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Offshore wind power policy and planning in Sweden ☆

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ABSTRACT

The main objective of this paper is to analyze the role of policy support schemes and planning systems for inducing offshore wind power development in Sweden. Specifically, it highlights the different types of economic, political and planning-related conditions that face offshore wind power investors in Sweden, and provides brief comparisons to the corresponding investment conditions in Denmark, Norway and the UK. The analysis shows that in Sweden existing policy incentives are generally too weak to promote a significant development of offshore wind power, and the paper provides a discussion about a number of political and economic aspects on the choice between different support schemes for offshore wind in the country. Swedish permitting and planning procedures, though, appear favorable to such a development, not the least in comparison to the corresponding processes in the other major offshore wind countries in Europe (e.g., the UK). On a general level the paper illustrates that the success and failure stories of national offshore wind policies and institutions cannot be easily transferred across country borders, and the analysis shows that both the political and the legal frameworks governing the investment situation for offshore wind farms in Denmark, Norway, Sweden and the UK differ significantly.

1. Introduction

The current concerns about climate change relate strongly to the past technological developments, which have fundamentally changed the structure of the energy sector by making possible the diffusion of new and less costly technologies. The energy production processes introduced during the 20th century – most notably those relying on the combustion of fossil fuels – have given rise to a significant increase in the emissions of greenhouse gases out of which carbon dioxide is the most important. The balance of evidence suggests, though, that these emissions are having a distinct negative impact on the global climate (e.g., IPCC, 2007). Somewhat paradoxically, policy makers worldwide now hope that future technological developments will solve the problems that technical change has caused in the past. This requires policy efforts in the energy sector to be heavily focused on innovation and technology diffusion activities as a complement to policies addressing explicitly the reduction of carbon emissions (e.g., emissions trading, carbon taxes, etc.) (Jaffe et al., 2005).

An essential component of the European Union's energy policy is the promotion of renewable energy sources in its Member Countries, and for the electricity sector the Renewables (RES-E) Directive (2001/77/EC) has played a key role in this policy endeavor. In addition to climate change, several other political ambitions are also provided as arguments for an increased reliance on electricity produced by renewable energy sources. These include, first and foremost, improved security of supply in the Union, but also social cohesion, local employment and environmental protection are put forward as key arguments. While the RES-E Directive has outlined quantitative goals for the development of renewable electricity in each country until the year 2010, it has also provided substantial freedom on the parts of national governments to select the policy instruments needed to fulfill these goals. The existing policy support schemes for renewable electricity (e.g., feed-in tariffs, green certificates, etc.) have primarily succeeded in stimulating the diffusion of relatively mature technologies, such as onshore wind power, but it has become increasingly important to also support the development of the more immature energy technologies in order to make it possible to comply cost-effectively with more stringent climate policy commitments in the future. In order to design efficient policies, though, a proper understanding of the economic, legal and institutional conditions that govern technology innovation and diffusion in the electric power sector is needed. Investments in new carbon-free electric power sources typically face a number

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of economic, political and institutional hurdles, and these can often differ across countries as well as across different renewable electricity technologies.

The main objective of this paper is to analyze the role of policy support schemes and planning systems for inducing offshore wind power development in Sweden. Specifically, we make use of economic and legal analysis to identify the different types of economic, political and planning-related uncertainties that face offshore wind power investors in Sweden. This implies that we assess the lifetime engineering costs of different types of wind power projects in Sweden, and then analyze the impact of the different policy instruments in use on the competitive cost position of these projects under varying rate-of-return requirements. We also recognize, though, that investment decisions will be influenced by the legal frameworks conditioning the permitting, planning and location of wind farms. The paper therefore also provides an analysis of important legal provisions and selected case law examples concerning the assessment of the environmental impacts of wind mills and the planning procedures for offshore wind mill installations in Sweden.

Throughout the paper we make brief comparisons to the corresponding investment conditions in three other European countries: Denmark, Norway and the United Kingdom (UK). In all of these countries there are great potentials for substantial future expansions of offshore wind power, and Denmark and the UK are already at the forefront of offshore wind development worldwide (see Section 2). Similar inter-country comparisons have been made for onshore power (e.g., Toke et al., 2008), but few previous studies highlight the special conditions offshore. The analysis indicates that the political and legal conditions for offshore wind power development differ considerably across these countries, and in the paper we also conclude that in Sweden these conditions vary considerably for onshore versus offshore wind power installations. The establishment of onshore wind farms in Sweden is negatively affected by the legal provisions governing the assessment of the environmental impacts of wind mills and the planning procedures for mill location (e.g., Söderholm et al., 2007). In contrast, Swedish offshore installations are primarily hampered by lack of policy support, while the legal conditions overall appear favorable.

In Section 2 we briefly review the past development of offshore wind power in Europe. Section 3 analyzes the economics of wind power in Sweden, and the impacts of policy on the lifetime power generation costs. We also address some political and economic aspects on the choice between future technology support policies in Sweden. In Section 4 we discuss environmental permitting and physical planning procedures for offshore wind power in Sweden, and compare these to the respective legal frameworks in Denmark, Norway and the UK.

2. Offshore capacity developments in an European perspective

Fig. 1 displays the development of offshore wind power capacity in Europe since 1998 and onwards. The growth in installed capacity has been high during this period, albeit from very low levels at the end of the 1990s. At the end of 2009, total installed European offshore wind power capacity amounted to 2056 MW, representing about 2 percent of total wind power capacity in Europe (EWEA, 2010). Globally Europe is a dominant player in the offshore wind sector and the associated production of turbines; as late as in 2007 European producers supplied turbines to all offshore wind power projects worldwide (EWEA, 2007).

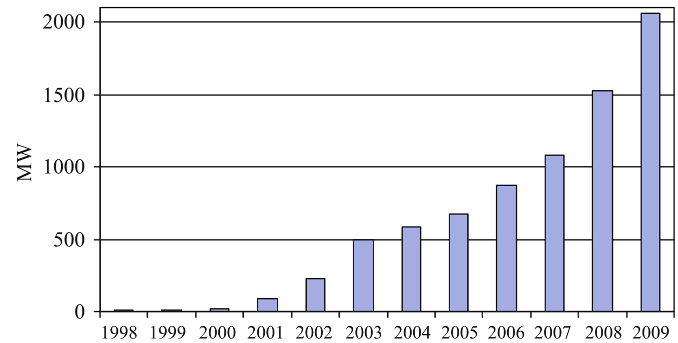

Fig. 1. Installed capacity of offshore wind power in Europe (MW), 1998–2009. *Sources:* EWEA (2008, 2010).

Table 1
Offshore wind power installations by country, 2009.
Source: EWEA (2010).

	Number of farms	Number of turbines	Installed capacity (MW)
United Kingdom	12	287	883
Denmark	9	305	639
Netherlands	4	130	247
Sweden	5	75	164
Germany	4	9	42
Belgium	1	6	30
Ireland	1	7	25
Finland	1	8	24
Norway	1	1	2
Total	38	828	2056

The UK and Denmark are the dominating producers of offshore wind power in Europe, and in 2009 their combined share of European offshore capacity amounted to 74 percent. Table 1 shows that total European offshore capacity is spread across 38 wind farms in nine countries, and 21 of these have been installed in either the UK or Denmark. The Netherlands and Sweden also have substantial offshore wind power resources, and in 2009 Sweden accounted for about 8 percent of total European capacity installed. Norway is still a minor player in the offshore market, and in 2009 the country's installed capacity was only 2.3 MW (EWEA, 2010). Nevertheless, Norway has very favorable wind potentials for increased offshore capacity, but so far the needed policy support to induce additional expansions has been lacking.

Over the years the European offshore wind farms have grown larger and larger, and they are typically built further away from shore and installed in deeper waters. For instance, the Horns Rev 2 wind farm, built in Denmark in 2009, has a capacity of 209 MW. In Sweden there are currently five offshore wind farms operating; most of them are comparatively small in terms of capacity (3–30 MW) but in 2007 the Lillgrund wind farm was established and it comprises 48 turbines with a total capacity of 110 MW. This farm is located about 7–10 km from shore and the water depth is 3–6 m (Meyer, 2007).

The rougher conditions offshore imply, though, that production costs are substantially higher compared to onshore installations. For instance, the investment cost for onshore wind power are normally estimated at Euro 0.8–1.2 million per MW, while the corresponding cost for offshore installations may often end up at Euro 1.7–2.3 million per MW (Lemming et al., 2007). The main reasons for this cost difference are the higher costs for foundation and grid connections at offshore wind farms. For a typical onshore wind power station the cost of foundations normally represents

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Table 2
Electricity prices required to make new wind power plants economical.
Sources: Hansson et al. (2007) and Söderholm (2009).

Plant type	Capacity (MW)	Required wholesale electricity prices (Euro per MWh)			
		Without policy support		*With* policy support	
Discount rate		6 percent	12 percent	6 percent	12 percent
Project					
Wind power—onshore	4	55	79	38	61
Wind power—onshore	40	47	68	30	50
Wind power—offshore	150	74	108	57	89
Wind power—offshore	750	83	120	66	102

4–6 percent of total investment costs, while the corresponding share for offshore installations may amount to over 20 percent (Lemming et al., 2007). The higher costs can also be explained by that fact that so far there exists no well-developed supply industry for the installation work offshore, and during recent years the offshore wind power industry has been forced to compete with the more established fossil fuel industry for these installation services (e.g., Sovacool et al., 2008).

The higher investment costs for offshore wind power are at least partly offset by the more favorable wind conditions at sea. An onshore wind farm can typically be utilized about 2000–3000 h per year while an offshore farm normally achieves a utilization rate of approximately 3000–4000 h annually. In addition, the environmental costs of offshore installations are overall lower than those typically experienced at onshore farms (Ek, 2006; Danish Energy Authority, 2005). For these reasons the future plans for increased offshore capacity are overall very optimistic.

Many countries – not the least Denmark and the UK – have presented ambitious expansion plans, and have partly redesigned their support systems and legislation to realize these plans. For instance, in 2007 the Danish government announced a policy target stating that by the year 2025 the share of renewable energy sources out of the country's total production of electric power should constitute 60 percent. This requires, it is argued, a doubling of the Danish capacity of wind mills, which in practice may imply the installation of up to 1000–2000 wind turbines offshore (Sovacool et al., 2008). Moreover, the UK government has announced its intention to expand offshore wind power to as much as 33 GW by the year 2020.

The remainder of this paper discusses the prospects for additional offshore wind power in Sweden. In doing this we pay particular attention to the economic and legal investment environment, and briefly contrast this to the corresponding conditions in Denmark, Norway and the UK.

3. The economics and policy of offshore wind power in Sweden

3.1. Power generation costs and the impact of policy

In Sweden there exist two sets of policy instruments that may support the establishment of offshore wind power: the green certificate system and an investment subsidy to pilot projects. *First*, the green certificate system for renewable electricity was introduced in 2003. Its aim has been to secure a pre-determined market share for renewable electric power sources, and promote a cost-effective competition between the different types of renewable energy sources. The new system has replaced previous subsidy programs (e.g., the so-called environmental bonus), and has provided a decent financial support to renewable electricity of around Euro 20–30 per MWh in addition to the regular electricity price. The price of certificates varies over time, and since 2006 the producers of renewable electricity can issue new certificates over a time period of 15 years. *Second*, in 2003 the Swedish Energy Agency launched an investment program aiming at supporting technological development in large-scale wind power. Investment support is only granted to selected projects that can contribute to such a development, and it is not dedicated solely to offshore establishments. The above-mentioned Lillgrund offshore wind farm was, though, made possible through an investment support of roughly Euro 20 million, and this project has, among other things, contributed with improved knowledge about the environmental impacts of offshore installations as well as about the so-called gravity foundation structure.[1]

Table 2 shows the wholesale electricity price levels that would be required to make different wind power projects economical, both in the absence as well as in the presence of the existing certificate system. The numbers are based on lifetime (levelized) costs, i.e., all power generation costs (capital, operation and fuel costs) discounted to a present value and then divided by the total discounted output over the economic lifetime of the plant (Bemis and DeAngelis, 1990), for a set of different onshore and offshore wind power projects. These cost estimates are based on the assumption of an economic lifetime of 20 years, and they include the costs for electric grid connections. The latter costs are assumed to be Euro 0.1 million per MW for onshore wind and Euro 0.25 million per MW for offshore installations (Hansson et al., 2007). This implies that occasionally the cost of offshore connections to the electric grid (i.e., including internal electric connections, transformers offshore and a cable to an existing onshore grid) can constitute about 20 percent of total investment cost for offshore projects.

The results in Table 2 illustrate that the economics of wind power is strongly affected by the use of higher discount rates. This is an outcome of the fact that the capital costs involved in wind power development form a sizeable part of the total lifetime costs, and the higher are the uncertainties about the future rate-of-return of the investment, the less competitive wind power will be. The lifetime cost of wind power is also strongly influenced by the policy support granted to wind projects through the green certificate system, and the prices presented in Table 2 builds on the assumption that investors receive an additional revenue (i.e., reduced cost) corresponding to Euro 20 per MWh over a 15-year period. Since the support to pilot projects is only granted to selected projects, it is not included in the economic assessment.

These results are well in line with those presented by Swedish Wind Energy (2008), and they confirm that overall wind power in Sweden requires public support to be economical in the Nordic electricity market. Specifically, over the last years the long-run

[1] The main foundation technology used offshore is monopile, followed by gravity foundations (thus applied at Lillgrund) and jackets (EWEA, 2010).

price of electricity has been at least around SEK 40 per MWh, and the additional revenues from the green certificate system imply that this scheme has been a key behind the expansion of onshore wind power in Sweden since 2006 (see also Pettersson and Söderholm, 2009). At reasonably low discount rates the net cost of onshore wind power is typically below this price level.[2] However, the results also indicate that the current support from the certificate system is far from adequate to also make offshore wind power an economically attractive investment alternative in Sweden.

The conclusion that offshore wind power is in need of additional financial support to be developed holds for all countries, but we do witness substantial differences across countries concerning the design and the size of this support. Since 2008 Norwegian wind power developers are provided a fixed feed-in tariff of about Euro 10 per MWh over a 15-year period. This financial support is however lowered if the electricity price is higher than (approximately) Euro 50 per MWh. Overall the Norwegian public support to wind power is considered too low to stimulate a significant expansion of even onshore wind power in the country, and as is shown in Table 1 the existing capacity of offshore installations is close to zero. In contrast, Danish energy policy pays significant attention to offshore wind power development, and since 2004 there exists a competitive bidding system for offshore wind installations (Danish Energy Authority, 2005). The companies that win the opening bids are guaranteed a fixed amount – in effect a feed-in tariff – for a future production equivalent to 50 000 full load hours (in practice a support lapsing over a 12-year time period) (Nielsen, 2007). An important feature of the Danish offshore tendering system is that the sites have been pre-selected by the country's government.[3]

In the UK there exists a similar support system to the one used in Sweden, although the UK system generally involves more certainty about the value of the certificates (e.g., there is a guaranteed price floor). The so-called Renewables Obligation (RO) scheme was introduced in 2002; it obliges electric utility companies to increase their share of renewable power sources, and it has induced a significant increase in UK wind power (Toke et al., 2008; Markard and Petersen, 2009). The offshore wind power sector has also benefited from investment subsidies as consented projects receive capital grants (in Round 1), but these are absent in the present UK system. Moreover, the renewable obligation certificates (ROCs) from offshore installations are assigned 1.5 times the value of other ROCs. While the policy support in the UK overall appears favorable to (at least large scale) offshore investors, the permitting and planning procedures have often been less promoting (see Section 4.2).

Unlike the situation in Denmark and the UK, the current Swedish policy stance on offshore wind power is ambiguous. In March 2010 the Swedish government announced its plans to extend the lifetime of the green certificate system (until the year 2035) and introduce a more ambitious target. The current target states that in 2016 the production of renewable electricity should have increased by a total of 17 TWh (compared to the 2002 level) (Swedish Energy Agency, 2007), and the current proposal implies an increase by 25 TWh until the year 2020. This will (ceteris paribus) imply increased certificate prices, but most studies suggest that the cost of offshore wind power is too high for this technology to become implemented even in the presence of a higher renewable electricity target (e.g., ECON, 2007). Instead we are more likely to witness an expansion of onshore wind power in the remote areas of the country (e.g., northern Sweden), where large forest-based wind farms currently are being planned. This suggests that a future expansion of offshore wind power in Sweden requires additional public support, and in the next subsection we discuss the issue of what could motivate such a support as well as the implications for the design of policy support scheme.

3.2. *The political economy of supporting offshore wind power in Sweden*

In introducing technology-specific public support schemes it is useful to make a distinction between the short- and long-term goals of climate and energy policy. The existing certificate system in Sweden is a technology-neutral policy instrument; it primarily supports the cost-effective introduction of relatively mature renewable electricity technologies to meet short-term policy goals, and could in this way lift some pressure on the depth of technological change needed in the future to reach longer-term targets (e.g., Fischer, 2009). It is equally important to stress that there exists no economic argument for picking out offshore wind power as a key technology in complying with the current climate policy targets. The carbon emissions from the Swedish electric power sector are primarily influenced by the European emissions trading system (EU ETS). In the presence of this scheme, public support to offshore wind power (or any other renewable energy technology) would lead to no net reductions in carbon dioxide emissions globally. If the production of renewable electricity increases, the power sector will either sell or bank surplus emissions allowances or use them to increase generation based on fossil fuels. Hence, total carbon emissions remain the same, and are given by the caps under the National Allocation Plans. Still, for political reasons it may be difficult to impose stringent caps within EU ETS, and in this way the support to renewable electricity represents a way of making possible the implementation of higher carbon prices in the future.[4]

Söderholm (2009) argues that the most convincing economic argument for designing a specific national support system to offshore wind power relates to the fulfillment of long-term

[2] Considering also the cost of other power generation technologies it can be noted that with the existing policies hydropower, nuclear power and onshore wind power represent the less costly alternatives. However, the development of new hydropower is restricted in Sweden by the low availability of appropriate sites and the difficulties in getting permission to build. In 2009 the Swedish Government announced its intention to abandon the moratorium on investments in new nuclear plants, and a new legislation will be put in place during 2010 (see also Michanek and Söderholm, 2009).

[3] The Danes have also designed a streamlined permitting process for these offshore projects (see also Section 4), and the Danish Energy Authority acts as an one-stop shop for environmental assessment and licensing procedures (Nielsen, 2007).

[4] In addition, even though Sweden cannot influence current global carbon dioxide emissions by promoting renewable electricity, the green certificate system does play another climate policy role. This is because in an attempt to precede stricter future requirements, Sweden has adopted a national emissions target significantly below the so-called assigned amounts that the European Union's burden-sharing agreement allots to the country for the period 2008–2012 (Carlén, 2007). Important differences between a national emission target and the option of fully utilizing the benefits of emissions trading within the EU ETS lie in how Sweden can meet its target, and where reductions will be made. Since not all sectors of the economy take part in the trading system at this point, the Swedish economy is divided into a trading and a non-trading sector. The adoption of a national emissions goal implies that if a firm in the trading sector chooses to buy permits, a corresponding reduction has to be made in the non-trading sector where the marginal cost of emission reductions is higher. An important implication of this is that it may make climate policy sense to support renewable electricity – not because this helps in coming any closer to the national goal – but rather because it represents one way of avoiding more costly emissions reductions in the non-trading sector. Thus, the Swedish green certificate system assists in improving the cost-effectiveness of the nation's climate policy. However, this is mainly an argument in favor of raising the quota in the green certificate scheme and not for supporting offshore wind power per se.

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climate and energy policy goals. A technology-specific support can be economically efficient under two conditions, namely: (a) the future cost of offshore wind power can become lower than the cost of the incumbent renewable energy technologies (e.g., onshore wind power) and that (b) these cost reductions cannot materialize in the absence of any policy intervention (see also Kolev and Riess, 2007). In other words, such a support would mainly aim at speeding up the process of technological development, i.e., it represents a policy measure that we do not choose to undertake in order to fulfill current policy goals (such as the existing quota in the green certificate system or the Kyoto commitments) but instead to lower the cost of achieving future (and even stricter) policy targets.[5] The question remains, though, whether offshore wind power is a strong candidate for such a support, and if so how this support ought to be designed? The answers to these questions require (among other things) a proper understanding of the process of technological development in the offshore wind sector.

A large number of studies show that technology learning in the production of wind turbines has been a major driving force in reducing the cost of onshore wind power production (e.g., Neij et al., 2004; McDonald and Schrattenholzer, 2000; Söderholm and Klaassen, 2007), and these conclusions appear equally valid for the offshore sector (e.g., Smit et al., 2007). There are also clear signs that most investors and turbine producers are keen to prevent that the knowledge generated through learning and research and development activities will not spill over to their competitors who then can copy the initial learning at a fraction of the costs. Still, the energy sector is likely to be characterized by significant knowledge spillovers, which are hard to internalize through, for instance, patent systems (e.g., Neuhoff, 2005). This is in part due to the scale and the time scale of the financial investments required for innovation, but also the fact that innovation activities in the renewable energy technology sector involve a large set of components and thus require the expertise of several companies.

During the last 10 years of expansion the offshore wind sector has benefited from the experiences of the expansion onshore, but there are strong indications that the offshore industry will gradually become a more independent part of the energy sector. This is partly due to the complexity of offshore installations, especially if the industry decides to conquer the deeper waters where wind conditions may be very favorable. The harsher conditions at sea imply different challenges, and it is likely that offshore developers will show a greater interest in wind turbines that exceed 5 MW. There is also much to gain from establishing a closer cooperation with the existing offshore oil and gas industry, e.g., in reducing the cost of installation work (Lemming et al., 2007).

The observation that technological learning (learning-by-doing) is a major source of technological progress in offshore wind power implies that it is necessary to pay particular attention to policy support schemes that stimulate a steady and continuous market expansion of this technology. This would facilitate the development of innovative component supplier and turbine industries, and in this way induce important learning activities. From this perspective neither the Swedish investment subsidy to pilot projects nor the Danish tendering system may be particularly efficient; they risk creating cycles of 'stop-and-go' with little investment activities taking place between the bidding rounds (e.g., Sawin, 2004). These support schemes also tend to mainly favor the big energy companies; these are better equipped to deal with the risk of future cost escalations, and may, for instance, present lower costs in a competitive bidding procedure just to win the bid for a certain location (Munksgaard and Morthorst, 2008). An important benefit of the Swedish pilot project support, though, is that it permits the authorities to select projects that address development issues that are particularly relevant to domestic conditions (e.g., research on offshore operations in cold climates).

It is hard to assert whether offshore wind power represents one of the future technological 'winners' that policy makers should pick out and offer generous public support, but if a strong case for such a support can be made, it is possible to identify two possible policy paths for Sweden. The *first* policy path involves a targeted and continuous production support (e.g., a fixed feed-in tariff) to offshore wind power in order to induce important technology learning impacts. This type of strategy can most likely not be motivated economically from a strictly national perspective, not the least since most of the relevant learning activities will take place among primarily foreign (e.g., Danish and German) wind turbine producers. Nevertheless, such a policy could constitute a meaningful way for the Swedish government to take on additional political responsibility in global climate policy. The policy would add to a global public good of knowledge in offshore wind power, something which in turn could facilitate the cost-effective diffusion of offshore wind projects at various locations around the world.

The *second* policy path is essentially the one followed at the present in Sweden, mainly manifested in the investment support to selected pilot projects. It appears to build on the idea that Sweden accumulates increased domestic knowledge about offshore establishments, primarily in order to facilitate its expansion in the country when (and if) the technology becomes economically commercial. Even if the Swedish offshore wind sector is heavily dependent on the global innovation system in turbine manufacturing and offshore installation work, it may make sense to support research and development activities that address specific issues related to, for instance, the country's geography, climate and institutional setting. Technological progress requires both R&D and learning, and for this reason R&D programs should typically not be designed in isolation from practical applications (Arrow et al., 2009). Clearly, the choice between these two offshore wind power policy strategies is far from straightforward, and no comprehensive assessment of these has so far been presented.

4. Permitting and planning: Sweden in international perspective

4.1. Offshore versus onshore wind power planning in Sweden

In Sweden the legal preconditions for the establishment of wind power have often constituted major hurdles for investors, and in particular for *onshore* installations (e.g., Söderholm et al., 2007). These obstacles to implementation can be found in: (a) the permitting procedure for environmental concession and (b) the territorial planning system.

First, the "environmental trial" relies on assessment rules outlined in the Environmental Code rather than on legal standards (e.g., noise limits), which prolongs the trial and increases the incentives to appeal. Some of the individual assessment rules have in turn been rather troublesome for wind power developers.

[5] A political motive for providing additional support to selected renewable energy technologies in Sweden (above that already provided by the green certificate system) would be that this could significantly decrease the producer rents generated in the existing system. While the Swedish green certificate system has promoted a cost-effective introduction of renewable electricity production it has also led to a significant transfer of wealth from electricity consumers to the producers (Bergek and Jacobsson, 2010).

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An important example is the so-called localization rule, which requires an objective assessment of the site in order to achieve the "best" location from an environmental point of view, with very little regard to the developer's access to the site. Moreover, the substantial rules concerning resource management have shown to increase the uncertainties involved in the assessment; the rules are supposed to give guidance to the use of land and water areas, but they are exceptionally vaguely formulated and their steering function is consequently almost lacking (Pettersson, 2008). At best, areas may be designated as "national interests" for wind power production, implying that the areas *shall* be protected against *prejudicial* activities. Still, if an area is of national interest also for other purposes (e.g., nature conservation), the rules provide very little guidance and leave the decision-makers with substantial discretion. Analyses of Swedish case law confirm that the prerequisites for wind power development provided by the resource management provisions are unpredictable both regarding the possibilities to avert obstructive activities as well as to explicitly promote wind power (e.g., Söderholm et al., 2007).

Second, the Swedish territorial planning system has a significant influence on the implementation of wind power, and compared to the corresponding systems in Denmark, Norway and the UK it stands out as the most decentralized. In principle the municipalities in Sweden must in some way assent to (i.e., plan for) the establishment of wind mills at a certain location in order for the installation to actually take place. Even though the national government (represented locally by the County Administrative Boards) is obliged to reject municipal plans not taking national interests into account, it is ultimately the municipalities which decide whether or not to accept the Boards' advice. In practice the courts also appear to pay a lot of attention to the municipal positions in the permitting process, especially if there is intense competition for land areas. All in all, the municipal planning monopoly in Sweden leaves substantial room for discretion and for de facto ignoring national (and indeed international) energy policy objectives (see also Khan, 2003).[6]

In sum, onshore installations in Sweden may trigger a great number of legal rules and permit requirements, and the uncertainties about the conditions for investments are normally substantial. In contrast, offshore installations above 1 MW on Swedish territory require two main permits (synchronised trial) as well as an environmental impact assessment, i.e., permit for environmental hazardous activity (EHA) as well as for water operations. The permit trial for EHA includes an assessment in accordance with the same substantial rules as for an onshore installation, i.e., the localization rule and the resource management provisions. These rules may in principle present the same obstacles, but the conflicts are much less distinct and the rules primarily represent major obstacles in the presence of intense competition for land areas. Also the impacts of the planning system (i.e., the planning monopoly and the detail plan requirement) appear to be less of a problem, unless it is a question of developments in, for instance, the archipelago, that is to say, rather close to built up areas. In essence, in Sweden the interests of those who object to wind mill installations at the local level gain strong legal protection, but in areas where such opposing interests are lacking the legislation provides a rather efficient trial of wind power farms.

In addition to the permit for EHA, offshore installations within the Swedish territory also require a permit for hydraulic (water) operations (WO). If the operator so wishes, the two trials (EHA and WO) can be coordinated. The special conditions applying to a WO permit states that such operations may only be undertaken if the benefits from the point of view of public and private interests are greater than the costs and damages associated with these operations. The purpose of the rule is thus to prevent installations or activities that are unjustified from an economic efficiency point of view. This social cost–benefit rule was applied by the Environmental Court of Appeal in the case of the Utgrunden wind farm (Case M 833-99).[7] The main issue in this court case concerned what was to be included in the cost–benefit assessment. The Court came to the conclusion that the state subsidies granted to wind power establishment at the time (i.e., the so-called environmental bonus) were to be regarded as benefits from a public point of view (i.e., an adapted economic value) in the weighting process. The subsidies reflect, it was argued, the implicit value of attaining an increased share of renewable energy. The Government shared the opinion of the Court and concluded that the increased supply of renewable energy as a result of the establishment was in compliance with the national environmental objectives, and would in this case exceed the costs and damages that the activity may cause. The above statements by the Court and the Government could prove to be important for the future of offshore wind power in Sweden. The case illustrates how the wind power interest – as a mean to achieve important national (and global) policy goals – can be visualized at the implementation stage and weighed against any local damages caused by the development. Similar legal approaches are however lacking in the case of wind power located onshore in Sweden.

Offshore wind power installations *outside* the Swedish territory, but within the Swedish economic zone, require only one permit, and it is granted by the Government.[8] Also this permit process includes an assessment in accordance with the resource management provisions and the general consideration rules as outlined in the Environmental Code, but the territorial planning legislation is not applicable. The trial for installations within the economic zone is thus rather straightforward in comparison with the trial for onshore developments. This is well exemplified in a court case from 2008. This case concerned the location of a wind farm in an area of: (a) national interest for wind power; but also suggested as a (b) special conservation area in accordance with the Habitats Directive (habitat for dolphins). In relation to the substantial rules, the Government concluded that the use of the area for wind power production would imply an efficient management of the natural resources in the area, and that it should be possible to install the wind farm without significant effects on the conservation area on condition that the required consultations and investigations were carried out.

In sum, the above shows that in Sweden the legal preconditions for offshore wind power development are more favorable than those applying to onshore installations. However, as was illustrated in Section 3, the current policy situation only offers weak financial incentives for offshore investors in the country. The introduction of a more generous financial support to Swedish offshore projects would therefore probably lead to a substantially increased interest in the Swedish waters among both domestic and foreign investors. This conclusion is supported by the notion that the planning and permitting regulations in other important offshore countries are (with the exception of Denmark) probably not as favorable. In the next subsection we comment briefly on the legal frameworks in Denmark, the UK and Norway.

[6] Depending on the size and location, onshore installations are also subject to a number of other permit requirements, including the government's permissibility trial (Pettersson, 2008).

[7] The Utgrunden offshore wind farm was established in 2000, and it has a total capacity of 10 MW (seven 1.5 MW turbines) (e.g., Meyer, 2007).

[8] In addition to the above, one final permit may be required (both on and outside Swedish territory), and this concerns the installation of cables on the continental shelf. This permit is also granted by the Government.

4.2. Offshore wind power planning and permitting in Denmark, the UK and Norway

The right to exploit wind energy within the Danish territorial waters and the economic zone belongs to the Danish government, who grants user rights according to a tendering procedure in which certain circumstances or conditions are viewed as particularly important. The actual development requires only *one* permit (and a special environmental impact assessment for electric installations offshore), all prepared and granted by the government. In practice the Danish Energy Authority coordinates the inter-departmental planning and permitting process with the intention to offer a "one-stop-shop" (e.g., Markard and Petersen, 2009). However, so far the financial support to offshore developers has been too low to achieve the very ambitious renewable energy targets of Danish energy policy (Munksgaard and Morthorst, 2008).

The corresponding processes in both Norway and the UK instead involve a number of permits (licenses/consents) as well as planning considerations. Potential developers require permission from The Crown Estate (as the owner of the majority of the seabed) as well as statutory consent from several governmental departments, here among: (a) a development consent (installation license) in accordance with s. 36 in the Electricity Act *or* an Order under the Transport and Works Act; (b) written consent (from the department of Transport) for coastal installations in accordance with the Coastal Protection Act (if the installation is likely to have an effect on navigation); (c) a license (from the Department for Environment, Food and Rural Affairs) in accordance with the Food and Environmental Protection Act; (d) a consent to put up structures and lay out cables (from the Environment Agency) under the Water Resources Act and (e) a planning permission under the Planning Act for necessary onshore infrastructure (Pettersson, 2008).

In the UK offshore wind power developments follow a tendering procedure where the prospective developers bid for site option agreements. Round 3 of offshore windfarm leasing was announced by The Crown Estate in 2008. The selection process in the first two development rounds roughly involved three stages: (a) pre-qualification (e.g., financial standing, offshore development expertise and wind turbine expertise); (b) site allocation and (c) granting of agreements for lease (Pettersson, 2008). Under Round 3 the role of The Crown Estate is more prominent including zonal contract management and co-investments. In this process, developers will join forces with The Crown Estate to identify suitable sites within each zone. The Crown Estate will however not be involved in the construction or operation of the wind farms (www.thecrownestate.co.uk).

The typical offshore installation thus requires quite a few applications, which presumably extends the time-frame for implementation. The fact that the consents are granted (or rejected) jointly however reduced the uncertainties associated with multiple concession trials. Overall, however, the legal process in the UK is complex and has partly slowed down the development of offshore wind projects (Markard and Petersen, 2009).

In order to simplify and make the development process for Nationally Significant Infrastructure Projects (NSIPs) faster and more transparent, an Independent Planning Commission (IPC) was set up in 2009 to replace the former consent regimes. As such, the IPC only decides applications for projects above certain limits laid down in the 2008 Planning Act, such as large wind farms. Once the IPC has been notified of a proposed application for development consent, the application process follows six steps ending with the Commission's decision. Any decision made by the IPC regarding offshore wind farm development has to be made within the framework of the Planning Act and the Government's energy policy statements (www.infrastructure.independent.gov.uk).

In Norway the permitting and planning systems are partly similar to the one in the UK, but here the practical experiences of significant offshore installations are virtually non-existent (Section 2). Offshore wind farms (≥ 1 kW) in Norwegian waters require installation concession in accordance with the Energy Act. The license application shall be accompanied by an environmental impact assessment. The installation must also be approved under the Sea and Water Act via a special detail plan for the purpose. Moreover, with reference to the Norwegian Planning and Building Act, a zoning plan that designates the area for *installations in water* will probably be required. Conformity with certain other laws is also required (and tried), such as the Act concerning relics of ancient culture. The noise pollution from the wind farm is also dealt with in the license trial (explicit exception for wind power development). Finally, the installation may also require permission to expropriate, as well as permission for *advance possession of entrance* (early entry) under the Expropriation Act for onshore infrastructure (Pettersson, 2008).

5. Concluding remarks

The analysis in this paper shows that the prevailing investment environment for Swedish wind power is in many ways contradictory. The current policy support scheme (and the planned changes in this) substantially improves the economics of onshore wind power investments, but the municipal planning monopoly in Sweden leaves substantial scope for local discretion and for de facto ignoring national energy policy objectives. Specifically, in Sweden only very vague guidelines are provided in specific cases, and in principle the municipalities in Sweden must in some way assent to (i.e., plan for) the establishment of wind mills at a certain location in order for the installation to actually take place.[9] For offshore wind power, though, the situation is many ways the reversed. For this less mature – but over time very promising – technology the policy incentives are too weak to promote significant development activities. At the same time, the permitting and planning procedures appear overall favorable to such a development, not the least in comparison to those in other major offshore countries in Europe.

The introduction of a more generous financial support to Swedish offshore wind projects would likely lead to a substantially increased interest for Swedish waters among domestic and foreign investors. In the paper we argue that such a support should primarily be viewed as a technology policy aiming at facilitating the future development and diffusion of offshore wind power to meet anticipated *long-term* climate and energy policy targets. The specific character of the policy support scheme chosen will depend on whether Sweden wishes to actively contribute to the promotion of global learning activities in the offshore industry, or instead solely focus on the future implementation of offshore wind power in a Swedish context and thus support R&D activities that facilitate this. At present, the Swedish policy primarily relies on the latter strategy.

On a more general level the analysis in the paper also illustrates that although public support to offshore wind power is necessary to promote its diffusion, the introduction of new policy schemes or the modification of existing ones should

[9] In a recent Government Bill (2008/09:146) a number of changes in the legal system are suggested that aim at facilitating future wind installations in the country. Still, overall these are fairly marginal and do not present a solution to the more general problems identified in this paper.

generally be preceded by an evaluation of the legal and institutional framework governing offshore development activities. Similar policy instruments – in terms of both size and design – can induce significantly different developments depending on the legal preconditions for the location and environmental assessment of offshore wind farms. The success and failure stories of technology support policies can thus not easily be transferred across country borders, and our analysis shows that both the political and the legal frameworks governing the investment conditions for offshore wind projects in Denmark, Norway, Sweden and the UK differ significantly.

These inter-country differences may also prove important for the future development of European energy policy. Energy and climate policy is largely international in scope, and in Europe there exist long-term political aspirations to integrate the different types of national support systems for renewable electricity sources (Midttun and Koefoed, 2003; Söderholm, 2008).[10] The presence of significant differences in terms of planning procedures and economic incentives for renewable energy projects may, however, create tensions since stringent conditions in one country will increase the joint, aggregate cost of attaining, for instance, the EU target for the share of renewable energy sources. The benefits of energy and climate policy (e.g., improved security-of-supply, reduced carbon dioxide emissions etc.) are largely international in scope, but the costs of implementation are typically borne at the local level; this fact may act as an impediment to increased international integration, but it may equally well put pressure on countries to reform local planning and permitting strategies. The offshore wind industry, with its international scope and great potential for genuinely large-scale wind power projects, may play an important role in this process.

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[10] The plans for a completely harmonized European renewable energy support system has, though, partly been abandoned (European Commission, 2008), but voluntary bilateral or multilateral cooperation between the Member States on renewable electricity support schemes are encouraged.

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