNING PÅ KOMMUNALT OG REGIONALT NIVEAU*; 2016;
54. Dyhr-Mikkelsen, K.; Sif Bundgaard, S.; Jacobsen, M.; Ellegaard Fich, C. *Evaluering af SEP-puljen og Superpuljen*; 2015;
55. Et energisk Nordjylland Projektbeskrivelse: Et energisk Nordjylland Available online: <http://www.kl.dk/partnerskab> (accessed on Nov 23, 2016).
56. Klima- Energi og Bygningsministeriet Varmeforsyningsloven - Bekendtgørelse af lov om varmforsyning - retsinformation.dk Available online: <https://www.retsinformation.dk/forms/r0710.aspx?id=165652> (accessed on May 2, 2016).
57. Erhvervs- og Vækstministeriet Planloven - Bekendtgørelse af lov om planlægning - retsinformation.dk Available online: <https://www.retsinformation.dk/forms/r0710.aspx?id=176182> (accessed on Jun 2, 2016).
58. Thellufsen, J. Z.; Lund, H. Roles of local and national energy systems in the integration of renewable energy. *Appl. Energy* **2016**, *183*, 419–429, doi:10.1016/j.apenergy.2016.09.005.

59. Carney, S.; Shackley, S. The greenhouse gas regional inventory project (GRIP): Designing and employing a regional greenhouse gas measurement tool for stakeholder use. *Energy Policy* **2009**, *37*, 4293–4302, doi:10.1016/J.ENPOL.2009.05.028.
60. Keirstead, J.; Schulz, N. B. London and beyond: Taking a closer look at urban energy policy. *Energy Policy* **2010**, *38*, 4870–4879, doi:10.1016/J.ENPOL.2009.07.025.
61. Sovacool, B. K.; Brown, M. A. Scaling the policy response to climate change. *Policy Soc.* **2009**, *27*, 317–328, doi:10.1016/J.POLSOC.2009.01.003.
62. Bale, C. S. E.; Varga, L.; Foxon, T. J. Energy and complexity: New ways forward. *Appl. Energy* **2015**, *138*, 150–159, doi:10.1016/J.APENERGY.2014.10.057.
63. Bulkeley, H.; Betsill, M. Rethinking Sustainable Cities: Multilevel Governance and the “Urban” Politics of Climate Change. *Env. Polit.* **2005**, *14*, 42–63, doi:10.1080/0964401042000310178.
64. PlanEnergi *Strategisk energiplanlægning på tværs af kommuner og aktører i Region Midtjylland*; 2015;
65. Frede Hvelplund Innovative Democracy, Political Economy, and the Transition to Renewable Energy. A full-Scale Experiment in Denmark 1976–2013. *Environ. Res. Eng. Manag.* **2013**, *4*, 5–21.