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Incentives and barriers for wind power expansion and system integration in Denmark

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ABSTRACT

In Denmark expansion of on-shore, near-shore and off-shore wind power is planned to increase the wind power share to 50% of electricity consumption by 2020. In this situation a continuation of past policies will not suffice, and a dual-track incentive system that both establishes incentives for investing in wind power and integration infrastructure with integration between the electricity, heating and transportation sectors, is required. The current Danish taxation system discourages electricity use and works against this integration. Likewise, the current day-ahead electricity spot market is not appropriate for a high-wind future as wind reduces price levels, but integration across sectors can partly assist in increasing demand and prices. The European Emission Trading System does not suffice in providing a level playing field for wind power and thus needs a revision. Another barrier for on-shore and near-shore wind power expansion is a growing citizens' resistance due to an unequal distribution of benefits and burdens. Ownership should be open for more types of investors – especially local investors – in order to ensure public support and local acceptance of wind power projects. The Danish political system needs to address these issues in order to promote further expansion of wind power in Denmark.

1. Introduction

Wind power has played an increasingly important role in the Danish energy system over the last four decades. As the significance of wind power has changed over the years, so have both the economic and organisational framework conditions and the energy system into which wind power needs to be integrated. Denmark has the World's highest wind power penetration (World Wind Energy Association, n.d.) (2012 data) with a share of 40% in 2015 (Energinet.dk, n.d.) yet has still ambitious expansion targets with 1000 MW additional off-shore capacity, 500 MW additional near-shore turbines and 500 MW additional on-shore capacity before 2020 (Ministry of Climate, Energy and Buildings, 2012). By 2020, the goal is that wind power should account for half the Danish electricity demand. By 2030, coal should be phased out of Danish energy supply, resulting in a power and heating sector 100% dependent on renewable energy sources (RES) by 2035 (Ministry of Climate, Energy and Buildings, 2017) which to a high extent are of a fluctuating or non-dispatchable nature.

Meeting these targets will not only affect wind power but will affect the entire Danish energy system, the way it is organised, the way it is operated, and the economy behind it. With its leading position in wind power, Denmark is first at encountering these issues.

While heading towards even more wind power, Denmark is also experiencing a certain political resistance to the development, and despite a substantial general support for wind power in the Danish population (Megafon, 2015), growing neighbour resistance is to an increasing degree hindering wind power projects based on large onshore wind turbines.

The Danish energy policy for the period from 2012 to 2020 is based on a political agreement confirmed in 2012 by a large majority in the Danish Parliament (Danish Government, 2016). This political agreement has provisions for the mentioned establishment of further wind turbines, where especially the near shore turbines have given rise to subsequent political controversies. In September 2016, the Swedish state-owned power company Vattenfall was the bid winner for a 350 MW near-shore tender with a price bid of only 63 €/MWh (Vattenfall, 2017) for a period of around 12 years and thereafter the market price. Over a 25 years lifetime this would result in an average payment around 40–50 €/MWh. The Danish government at that time wished to cancel the tender, claiming that the cost was too high. With a new coalition government formed in November 2016, the plans were reinstated. The process demonstrates that the political will behind the political agreement of 2012 is uncertain.

Abbreviations: CHP, Cogeneration of heat and power; DH, District heating; ETS, Emission trading system; NGO, Non-governmental organisation; PSO, Public Service Obligation; PV, Photo voltaic; RES, Renewable energy sources; TSO, Transmission system operator

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In order to ensure a robust base for investors in RES in Denmark, these technologies are offered an extra production payment in the first 7–12 years of production. During the autumn of 2016 the Danish government claimed that the Public Service Obligation (PSO) fee - a part of which assists wind power development – would increase strongly during the next years and harm the competiveness of Danish industry. This statement was contested by the Danish Association of Wind turbine producers arguing that the Government's assumed wind power prices were too high (80–100 €/MWh) – which is confirmed by the above-mentioned bid by Vattenfall. Nonetheless, in November 2016, the Danish government decided to phase out the PSO system over a five year period and replace this support for wind power by funding via the annual Danish fiscal budget. Thus, payment for renewable energy in Denmark is gradually being shifted from a PSO system based on a polluter-pays-principle to a tax financed system where RES support will compete in the political arena against other budgets of societal interest.

1.1. Scope and analytical approach of the article

The present Danish wind power development is meeting a series of challenges, including the development and implementation of a technological infrastructure for the integration of large shares of wind power. In addition, there is a growing local resistance towards large onshore wind power projects, and a reduced political will to give long-term financial support for wind power.

The article draws on a large body of existing work describing the development of wind power in Denmark. The most important new element is the analysis of the interrelationship between the technical needs for a wind power integration infrastructure and a *dual-track* incentive system that addresses both how to ensure that the planned investments in wind power are carried out, and how to ensure the development and proper operation of the required wind power integration infrastructure.

The above challenges are analysed by means of an interdisciplinary approach where wind power is seen in the nexus of concrete technological energy system changes and the economic, organisational and spatial planning structures that aids the changes.

We have chosen a technology-social science interdisciplinary approach as a consequence of the present fundamental transition phase with its increasing wind power integration challenges. Furthermore the need for a dual-track incentive system in combination with the acceptance challenge entails an analytical approach that encompasses the interrelationship between economic, organisational and spatial dimensions.

Methodologically, our analyses deals with the investment conditions closest to the actors that take investment decisions, such as consumers, wind turbine owners, and CHP owners. And with regard to these actors we analyse whether their concrete economic conditions such as energy taxes and tariffs lead them to invest in solutions that are economically best for society. Although we do not make concrete economic analyses in this article, we do quote economic assessments from our references. When these refer to what is “economically best for society”, they mean solutions with the highest net present value where energy taxes are excluded from the calculations.

In situations where we cannot refer to concrete economic calculations, we evaluate whether there are areas where the level of equal competition with regard to tariffs, taxes and market conditions, etc. can be increased. In these situations we assume that an increased degree of equal conditions leads to economically better solutions from a societal point of view.

Our analysis is thus dealing with what could be called the *first order* analytical level, and we delimit ourselves from analyses of the political and cognitive level, that influences the first order conditions. Here we call this the *second order* analytical level.

We thus do not analyse the political processes behind different tax and tariff regimes. It is for instance a valid hypothesis that the natural gas companies have no interest in opening the heat market for wind power. Regarding the rivalry between local integration systems and transmission lines it also is a valid hypothesis that the Danish transmission system operator (TSO), Energinet.dk, has strong interests and an organisational inertia that support the need for transmission interconnectors. Likewise, we analyse the acceptance problems linked to distant ownership of wind power projects, but we do not thoroughly analyse the political process hampering the change from distant ownership to more local ownership. It is a valid hypothesis that the large energy companies and their organisation, Danish Energy Association, does not support local ownership of wind turbines, as this would make the large energy companies lose ownership shares. We analyse the effects upon wind power economy and smart energy systems of the Nordpool spot market construction, but we do not analyse the interest groups and political processes behind different market designs.

The methodological reason behind our focus upon the *first order* analytical level is that we see analysis at this level as a first step in a political process of transition from one energy system to another. We find it important first to analyse which technical energy systems are required and which *first order* policy solutions could support the development and implementation of these systems. When this is done, the base for an analysis of the *second order* questions is established, and it only becomes relevant and possible to pose questions like *why are we not changing the energy taxes,* once we have calculated in a *first order* analysis that this would be economically beneficial for society. Or for instance *why don't we create equal competition between transmission interconnectors, and local and regional integration of wind power in smart energy systems*.

So when this analysis concludes with the authors' proposals for new constructive strategies for the future development of Danish wind power our suggestions are the ones that according to our *first order* analyses should be implemented in order to develop the energy system that with the lowest societal costs assures the development and implementation of the planned wind power development and its infrastructure.

It is our intention to design proposals that will generate the cheapest solutions for society, and this is useful, but clearly not enough. A next step in the analysis would be to deal with the political processes leading to different policies at the above areas, but this is beyond the scope of this article.

Another important element of the article is the analysis of the increasing problem of acceptance of wind power linked to large onshore wind turbines where benefits and burdens are distributed unevenly.

1.2. Structure of the article

In accordance with the above challenges and analytical approaches, the article is organised as follows:

Section 2 provides a brief summary of the historical development leading up to the Danish role as global pioneer of modern wind power in the 1970s. The subsequent sections treat a number of the present issues for Danish wind power with proposals for solutions.

Section 3 describes the overall systems problems for the Danish electricity sector with fluctuating wind power covering more than 40 per cent of the electricity consumption. Different strategies have been proposed including interconnectors between neighbouring countries. An alternative proposal is based on smart energy systems that are taking advantage of a closer co-operation between the sectors for heat, electricity and transportation with a view to facilitate local integration of renewable energy sources.

Section 4 outlines our proposal for an incentive system, discussed in more detail in Sections 5, 6 and 7.

Section 5 describes the present form of economic incentives for Danish wind power, and addresses how to establish incentives that