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TOWARDS A STRATEGY FOR OFFSHORE WIND POWER IN SWEDEN

Staffan Jacobsson
Kersti Karltorp
Department of Energy and Environment, Chalmers University of Technology*

Fredrik Dolff
Miljöbyrån Ecoplan AB, Göteborg

*Division of Environmental Systems Analysis
Chapter reviewer: Björn Sandén, Environmental Systems Analysis, Energy and Environment, Chalmers.

INTRODUCTION

The first offshore wind power farm was built in 1991 (in Denmark) but the diffusion of wind turbines took place mainly onshore.[1] By 2013, European offshore turbines supplied 24 TWh but there are expectations of a supply of 140 TWh by 2020.[2] For 2030, UK and Germany expect the supply to increase to about 115 and 87 TWh respectively.[3] The longer term potential is much larger and in the European Commission's Vision 2050 scenario analysis, 800 TWh are supplied (see Chapter 3 on the global potential).[4] Hence, offshore wind power is seen as a strategic technology in EU's efforts to decarbonise electricity generation.

Multifaceted government policies are applied in mainly UK, Germany and Denmark to support development and deployment of offshore wind power, that is,

1 This chapter draws on Jacobsson, S. and Karltorp, K. (2013) Mechanisms blocking the dynamics of the European offshore wind energy industry – challenges for policy intervention, *Energy Policy*, 63:1182-1195; Jacobsson et al. (2013) *Bidrag till en handlingsplan för havsbaserad vindkraft i Sverige – för säkrad eltillförsel, stabilt klimat och industriell utveckling* (Report 2013:11) Gothenburg, Sweden: Environmental Systems Analysis, Chalmers University of Technology. We are grateful to Västra Götalandsregionen for co-funding and providing an arena for discussing our work

2 Beurskens, L., Hekkenberg, M. and Vethman, P. (2011) *Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States*. Petten, the Netherlands: ECN and EEA. (ECN-E--10-069).

3 E.ON (2011) *E.ON Offshore Wind Energy Fact book*. Düsseldorf Germany: E.ON Climate & Renewables, states that the goals are 33 and 25 GW respectively and we assume a capacity factor of 40%.

4 In European Commission (2011) *Energy Roadmap 2050, Impact assessment and scenario analysis.* Brussels, Belgium: European Commission (SEC (2011) 1565)., the average supply of offshore wind power in five decarbonisation scenarios is 234 GW, or 818TWh with 40% capacity factor.

interventions are not limited to forming a market but include other dimensions in the industrialisation of the technology. Expectations of an extensive deployment are shared by many firms in the value chain, including component suppliers, turbine manufacturers, utilities, harbours, shipyards and logistics firms. A whole industrial system has begun to develop in northern Europe.

In this chapter, we argue that Sweden should shift from a passive to an active stance towards offshore wind power and initiate a process that eventually leads to a large-scale deployment. In the next section, we argue that offshore wind power is a desirable technology to develop in Sweden and we suggest a target for Sweden in 2030. This is followed by an analysis of mechanisms that may obstruct meeting that target and points to ways of overcoming these. In the final section, we discuss how a strategy for Sweden could be formed.

WHY BUILD OFFSHORE WIND TURBINES IN SWEDEN?

There is a significant potential for offshore wind power in Sweden, as there is in Finland and in the Baltic Sea Region at large.[5] An example may illustrate the scale involved. If (i) 3000 km^2 of a total of 30 000 km^2 of Swedish waters which the Baltic Sea Region Energy Co-operation (BASREC) judges to be attractive for offshore wind power is put aside for that purpose,[6] (ii) 5 MW is installed per km^2 and (iii) these have a capacity factor of 40% (3500 hours per year), the annual supply would be more than 50 TWh, or about one third of current Swedish supply of electricity. A number of firms have seen this potential and about 24 TWh could be produced in projects where firms currently either have or are applying for permissions to build offshore wind farms.

But, is an extensive deployment desirable in Sweden? In the debate, two arguments are frequently put forward against investment in new capacity to supply electricity from renewable energy sources. First, Sweden is currently a net exporter of electricity and is expected to remain so for some time.[7] Second, Sweden has already met its EU 2020 goal.

While correct technically, these arguments are weak in that they have a too short time horizon and focus on Sweden only. First, there is a considerable risk that a substantial production gap will emerge in Sweden, and in the larger Nordpool area, when the aging nuclear power plants (35 years on average) reach the end of their lifetimes. With, say, a 50 years' life-time, there may be a production gap of about 30 TWh for Sweden in 2032 and more beyond that date (Figure 15.1).[8] For Nordpool, the gap may exceed 100 TWh in 2035.

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5 This includes the west coast of Sweden and the Danish isles.

6 Baltic Sea Region Energy Co-operation (BASREC) (2012) *Conditions for deployment of wind power in the Baltic Sea Region*, Berlin, Germany and Stockholm, Sweden: BASREC.

7 Naturvårdsverket (2012) *Underlag till en färdplan för ett Sverige utan klimatutsläpp 2050*. Bromma, Sweden: Swedish Environmental Protection Agency. (Report 6537).

8 For nuclear power, we use the average production per reactor for the past ten years and add some supply since investments in new capacity have been made. For wind power and biopower, we use the Swedish Energy Agency's (2013) long-term scenario from which we also have taken data on electricity demand. Their scenario ends in 2030 and the production of wind and biopower is assumed to remain at the level in 2030 (33 TWh). For hydro power, we use the average production 2003-2012 which was 65 TWh. For details, see Jacobsson et al. (2013) *Bidrag till en handlingsplan för havsbaserad vindkraft i Sverige – för säkrad eltillförsel, stabilt klimat och industriell utveckling* (Report 2013:11) Gothenburg, Sweden: Environmental Systems Analysis, Chalmers University of Technology.

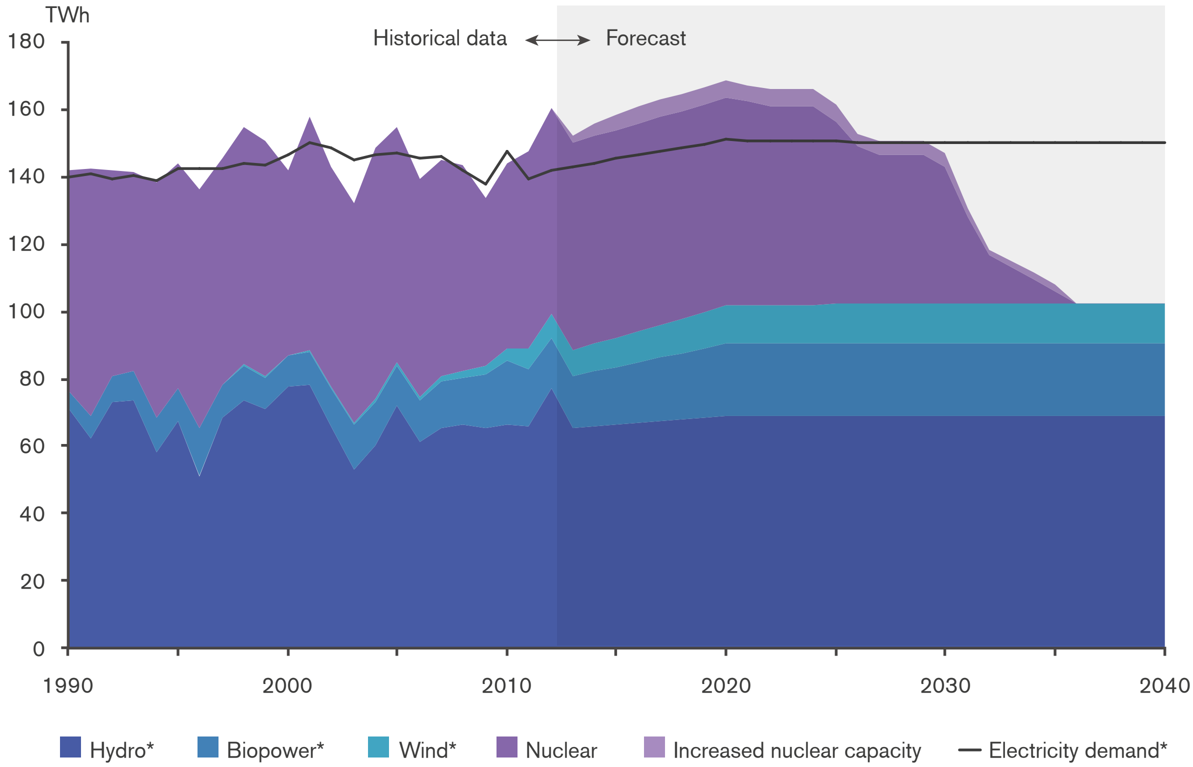

Figure 15.1 The emerging gap between electricity use and supply in Sweden. Source: Jacobsson et al. (2013).

Whereas the time-frame may be thought of as long, it is not long in the context of building new capacity. The environmental assessment of the Finnish nuclear plant in Olkiluoto started in 1998[9] and the reactor is not expected to be finished until 2016. Also offshore wind power farms have long lead-times. Several larger projects in Swedish waters expect to take about 15 years from the first idea to completion (Blekinge Offshore, Stora Midsjöbanken) and industry representatives emphasise the long lead-times of new projects – about 9-14 years.

Second, in the EU as a whole, the size of the expected production gap is immense – between 2020 and 2050 new investments may be required to supply close to 3000 TWh of renewable electricity (Figure 15.2).[10] It is, therefore, not helpful to frame the debate as if this were an irrelevant issue – Sweden is part of the EU and cannot be isolated from the implications of the goal of decarbonising the EU electricity supply in a few decades.

Initiating an extensive deployment now would, thus, contribute to ensuring that

9 Energimyndigheten (2010) *Kärnkraften nu och i framtiden*. Eskilstuna, Sweden: Swedish Energy Agency. (ER 2010:21).

10 In this scenario we have made the following assumptions: Electricity demand continues to increase at the same rate as between the years 2001 and 2010, i.e. 0.85% per year. This gives an electricity demand of nearly 5 000 TWh in 2050. All electricity generation from fossil fuels are phased out by 2050, a decrease of 1676 TWh. The life-span of existing nuclear plants is 50 years, which gives a production of 15.4 TWh in 2050, a decrease by 906 TWh. By 2020, the National Renewable Energy Action Plans estimate to add 578 TWh from renewable energy sources (Beurskens, L., Hekkenberg, M. and Vethman, P. (2011) *Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States*. Petten, the Netherlands: ECN and EEA. (ECN-E--10-069) p. 263). New nuclear plants are expected to produce 527 TWh, which is the average from the Energy Roadmap 2050 five decarbonisation scenarios. With these assumptions, there will be a need to invest in capacity to supply nearly 2900 TWh between 2020 and 2050. For more details, see see Jacobsson et al. (2013) *Bidrag till en handlingsplan för havsbaserad vindkraft i Sverige – för säkrad eltillförsel, stabilt klimat och industriell utveckling* (Report 2013:11) Gothenburg, Sweden: Environmental Systems Analysis, Chalmers University of Technology. Through ambitious energy saving measures, the sum may be reduced but the challenge is still huge.

Sweden and Nordpool countries have access to the required volumes of electricity when the nuclear plants are taken off-line. The potential is also large enough to allow for a substantial contribution to meeting EU's goal through electricity export.

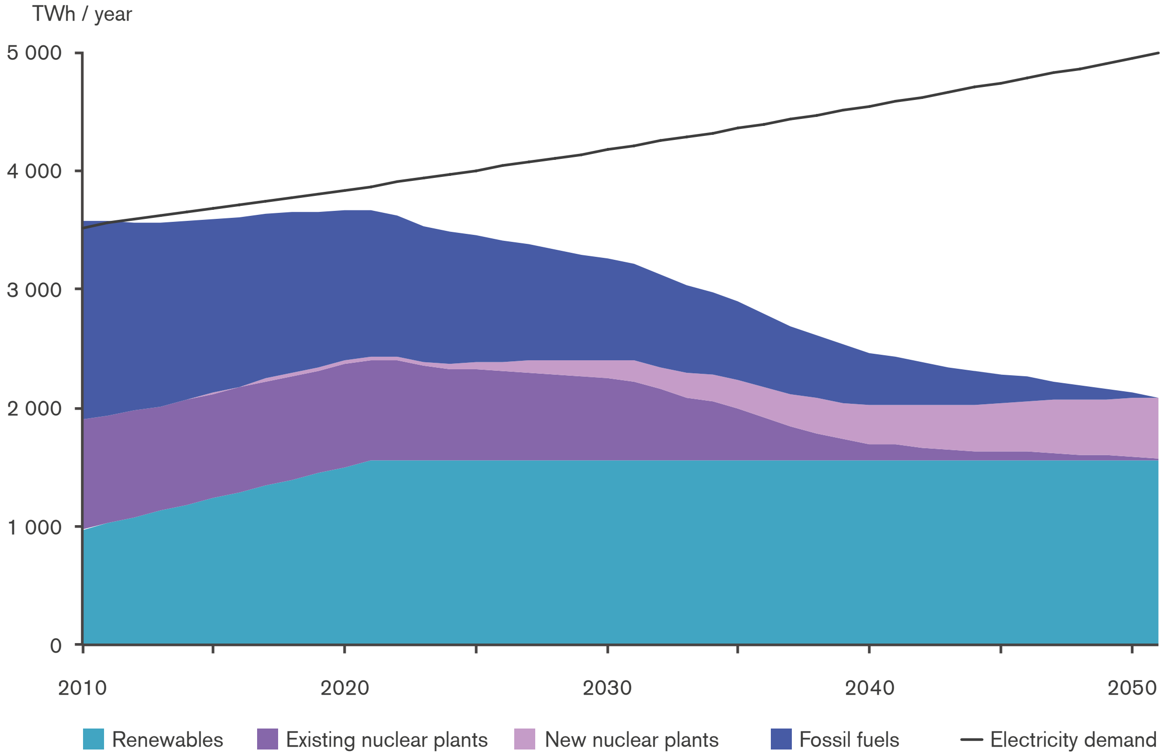

Figure 15.2 The emerging gap between electricity use and supply in EU, including Norway and Switzerland. Source: Jacobsson et al. (2013).

A deployment will be associated with new business opportunities. First, available evidence suggests that it is cheaper to generate offshore wind power in the Baltic Sea than in the North Sea. Indeed, it has been argued that with "inner-sea technology" costs may be up to 25-30% lower.[11] Sweden may, therefore, develop into a cost-efficient supplier of wind power. Second, a deployment would provide a home market for suppliers which may simplify for them to take shares of the emerging EU market – reaching a goal of 44 GW by 2020 is estimated to involve investment of about 135 billion EUR.[12] As Sweden has a strong engineering industry, this market may be a significant source of growth. Some firms are already in the industry, such as ABB in transmission, SKF and DIAB in components and GVA in marine technology. A home market would be expected to make it easier for firms in related industries to follow these and diversify into the offshore wind power supply chain. These firms may be found in e.g. steel, cement and shipbuilding industries, in shipping as well as in harbours. It may also benefit technology based start-ups, such as Hexicon, HM Power, Falkung Environmental Energy and SeaTwirl Energy Systems. Third, while these, and other firms, may supply products and services to

11 The conditions are less harsh in the Baltic Sea with less salty water and smaller waves, which influences the technology which is most appropriate, see e.g. Malmberg, H. (2012) *Havsbaserad vindkraft i Östersjön. Inventering av frågeställningar och analys av förutsättningar för lönsamhet.* Stockholm, Sweden: Svensk Vindenergi.

12 KPMG (2010) *Offshore Wind in Europe - 2010 Market Report.* Germany: KPMG AG Wirtschaftsprüfungsgesellschaft; Rabobank (2011) Reaching EUR 10c/KWh… 10 ways to cut subsidies in offshore wind. Utrecht.

North Sea applications, an early Swedish home market for "inner-sea technology" may provide an opportunity to develop new solutions that can be sold to other markets. This may even include turbines that are optimised for the wind conditions in the Baltic Sea

In sum, there are strong reasons for initiating an extensive deployment of off-shore wind turbines. The Vision is to *ensure an adequate supply of electricity in Sweden and Nordpool by about 2030, contribute to EU's decarbonisation and induce industrial growth in Sweden.* It is harder though to set realistic goals with respect to deployment in Swedish waters. Varying, but long, lead-times make it problematic to assess the speed at which deployment may occur. However, if we assume that a supporting regulatory framework is in place in 2015 and if all farms with permissions are built, these could be in place between 2019 and 2023 and provide about 8 TWh/year. Farms for which permission is being sought could be built a few years later, providing about 12 TWh/year. With a supporting framework, we would expect yet more farms to be planned and built before 2030. Hence, by 2030, it is conceivable that 30 TWh could be supplied annually. Even if this figure is uncertain, it is noteworthy that it is close to the above estimated production gap in the early 2030s. Hence, a preliminary target may be set at 30 TWh/year (8.5 GW) by 2030.

This is an ambitious target for an industry which is still young and a considerable risk is that the supply capacity of the EU capital goods industry will not grow fast enough. In 2012, 1.2 GW was built in Europe, a figure which is expected to grow to 1.9 GW in 2014.[13] Reaching the Swedish goal of 8.5 GW by 2030 would, thus, mean that the capital goods industry would sell only to the Swedish market for more than four years. To reach the EU goals of 44 GW around 2020 and 234 GW by 2050, its capacity must increase significantly. While this illustrates the risks for significant bottlenecks, it also highlights the business opportunities involved. In the following sections, we identify a number of obstacles to an extensive deployment and discuss how they may be removed.

FORMING MARKETS

The Swedish Tradable Green Certificate system (TGC) is designed to induce investments in the lowest-cost technologies, which are currently onshore wind power and biomass CHP. For four reasons, it is an unsuitable regulatory frame-work to promote investments in offshore wind farms. First, costs for offshore may be 40-50% higher than for onshore.[14] This is particularly problematic today (2014) when the price of electricity is low at the same time as the certificate price is low. The combined revenue dropped from about 9 eurocents/kWh in 2010 to 5 in 2012.[15] Second, a strong fluctuation in the revenue streams creates uncertainties, in particular with the long lead-times involved, which is likely to increase the cost of capital.

13 EWEA (2013) *The European offshore wind industry - key trends and statistics 2012*. Brussels, Belgium: European Wind Energy Association.

14 Malmberg, H. (2012) *Havsbaserad vindkraft i Östersjön. Inventering av frågeställningar och analys av förutsättningar för lönsamhet.* Stockholm, Sweden: Svensk Vindenergi.; Elforsk (2011) *El från nya och framtida anläggningar 2011, Sammanfattande rapport.* Stockholm, Sweden: Elforsk AB. (Report 11:26).

15 Jacobsson et al. (2013) *Bidrag till en handlingsplan för havsbaserad vindkraft i Sverige – för säkrad eltillförsel, stabilt klimat och industriell utveckling* (Report 2013:11) Gothenburg, Sweden: Environmental Systems Analysis, Chalmers University of Technology.

Third, it is a quota-based system and when the quota is filled, the price of certificates drops. An investment in an offshore wind farm is so large that it may fill the quota and, therefore, lead to reduced income for *all* investors, including the firm that makes that investment. An extensive deployment of offshore wind power would therefore require a political guarantee that the quota is increased - a political risk. Fourth, if the quota increases at the rate required to induce an extensive deployment of offshore wind turbines, it would raise the price of the certificates[16] and, consequently, lead to large rents for investors in less costly technologies.[17]

For these reasons, we propose that another policy is used. Inspiration may be sought in three leading countries. The German feed-in law provides a fixed and technology-specific payment per kWh for a given number of years. The payment increases with distance from shore and a "sprinter bonus" is given to early investors. UK is shifting to a similar system and feed-in tariffs (strike prices) were recently published. Finally, Denmark applies an auctioning system where the winner receives a feed-in tariff.

Swedish Wind Energy [18] proposes an auctioning system which is adjusted to the Swedish context where a number of farms have permissions to build. While the proposal has merits, there are disadvantages too. Most importantly, auctioning generates an unattractive risk-to-revenue ratio. From the perspective of an investor in an offshore wind farm, there are significant uncertainties with respect to technology (including geo-technology), suppliers, construction, grid connection, market and politics. These risks are larger for early investors than for followers (as learning normally takes place) and investors compare these risks with expected revenues. A policy which, in an early phase in the development of the industry, can be expected to lead to the desired deployment must involve an attractive balance between revenue and these risks. An auctioning tool which prioritises lowest cost has a questionable credibility in that respect, even if the political risk is kept low and grid connection is guaranteed.

Long lead times in acquiring permissions (see below) add costs and risks and if investors need to do geotechnical studies (which are expensive) to be able to make a bid, costs will increase further. All in all, *an auctioning procedure is likely to be associated with high initial costs, low and uncertain revenues and many risks*. For an industry which is deemed to be strategic, these features are problematic.

We propose instead that a feed-in policy is developed to support the deployment of offshore wind turbines. A guaranteed and cost-covering payment for a number of years, with a certain risk compensation built in for early investors, creates a more attractive balance between risks and revenues. Cost reductions may be stimulated, as in Germany and UK, by a gradual reduction in feed-in tariffs for new projects. The main challenge is to set the tariffs, which requires that the government has the required technology-specific competence. Although the cost level is project specific, an initial tariff of around 85öre/kWh is perhaps of the right order

16 This assumes that the quota cannot be met by deployment of onshore wind power.
17 Bergek, A. and Jacobsson, S. (2010) Are Tradable Green Certificates a cost-efficient policy driving technical change or a rent-generating machine? Lessons from Sweden 2003-2008. *Energy Policy*, 38:1255–1271..
18 Svensk Vindenergi (2013) *Särskild satsning på havsbaserad vindkraft.* Stockholm, Sweden: Svensk Vindenergi.

of magnitude; less if investors do not pay for transmission lines to the national grid.[19]

As there is great uncertainty in the timing of the ”retirement” of the current nuclear plants, an expansion in the capacity to supply electricity from offshore wind farms needs to be combined with organising for a greater trade in electricity. This would involve an increase in the transmission capacity (see Chapter 9) and a regulatory framework which guarantees prices that cover costs. A framework could be agreed upon by Nordpool and be supplemented with bilateral agreements with other countries, such as Germany.[20]

PERMISSIONS AND MARITIME SPATIAL PLANNING

Different industries (e.g. fishing) compete over the marine space as does the military. Indeed, the military has objected to plans for a 2.5 GW farm (Blekinge Offshore) and constitutes a serious obstacle to deployment in Sweden. Environmental concerns put additional items on the agenda, including objections from coastal populations (see also Chapters 6 and 8). Applications for permission to build offshore farms are, therefore, often contested.

Within the Swedish territorial limit, it is also a complex process to apply for permissions, involving many actors, long lead-times, high cost and uncertainty for investors.[21] For instance, the project developer WPD had to make 11 different applications to get permission to build a farm (Storgrundet). The work was started in 2006 and in 2013 they reached the stage where they applied for permission to build the transmission cable.

The process of applying for permission has to be simplified and speeded up. It would help if parts of the sea are dedicated to offshore wind farms. So far, only a few European countries (Denmark, Germany and Britain) have done so but such areas are needed, as an element in a comprehensive maritime spatial planning, to reduce uncertainties for investors and the time and costs of acquiring permission.[22] The recently created Swedish Agency for Marine and Water Management has the responsibility to develop a comprehensive policy for the sea and it is vital that it develops a plan for offshore wind power (see Chapter 8 for a related discussion on other forms of ocean energy). It is, however, important that (i) the development of a plan does not delay investments in farms which already have permissions (ii) it is done in dialogue with project developers and (iii) the plan is flexible to accommodate for new technology and improved knowledge of the sea floor.

19 Elforsk (2011) *El från nya och framtida anläggningar 2011, Sammanfattande rapport.* Stockholm, Sweden: Elforsk AB. (Report 11:26).; Malmberg, H. (2012) *Havsbaserad vindkraft i Östersjön. Inventering av frågeställningar och analys av förutsättningar för lönsamhet.* Stockholm, Sweden: Svensk Vindenergi.

20 The supply of intermittent power grows quickly in Germany which may reduce the interest in buying intermittent power from Sweden (see Chapter 13, Figure 13.2). However, Germany has problems with its deployment of offshore wind farms, has a very large gap to fill (both coal and nuclear) and is tormented by a cost discussion (Chapter 14). Imports of relatively cheap Swedish offshore wind power may, therefore, be attractive.

21 Beyond the territorial limit, an investor only needs approval from the Government and the process is much easier.

22 Västra Götalandsregionen (2010) *Förutsättningar för havsbaserad vindkraft* Power Väst; Baltic Sea Region Energy Co-operation (BASREC) (2012) *Conditions for deployment of wind power in the Baltic Sea Region*, Berlin, Germany and Stockholm, Sweden: BASREC

TRANSMISSION AND HARBOURS

Investors in offshore wind farms are obliged to pay for building the transmission cable and the connection to the land-based grid and, sometimes, to upgrade that grid. With an extensive deployment of offshore wind farms, the regulation risks leading to inefficiencies due to lack of coordination between investments in farms and the grid. Svenska Kraftnät[23] emphasises the importance of coordinating investments in the onshore grid and deployment of wind turbines. Similarly, an extensive deployment of off-shore wind farms would require a coordination of investments in these and in the offshore grid to ensure cost efficiency and supply security.

In Germany and UK, there is an understanding that it is not self-evident how an appropriate regulation looks like and both countries have made large changes in initial policies. These are made to make sure that investors, neither in the grid nor in wind farms, are landed with "stranded assets" and that investments in *different* offshore farms are coordinated with the investments in the grid – instead of building a separate transmission cables to each farm, synergies are created through a common infrastructure.[24] Cost efficiency may, therefore, require that farms are built in clusters which take us back to maritime spatial planning. Some of these clusters may come to cross borders which mean that there may be a need for coordination between countries. An example is E.ON's planned farm Södra Midsjöbanken and Polish farms on the other side of the border. As argued by several,[25] it may be advantageous to build transnational grids with a strengthened capacity for trading electricity across borders. This leads to the notion of building an international grid that connects several countries in the Baltic Sea region. Such a grid may also help handle uncertainties with respect to imbalances between supply and demand due to the uncertainties in the life-times of nuclear plants and the intermittent nature of wind power production (see Chapter 9).

Harbours constitute another vital infrastructure. A number of European harbours invest in facilities for supporting the deployment of offshore wind turbines. One of these is Bremerhaven and others are Cuxhaven and Belfast, the latter building a 100 000 m^2 facility.[26] This infrastructure is vital for deployment and service of the turbines but also as a base for manufacturers of components and turbines. Yet, costs for rebuilding harbours are high and in Britain, the government has allocated about 150 million EUR to support the transformation of harbours. For investments to be taken, it is vital that the regulatory framework for forming markets is credible, stable and long-term and that project developers agree to use a particular facility.

FINANCIAL AND HUMAN CAPITAL

A recurrent theme in the European debate is the gap between the volume of capital required to be invested in transforming the energy system and the volume

23 Svenska Kraftnät (2012) P*erspektivplan 2025 – en utvecklingsplan för det svenska stamnätet*. Stockholm, Sweden: Svenska Kraftnät.

24 See e.g. EoN (2011) and von la Chevallerie (2013) Clearer path ahead under new grid connection rules, Offshore special report, *Windpower Monthly*, April.

25 See e.g. Deutsche Bank Climate Change Advisors (2011) *UK Offshore Wind: Opportunity, Cost and Financing.* London, UK and New York, NY, USA: DB Group

26 Huss, M. (2013) Presentation. *Windforce Baltic Sea*. Stockholm, Sweden, Feb. 20-21.

that is currently invested.[27] Industrialists argue that lack of financial capital will constitute one of the largest obstacles to an extensive deployment in Sweden. To generate a capacity to supply, say, 30 TWh/year may cost in the order of 25 billion EUR (with current prices).[28] A necessary condition for this capital to be made available, at reasonable prices, is that there are long-term and stable regulatory frameworks which keep political uncertainties down.[29]

While such frameworks are necessary, they are probably not sufficient for a number of reasons that are further discussed in Chapter 16. First, utilities do not have the financial capacity to fund investments over their balance sheet, especially if they are engaged in several farms simultaneously. Second, financial actors associate offshore wind power with high risk and are therefore hesitant to invest, in particular before the farm has been built. Third, the financial crisis reduces access to capital from commercial banks. Finally, some banks have developed an extensive business which involves short-term speculative investments in financial products rather than long-term investments in industrial projects such as offshore wind farms.

Deutsche Bank [30]concludes that: *"Insufficient capacity in debt capital markets, perceived risk around policy support frameworks, risk around new technologies being rolled out ...have made low carbon infrastructure financing unachievable without scaled up Government intervention*."

The German and UK governments responded by strengthening the role of public investment banks (KfW and Green Investment Bank), aiming to reduce the risks for private investors.[31] "Green bonds" is another option where a public bank, say SBAB in Sweden, issues green bonds for which the state acts as guarantor. Together with a guaranteed feed-in payment, this would not only take away the need for risk premium but also open up for e.g. pension funds to channel some of their capital into this industry. Creative solutions are, thus, required to ensure supply of sufficient capital, at a reasonable cost.

An extensive deployment also necessitates that specialised human capital is made available. This includes, e.g. operation and maintenance personnel, staff with competence in environmental impact assessment and PhDs in electrical engineering who are specialised in grid design and development (see Chapter 16 for a more detailed discussion). Blekinge Offshore, for example, estimates that 150 technicians for operation & maintenance will be needed. The scale of this challenge depends on the target for deployment and the level of ambition for industrial growth in the field. With a high level of ambition, bottlenecks will occur but these can be reduced by coordinating research and educational policy with energy and industrial policies.

27 Jacobsson, R. and Jacobsson, S. (2012) The emerging funding gap for the European Energy Sector – will the financial sector deliver? *Environmental Innovations and Sustainable Transitions* 5:49-59; Rubel et al. (2013) *EU 2020 Offshore-Wind Targets. The € 110 Billion Financing Challenge.* Frankfurt, Germany: The Boston Consulting Group.

28 The cost estimates in Elforsk (2011) *El från nya och framtida anläggningar 2011, Sammanfattande rapport.* Stockholm, Sweden: Elforsk AB. (Report 11:26) would lead to an investment cost of 311billion SEK. Based on indicated costs of current projects in Sweden we get 240 billion SEK. For the estimate in the text, we averaged these figures.

29 Deutsche Bank Climate Change Advisors (2011) *UK Offshore Wind: Opportunity, Cost and Financing.* London, UK and New York, NY, USA: DB Group; Rubel et al. 2013.

30 Deutsche Bank (2011) p. 39.

31 KfW, for instance, invests 5 billion Euros in offshore wind farms.

RESEARCH AND INNOVATION

The cost of offshore wind power is expected to decline with increased deployment but a deployment further from shore, and in more difficult conditions, may offset the effects of learning. Moreover, learning requires dedicated efforts in the whole value chain, for example to create standardised solutions for combining foundations and turbines, net connections[32] and logistics.[33] Other examples are new turbine technology, new crane technology in harbours and ships to transport and install foundations and turbines.

In order to stimulate technical change that reduces costs and enables industrial growth, the leading countries fund organisations for conducting applied R&D and contributing to innovation processes. Risø in Denmark is perhaps the most famous of these. In Germany, a Fraunhofer institute dedicated to offshore wind power was created in 2005 and in Britain, the Offshore Renewable Energy Catapult was recently founded, inspired by the Fraunhofer Institute.

The applied R&D focusses on solving problems associated with the severe conditions in the North Sea. For Sweden, and other countries around the Baltic Sea, "North Sea" technology needs to be supplemented with technology which is adjusted to the specific conditions in the Baltic Sea, i.e. "inner sea technology". As mentioned earlier, the difference may constitute an opportunity for firms developing along a somewhat different technological trajectory. In part, attractive market conditions will induce such efforts but these may be supplemented with an applied RD&D (research, development and demonstration) program (co)funded by the state and involving universities of technology. While the details of such a programme cannot be specified, some examples of knowledge fields may be given:[34] foundations, including those that can manage ice and technology to install foundations; turbines which are dimensioned to wind conditions in the Baltic Sea; logistics solutions (including specialised ships) and transmission solutions. A further area would be floating turbines – a technology which is independent of sea floor conditions and which builds on marine technology, a strength in Sweden.

CONCLUDING DISCUSSION

In this section, we summarise our findings and identify further issues in forming a strategy for Sweden. Although an extensive deployment of offshore wind turbines is contested, we have argued that it is desirable in order to (i) ensure an adequate supply of electricity in Sweden and Nordpool by about 2030 (ii) contribute to EU's decarbonisation and (iii) induce industrial growth. We have also argued for a target of about 30 TWh in 2030.

32 Knight, S. (2013) Cabling standards hold key to cutting costs, Offshore special report, *Wind Power Monthly* April.
33 Huss, M. (2013) Presentation. *Windforce Baltic Sea*. Stockholm, Sweden, Feb. 20-21.
34 Dalén, G. (2013) Presentation. *Windforce Baltic Sea*. Stockholm, Sweden, Feb. 20-21.

Market	Design a feed-in law that provides an attractive balance between risks, costs and revenues for investors
Permission	Organise the application process for permission to reduce lead-times and costs, inter alia though maritime spatial planning
Transmission	Find a regulatory framework for extending the onshore and offshore transmission grid that guarantees connections and simplifies coordination of investments within and across borders
Harbours	Create long-term targets as well as stable and attractive conditions necessary for harbours to undertake investments
Financial capital	Secure access to the capital required for an extensive deployment and at reasonable costs
Human capital	Secure access to specialised human capital
R&D and innovation	Form a RD&D program with particular emphasis on technical solutions appropriate for the Baltic Sea

Figure 15.3 Policy challenges for offshore wind power in Sweden.

As in other countries, the strategy to reach this goal needs to be multifaceted. With respect to market formation policy, we proposed a feed-in law in order to find an attractive balance between risks, costs and revenues for investors. An effective strategy would also need to incorporate policies that help overcoming obstacles in sex other areas, see Figure 15.3

It is urgent to develop and implement the strategy due to the long lead-times in many fields. We have referred to those in planning and building the farms but they are also present in planning and building transmission grids and in rebuilding harbours. Moreover, there are long lead-times in changing regulatory frameworks, developing new educational programmes and setting up, conducting and benefitting from an RD&D programme.

The range of challenges indicates that several government departments and agencies need to be involved in formulating and implementing a strategy. We have mentioned the Swedish Agency for Marine and Water Management and Svenska Kraftnät (the Swedish National Grid) but there are more, including the Ministry Education and Research and Ministry of Enterprise, Energy and Communications as well as the Swedish Energy Agency. Their respective policies need to be coordinated.

Coordination with other countries in the Baltic Sea region may also be desirable, e.g. in terms of grid development. This adds complexity but there are also advantages. Collaborating with Finland, for instance, could give several advantages. First, as the physical conditions resemble those in Sweden, coordinating RD&D programmes may reduce costs and strengthen industrial growth in both countries. Second, with a common market formation programme, the region would be more attractive for firms in the whole value chain. It may, for example, require 500-600 turbines to be built over a two-year period in order for firms to undertake investment in a specially designed ship to transport and install the turbines. Collaborating with Finland would, therefore, be a way to enhance industrialisation in the region as a whole. The form for collaboration may be inspired by the German-French coordination of "Energiewende" with a joint office for renewable energy.[35] Third, in order to reduce the negative effect of intermittent supply, a plan for locating turbines across the Baltic Sea may be useful.

Finally, as for further issues to explore in forming a strategy, we need to ascertain the cost advantages of "inner-sea technology" and establish how to manage the intermittent supply of wind power (Chapter 9 and 11). Again, we need to acknowledge the time horizon. If our target is met, there is close to two decades available to solve the issue of intermittency. We should also acknowledge the potential growth that may come out of finding solutions, e.g. in the form of electricity storage (Chapter 5 and 12) and demand-side management technologies (Chapter 10).

35 Altmeier, P. and Batho, D. (2013) *Gemeinsame Erklärung über die Zusammenarbeit im Bereich erneuerbarer Energien und die Schaffung eines Deutsch-französischen Büros für Erneuerbare Energien im Rahmen der Energiewende.* Paris, France.